From Brick to Click

Using the New Economy to Drive Emissions to Zero in the City of San Francisco

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Introduction

Around the world, consumer preferences and behavior are rapidly changing in response to and also driving technology advancements. The changes are particularly notable in California, the Bay Area and the City of San Francisco where innovations are born and adopted early. The growth in delivery and mobility sectors spurred by advances in modern communication is particularly aggressive in its competition with traditional consumer shopping in physical stores. In this primer, I show that simple scaling considerations reveal the powerful forces and the major changes associated with the transition from "brick" to "click". Data acquisition can better quantify the changes taking place. With robust data in hand, valuable analysis can be achieved in the service of defining and guiding policy. Thoughtful, responsive and even anticipatory regulations of delivery can help drive the new economy towards zero emissions as well as enhance the economy, improve traffic flow, promote health, ensure safety, and achieve a more inclusive society. The diverse, welcoming culture of San Francisco together with our population of innovators and early adopters present a healthy mix that can help the City and inform the world. To help start the discussion, and to help focus on which data should be collected, I have included some policy recommendations.

Background and Motivation

Department stores such as Sears, K-Mart, J.C. Penney and Macy's have been closing locations for the last several years. For example, Sears had more than 3,500 stores in 2011 but only about 1,400 store by early 2017[1, 2]. Mall stores and other chains are closing and many are declaring bankruptcy[3]. Meanwhile, eBay, UPS and especially FedEx and Amazon continue with rapid growth. In mid-2017, Amazon neared parity with Macy's as the largest U.S. clothing seller, according to Cowne & Co. analysts, as reported by Anne D'Innocenzio, Associated Press[4]. Moreover, newer enterprises such as Instacart, UberEATS, Amazon Fresh (and more significantly Amazon's purchase of Whole Foods in 2017) foreshadows continued growth in the new economy and expansion beyond consumer goods to perishables and prepared meals. In mid-2017, only 1-2% of grocery sales were online[5]. Delivery and in-store pick up is expected to grow, further changing the mobile culture. As with ride hailing services such as Uber and Lyft, customers are expecting and demanding, rapid, affordable, intuitive service. In all these cases, the need for and associated hassles of private vehicles is reduced. But what are the effects of these conveniences on the environment with respect to for example traffic congestion, safety, sustainability and emissions? For ride hailing, the vehicle miles travelled increases[6] while the number of vehicles, especially parked vehicles presumably decreases. What about delivery services? The wide spread adoption of a host of delivery services, curbside pick-up services, Uber package, etc. are bound to change traffic patterns. Land use patterns may be impacted,

from the expansion of curbside pick-up locations to converting closed businesses into high rise housing. Quantifying these changes and measuring their greater impact is important for city planners and governance so that rational decisions for continuous improvement can be made. Quantification of the online economy, and the resulting mobile delivery services can help evaluate the pluses and minuses. In particular, it is important to establish metrics to weigh the benefits experienced by the customers of these services against externalities such as environmental impact affecting the greater citizenry.

Vehicle Miles Travelled

To uncover the likely impact of the transition from "brick" to "click," particularly on policy framework such as the city's ambitious climate goals, traffic flow and congestion, public health and quality of life, jobs, and the economy, we consider two simple models with just nine consumers, Figure 1. Such sketches help visualize the transition.

In general, delivery service trucks and their driver are assigned N customer delivery locations/homes, known as "drops". Figure 1 illustrates a simple case with N=9 and for additional simplicity we consider one package per drop. The delivery vehicle leaves the distribution center (green triangle) drives along a path connecting the customer homes (dots in the figure) in an efficient loop (blue). The blue lines of the loop graphically delineate the vehicle miles travelled, VMT. The N packages are delivered by covering a minimum distance, D, thereby reducing vehicle emissions and package delivery cost. Note that the efficiency, N/D, is higher in regions of high drop density because the distance between drops is shorter. Adding customers also increases drop density and decreases the distance between drops. Therefore, increasing the number of customers *increases efficiency*.

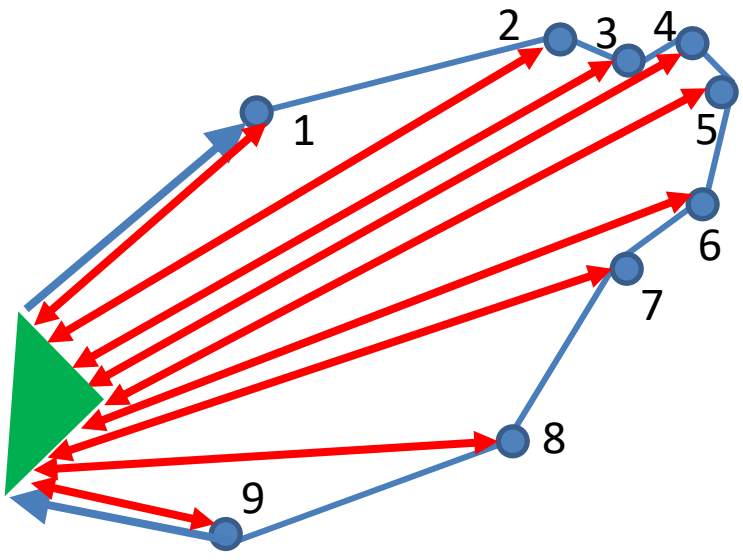

Figure 1. Two simplified consumer models. Package delivery service ("click") delivers sequentially to homes in a single clockwise loop, blue. The delivery truck loads at the distribution center (green triangle) travels sequentially to home 1 through 9 and returns. The blue path is the vehicle miles traveled, VMT. For the same configuration/geometry, mall shopping ("brick") requires much more VMT because a round trip (shown in red as a double-ended arrow) to the shopping mall (green triangle) is required *for all nine homes*. A more realistic number of packages, e.g. 100, would show a more pronounced difference in VMT

Comparison with mall shopping is striking. For simplicity we use the same configuration of customers, Figure 1, where the green triangle now represents a shopping mall. The double ended red arrows signify round trips to the shopping mall from homes 1 through 9. The total VMT (the length of the arrows doubled) is clearly greater than the total length of the blue lines

depicting the VMT for delivery. Moreover, unlike delivery, increasing the number of customers does not improve efficiency of mall shopping because more shoppers requires more VMT which leaves efficiency unchanged. A more realistic delivery model would have a hundred drops, but would be difficult to illustrate. Nevertheless, it is easy to see that the comparison to a hundred mall shoppers would be even more dramatic.

For convenience, and simplicity, the models in Figure 1 assume the same central location for both the shopping mall and the delivery distribution center and the same distribution of customers. Since one possibility for the many mall sites that are closing is in fact erecting new fulfillment centers, the simplifying assumption of central locations for both models may actually be true in some cases. More often, however, fulfillment centers are located further from the city center than malls. These added miles have low impact on VMT because they are shared, or diluted, by the large number of customers, N. It is important to note that retailers, such as Walmart and Target, are recognizing the potential of their centrally located stores for enabling fast distribution and delivery.

The simple comparison illustrated in Figure 1, especially for realistic N is a strong force that is powering delivery service business models, namely reductions in VMT and consequently in costs and thankfully decreasing emissions. The simple models show how additional reductions accrue as drop density increases, further powering the online economy. Moreover, shoppers can compare prices quickly online at home saving their own precious time as well as the cost of driving and perhaps even of owning a vehicle. With cleaner delivery vehicles (UPS uses natural gas, which runs cleaner and produces less GHG than gasoline or diesel) the environment and health of the citizenry are better served even with the trucks being larger than private cars. Zero-emission vehicles, hydrogen fuel cell electric, battery electric, and combinations, as being considered by delivery companies[7], can help dramatically.

Other factors favoring the new economy

It is interesting to note the results of recent research by a University of British Columbia and Harvard Business School collaboration[8]. The findings suggest that using money to buy free time --such as paying to delegate household chores like cleaning and cooking -- is linked to greater life satisfaction than using the money to "buy things." Presumably, a new item produces the same joy (or lack thereof) regardless of the method of purchase, but *clicking* brings greater life satisfaction due to the time saved by delegating the physical act of shopping. The mobile economy brings many ways to save time in driving and in parking. Incidentally, from an environmental point of view, the worst situation is when a shopper drives to store, selects purchases, *has them delivered*, and drives home alone in an otherwise empty car. Another "problem" or uncertainty of the new economy is what people do with the time (and VMT) they have saved; do they go for a drive?

The lower VMT and attendant decrease in costs, along with convenience to the customer, are strong drivers in the new economy. Decreasing VMT leads to less congestion and pollution, especially with thoughtful policy. These improvements (along with safe, curbside passenger pick-up that couples with efficient metropolitan transit) propel the new economy and lessen the need for private vehicles. Since vehicle ownership can be a large portion of a low-income budget, eliminating the need for a private vehicle may help alleviate a significant portion of the cost burden that low-income people face.

Affordable and quick transportation and delivery, available to all (no personal car needed), could increase disposable income which typically improves the economy and creates jobs in ways that defy predictions but seem obvious afterwards. With fewer cars, parking demands are relaxed thereby freeing space for parklets, convenient and safe loading zones, improved recycling and refuse pick-up, as well as quality of life advancements such as more interesting routes for foot traffic and bicycling with better flow and greatly reduced hazards.

Challenges and detractors

The expected improvement to traffic flow due to the decreased VMT may be offset by the large number of stops and double parking of delivery vans thereby clogging streets, see Figure 2. Casual observations suggest that delivery truck drivers are working with time factors such as deadlines or productivity rewards. These factors spur faster driving and result in agitation of the streets, more noise, safety concerns and even collisions. Public opinion almost certainly reflects this negative while at the same time customers are simultaneously calling for faster service. Delivery vehicles generally weigh more than passenger cars and physical consequences of a collision as well as the simple perception of friendliness is more strongly perceived than those same factors for typical personal vehicles. Economic factors appear to call for ever larger trucks and larger loads.

Figure 2. The rapid expansion of e-commerce is causing unwanted congestion by double parked trucks, as shown here in San Francisco during delivery and load redistribution. The City might address such problems by helping, leveraging and guiding the fast-evolving new economy and, at the same time, accelerate emission reduction and improve sustainability. *photo credit,* T E Felter

It is critical to note that these externalities are often not borne by the delivery service or their customers. Rather, these aspects are born by the citizenry in general. In short, the delivery customers reap the advantages and propel the new economy, but often residents and workers are subjected to a negative experience. Ideally, policy, regulations and taxes will fairly bill the users, improve the quality of life for all and meet City initiatives for the environment and for decreasing the wealth divide.

The delivery model may be an inadvertent service-economy microcosm of society and the increasing gap between the population segments of the have-less and the have-more. Casual observations as well as the writing styles posted in blogs that focus on deliveries suggest an asymmetry. Customers often complain in a college-educated writing style about late deliveries

and damaged goods. Delivery personnel generally write in a more informal, even vernacular style, about slights and difficulties of the job. Self-driving cars may displace drivers (a large cost in delivery) in the sharing economy and therefore offer lower fares, hopefully bringing more of the have-less a convenient mode of transportation … but at the undesirable cost of eliminating jobs for drivers.

Traditional and manufacturing jobs in the U.S. have always been challenged by domestic automation and by the world pool of cheap labor, yet unemployment has remained relatively stable. As the once luxuries of only the rich (frequent air travel, prevalent air conditioning, healthier food) are more widely spread, new jobs emerge. The problem is not with unemployment as much as it is with the wealth divide and churn: the new and emerging jobs benefit one demographic while the old, disappearing jobs crush another. These changes are enormously disruptive to hard fought careers and are especially hard on middle and late career employees with hard to acquire skills that are suddenly no longer needed. To take one familiar example, the automobile brought huge benefits to society but wheelwrights and stable hands suffered during the transition. Forecasting changes caused by the new mobility should help organizations focus on lessening the burden on those most affected.

Waste and Recycling considerations

Other negative factors of delivery include effects on waste collection and recycling. Delivery service, as with take-out and other modern conveniences, relies on packaging. Spent packing materials are an increasing fraction of the city's refuse. The widely used but simple recycling of the 1980's has transformed to a more complex industry in the early 21st century, see Figure 3. San Francisco is credited with high rates of waste diversion[9] but to continue progress,

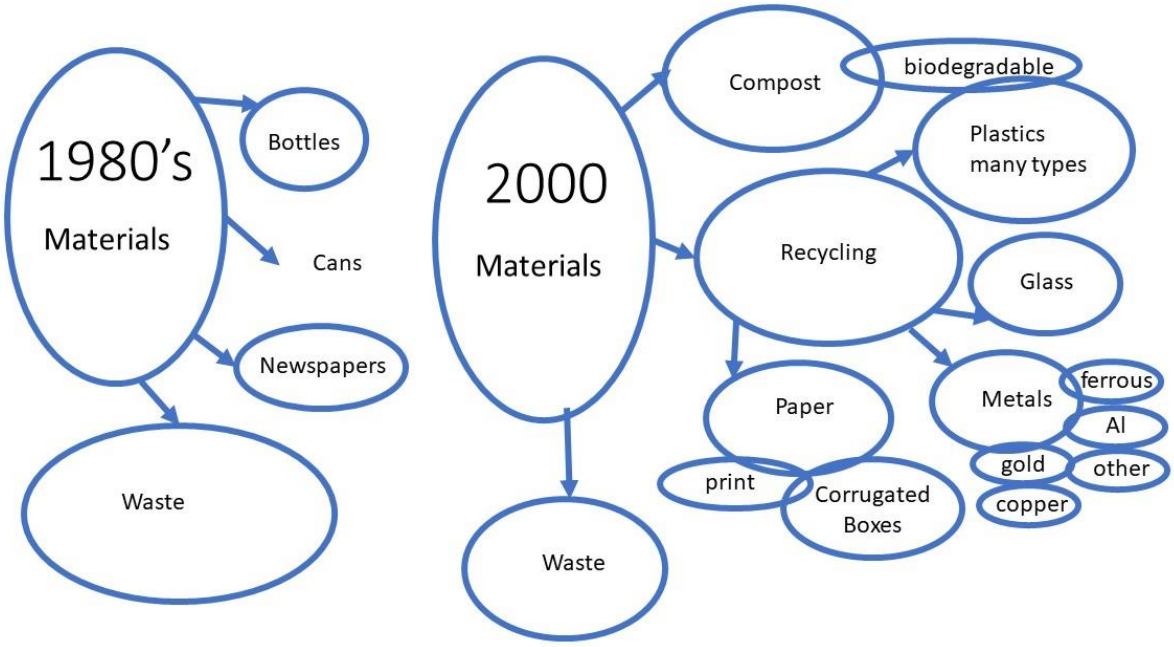

Figure 3. The magnitude and complexity of waste management increases with *the culture of convenience:* takeout, home delivery and online shopping.

it is necessary to counteract as one recycler called "the Amazon Effect."[10] What used to come in a glass bottle now comes in one with "three different types of plastic, the bottle, the cap and the label."[10] City refuse has shifted from metal, glass and paper to many types of plastic and other materials and much more corrugated cardboard thereby diluting the traditional urban ores. The increased difficulty in recovery, coupled with a falling market for these recyclable materials squeezes profit from both sides. Moreover, waste generation is more distributed to residential areas now and less at centrally located big box stores and commercial areas. The effect is to now cause a negative externality in the form of more waste trucks and higher collection costs. Growing complexity and the increasing number of waste components makes recycling more difficult and therefore more expensive. New recovery, recycling and compositing infrastructure and investment will be required statewide. How will the capital be obtained, who will ultimately pay back these costs? How will rates be set? These questions are difficult to answer in quiet times, but what about now with rapid changes in recycling largely spurred by the growth in online shopping and additional quantities and types of packaging materials that must be disposed? Some of these extra costs would be covered by the delivery customers through increased waste collection costs, but street litter and illegal dumping an ongoing challenge for most cities, including San Francisco, will increase.

Critical data and sources

Good public policy relies on a number of key factors including enlightened and effective elected officials, great administrators and bureaus, an engaged citizenry, public transparency, careful studies and accurate facts, i.e. *data*. This section outlines the type of data that will be useful in evaluating needs and guiding policies for package delivery.

Delivery traffic data is complex. In addition to vehicle miles per package, many other factors should be considered. The weight and size of the vehicles as well as their emissions of pollutants and noise. How do the trucks influence traffic flow and other aspects of the city environment as well as affect policy goals such as sustainability? Some information may be difficult to measure such as the effect on the general population's health and safety to perceptions, information overload, inclusiveness, esthetics and so on. Other information may be more readily available.

The Vision Zero initiative seeks to eliminate severe injuries and death by automobile collisions in the city of San Francisco. Partnering with these organizers in data collection and analysis may make it possible to compare collision rates of different shopping modes, in particular delivery vs. mall shopping. Well-trained and periodically tested drivers (as well as self-driving delivery vehicles, sidewalk roaming delivery robots and airborne drones in the future) won't be driving under the influence (or distracted) nor fall into road rage, but will their overall safety record beat that of the shopping public? Collision data and analysis is guiding the approach for Vison Zero goals which could include policy on delivery regulation.

Vehicle citations for moving violations as well as for double parking and other types of stationary interference with traffic can be an important source of data. Upgrading these enforcement programs to make data more available and easier to analyze could help policymakers. Observations of ongoing traffic, in particular the percent of various delivery vehicle types for various times of day and routes, as well as trends over the coming years, while valuable, could be difficult and costly to deploy. However, representative data could be

collected as a byproduct of dash cams on city vehicles with appropriate pattern recognition software which anonymizes the data. Dash cams on city vehicles could augment or confirm information from parking space utilization (are spaces getting easier to find?), parking citations, etc., again with proper pattern recognition software. Since the software would only be recording vehicle types, and not drivers or identifying information such as license plate, public privacy is maintained. Information from postal services for deliveries in the city can quantify delivery associated with online shopping. Commercial navigational aids such as Waze etc. might be useful for quantifying collisions and other sources of congestion.

The delivery businesses themselves can be sources of trip typologies. While companies have traditionally resisted supplying data, 2017 witnessed abrupt turn arounds with proper incentives and negotiations. Thus, the city has vastly improved registration of Airbnb providers simply by partnering with the company to make registration with the city an easy, low-cost, automatic part of the online application to become a provider. Similarly, Uber is supplying information about their drivers that was previously guarded as a privacy concern. It may be possible for the City to push forward and collect and anonymize a wealth of information from delivery services. The simple total of fuel used and therefore greenhouse gas emitted of all delivery services summed together would be very valuable an easily skirt business proprietary information. The delivery services may be willing to supply trip typologies and therefore the number of packages, number of miles driven per package, number of stops, length of stops, again aggregating the data to remove business sensitive information. Tax records might be used to provide the number of employees, the amount of driver overtime, and other factors that can be related to the impact of these businesses on the city. General information, such as number of packages per year and the (growing) percent of e-sales and deliveries every year may provide enough high-level information to inform decision making without getting hung up on the details.

Citywide information outside the domain of traffic can be used to gauge the amount and effect of new delivery technologies. Registration of garage conversions to bedrooms is an indicator of increased value of living space compared to private parking. The owners may have decided that they can get by without a car or that the hassle of street parking is acceptable. Note that the new mobility - and a lower population of private cars - should make parking more available. Conversions of retail space to housing is a reflection of the new economy. Applications for the placement of smart lockers is another. The composition of waste sent to landfill and recycled materials are useful sources of data that reflect changes in the new economy that are largely driven by the amount and type of packaging materials associated with deliveries. Analyzing this stream of data and comparing with alternatives can provide city planners insights to improved regulations and policy.

Policy vision and incentives

It is useful to consider methods to help the new economy benefit all residents, workers and visitors to San Francisco. Understanding some of the possibilities can inform and guide which data are most useful in defining goals and policy necessary for building a Master Mobility Plan for the City of San Francisco, as is being done in Seattle.[11]

Is it possible to introduce new regulations that require registration of delivery vehicles for driving inside the city? Regulation and registration of delivery vehicles, as with all motor vehicles, are set by the State DMV and by the Federal government. Nevertheless, cities do have precedence for exercising local control. London limits half the cars that can enter the city

according to odd/even license plate. Cities frequently close or limit street access for events or repairs. Local, *city* registration of delivery vehicles is, at its core, a similar limitation on street access, balancing the needs and safety of everyone in the city with free enterprise. The city could phase in zero emission vehicles for delivery, ZEVD, by mandating that the registration of conventional, fossil-fueled delivery vehicles would expire without an option to renew after a number of years or by increasing registration fees for the use of conventional vehicles. These levers can ensure widespread conversion to ZEVD without being an undue burden to the business if the conversion rate is consistent with the turnover of business fleet vehicles. Exceptions or longer grace periods for small businesses, stores or hardships could be considered.

Because the cost of a delivery truck is outweighed by the salary and benefits owed to the driver (or the purchase of early versions of self-driving technology), the cost of upgrading a delivery truck to zero emissions is lost in the noise of the other costs. Moreover, the "bang for the buck" is enormous because a very large quantity of emissions is eliminated, year after year, from the many miles travelled. Policy that mandates delivery vehicles to have zero emissions therefore captures the benefits of the new economy and strongly helps the state and city governments meet aggressive emission targets. In short, a highly regulated (or motivated, see below) delivery company could adapt ZEVD in a few years, or a few hundred thousand miles of each vehicle.

In contrast, change out of the entire fleet of presently driven family fossil fueled vehicles to zero emission, although critical due to the massive total VMT of the public, is a much more formidable problem. The cost of zero-emission vehicles is too high for rapid widespread adoption by most of the public. Widespread adoption would involve decades of time and millions of vehicles. However, with sufficient advances in the mobility sector (perhaps aided by enlightened policy), families in coming decades may opt out of private vehicle relying exclusively on mobility options which, of course, have all the latest technologies, including zero emissions.

Political difficulties with creating registration requirements for city delivery would be substantial. Delivery services will be less than enthusiastic about new regulations, the costs and complication of registering delivery vehicles, and dealing with an imposed turnover to a new fleet technology. However, there may be some incentives for these businesses that the City

Figure 4. Shared reception "smart lockers" reduce costs and speed up deliveries. An app notifies the customer of an arriving package and makes good use of a small footprint by assigning the right size locker. Using small areas from targeted sidewalks and public spaces and requiring servicing by *ZEVD-only* can reduce fossil-fueled shopping by residents. Smart lockers decrease packaging requirements and facilitate customer returns. *photo credit*, TEF

could provide to help create a partnership by, for example, free or discounted fast-charging or hydrogen fueling as well as additional cost savings and "perks." Other incentives can require less City infrastructure and costs while reducing some of the ill effects of the ongoing expansion of delivery services. Such incentives increase safety and quality of life and therefore public acceptance while benefitting the delivery services and their customers.

Unforeseen innovation by the new economy, such as the experiments with smart lockers, see Figure 4, suggest specific avenues for collaboration with the City during the present time of fluid and rapid evolution. For example, the City could zone some areas for smart lockers and ease approvals for other innovations. The city could augment these and other locations by designating special loading zones, lanes and alley ways for ZEVD's or, more generally for *any* zero-emission vehicle. For example, Yellow/green loading zones, see Figure 5, could easily be repurposed with signs such as *short-term ZEV Delivery Vehicles Only* or new zones could be carved out of metered parking spaces. The new zones could expand operation into evening hours utilizing quiet operation of ZEVD. City regulations could permit additional *ZEVD only* parking for stores serving as pickup locations. Dedicated safe zones could also be set up that allow for transferring packages from larger vehicles to smaller ones, solving an increasingly common interference, as seen in Figure 2. Moreover, the delivery sector is experimenting with smaller, nimbler vehicles, including, carts, bikes and customer walk up, Figure 6. Special zoning could help enable these new innovations as well.

Figure 5. Ten-minute curbside parking is valuable to delivery companies, is safer than double parking and relieves congestion. Reclaiming parking spaces for short term passenger and package loading areas, *for Zero Emission Vehicles only*, can incentivize a quick switch to clean technologies in the rapidly expanding mobility economy and lower reliance on the fossil-fueled family car. *photo credit*, TEF

With a greater number of convenient loading locations, the delivery service reduces the need for double parking decreases the number of traffic tickets, improves safety for their drivers and for the public and reduces traffic congestion. These "perks" improve the efficiency of delivery services to the benefit of the businesses themselves and their customers. Some special zones might double as safe places for ride-hailing and ride sharing for *zero-emission passenger vehicles.* As ride services grow, the need for personal automobiles and parking for them decreases thereby freeing valuable space for safe delivery and passenger pick-up/drop-off. Renting or auctioning "liberated" metered parking to support and guide the mobile economy could bring revenue to the city and improve quality of life.

Siting new and changed zones will certainly engender lots of public comment, including the "not in my backyard complaint." This complaint and others surfaced at the outset of projects to reclaim parking spaces for "parklets" but died once pilot projects succeeded, changing forever the culture and expectations of San Franciscans. Local benefits such as cleaner air, quieter streets, less congestion, smaller delivery vehicles, a safer street and closer and faster package pickup options can "sell" conversion of parking to *ZEV only* locations in neighborhoods. Partnering with zero emission ride-share vehicles could leverage these benefits by providing more convenient and safer pick up and drop off points for passengers during commute hours, and delivery during other times. Other experiments in reclaiming parking spaces for the benefit of residents, notably Ford's and other bicycle sharing innovations, prove that with the right project, the City can experiment with innovative and worthy ideas with public support.

It is easy to imagine ways to ensure delivery services meet their responsibilities to public safety and ease congestion. For example, the City could augment the 311 system, perhaps by calling for open source coding, with a smart phone APP that takes a snapshot of an offending delivery vehicle, reads the plate and sends the info to the city with a gps tag. A city office, or perhaps the APP itself, would alert the delivery service or even the nearest traffic officer.

Additional levers the City may use to accommodate and guide delivery services involve building codes. Newer buildings might be required to include spaces for the coming expansion of e-deliveries including curbside access, mailrooms and even facilities for drone-friendly and secure roof top drop off. It is interesting to note that many older buildings, built in the 20's through the 40's have first floor rooms designed for package pickup and mail.

Finally, it is important to note that appropriate producer responsibility policies may help remedy the increased waste stream due to packaging associated with delivery. Delivery services could be required or incentivized to help out by picking up used - but clean - packaging. These materials can be recycled, or even reused, if they are properly handled and separated. Smart lockers such as shown in Figure 5 could enable the easy return of reusable packaging materials including un-flattened boxes bearing company logos for direct re-use. With package identification readers, it should be possible to credit customers for returning boxes and packaging materials. In this way, the high value of the materials is retained and the delivery organization lowers the amount and costs of new shipping materials and can claim credits for sustainable

Figure 6. Delivery services and vehicle manufactures are experimenting with new delivery modalities and zero emission technologies. Policy and regulations can help usher in clean practices that benefit communities with quieter and safer roads while improving delivery times and productivity. *photo credit:* UPS

practices. This avoids the inevitable mixing with bottles, cans etc. in conventional household collection along with the subsequent sorting in the recycling center. Note that recovering these materials populates trucks during the return trip, which would otherwise be empty, or nearly empty, and therefore not generating revenue. The value of pristine packaging and clean recycled materials helps brings in an additional revenue stream, as well as great PR for the delivery company. Indeed, the ability to easily reuse materials along with the well-defined nature of the smart locker compartments and their inherent protection from weather and other hazards may lead to more efficient packaging systems that reduce the amount and costs of waste and shipping.

Summary

Valuable data collected from city and private sources on the new mobility economy can help guide policy and regulations of this rapidly growing and evolving sector. These data sources, selected in part by likely policy and regulations of the future, can help inform urban planners in their quest to lower vehicle emissions, improve safety, better the environment, improve the health, safety and welfare of visitors and residents, and move to a renewable economy.

This primer focuses on the fast-growing mobile delivery. Relatively simple policy can assist the new economy while helping the city of San Francisco meet aggressive emission goals. For example, Figure 7 presents a flow chart of a "Virtuous Cycle" that propels delivery *and*

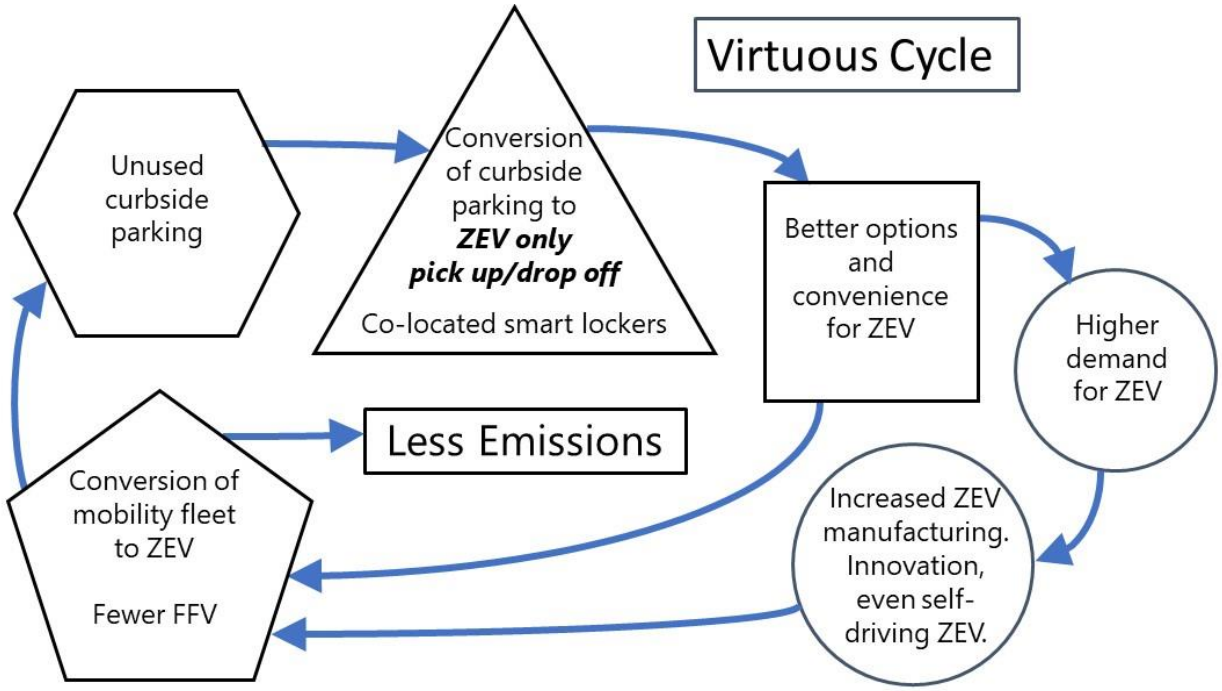

Figure 7. Virtuous cycle based on curbside pick-up and drop-off that supports rideshare, delivery and private auto for *ZEV only*, could quickly and cheaply reduce the population of fossil-fuel vehicles (and their emissions) and drive innovation that accelerates widespread ZEV adoption by consumers.

emission reductions. Starting at the triangle, top center, some curbside parking is converted to zones designated *for Zero Emission Vehicle only pick up/drop off.* Such zones would benefit delivery services, perhaps with additional perks such as carving out adjacent locations for smart lockers such as shown in Figure 5. *ZEV only pick up/drop off* zones could also help ride-sharing services (especially during commuting times), and even encourage adoption of ZEVs by busy "soccer" and "piano" parents. These options and conveniences (shown as the square in Figure 7), incentivize conversion of the mobility fleet to ZEV (pentagon). The better options and conveniences for ZEV help grow the fleet, reducing residents' and visitors' need for private autos which are generally fossil fueled vehicles, FFV. Some owners will decide to feed their last parking meter and sell their car. All of this reduces emissions (central rectangle). Moreover, the trend leads to less need for street parking (hexagon) which can then be converted to more *ZEV only pick up/drop off* zones, and the cycle repeats. This approach helps other virtuous cycles such as innovation and manufacturing of ZEV shown in Figure 7 as circles. Bike shares and bike delivery, Figure 6, may be encouraged to further reduce the use of FFV and free up valuable curbsides for ZEV use. Compliance of *ZEV only* areas can be monitored by Fast Track or similar devices.

Recommendations

- Encourage academia to model traffic flow with and without special zones for zero emission delivery vehicles.
- Encourage academia or city planners to poll visitors and residents on curbside mobility access *for ZEV only* and the associated virtuous cycle
- Explore more efficient recycling and even better the re-use of packaging materials made possible by utilizing the backend of the delivery process, i.e. the generally empty return trips of delivery vehicles.
- Personal deliveries are becoming a key part of VMT in San Francisco and should be added to current travel demand models
- Ask delivery services about the utility of and best locations for ZEV only areas, locations for smart lockers and overviews of other innovations that can improve operation of their businesses. Also determine the state of development of ZEV's suitable for these businesses.
- Explore the topic of regulation of delivery vehicles for driving within the city, for example requiring zero emission vehicles. Explore "perks" or incentives for ZEV delivery, e.g. special access to alley ways, ZEV designated pick-up/drop-off.
- Engage 311 program management on options for delivery improvements
- Engage enforcement and land use programs for data sharing
- Ask innovative software developers (or academic researchers) to develop pattern recognition code for dash cams on city vehicles. The goal of the software is to automate and anonymize the collection of public vehicle operations, including type, location, and behavior of delivery vehicles.

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