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1. ABSTRACT

Freight movement is essential to the function of metropolitan areas, yet it generates many externalities, including congestion, air pollution, noise, and greenhouse gas emissions. Metropolitan areas around the world are seeking ways to manage urban freight and its impacts. This paper presents results from a comprehensive international survey of urban freight management strategies. Our purpose was to examine the effectiveness of alternative strategies and assess their transferability for broad US implementation. We use three categories to describe urban freight strategies: last mile/first mile deliveries and pickups, environmental mitigation, and trade node strategies. We find that there are many possibilities for better managing urban freight and its impacts including labeling and certification programs, incentive-based voluntary emissions reductions programs, local land use and parking policies, and more stringent national fuel efficiency and emissions standards for heavy duty trucks. More research is needed on intra-metropolitan freight movements and on the effectiveness of existing policies and strategies.

2. INTRODUCTION

Commercial transport is crucial for the functioning of metropolitan areas. Trucks and vans provide local 'last mile' deliveries and pickups, as well as most medium haul freight transport. In metro areas that serve as trade hubs, trucks are a major part of wholesaling, distribution, logistics and intermodal operations. Commercial traffic generates significant externalities in metro areas, including congestion, air pollution (small particulates, NO_x, greenhouse gas emissions), noise, and traffic incidents. In addition, heavy duty vehicles affect pavements and generate additional demands for increased road capacity.

Metro areas are seeking ways to better manage goods movements. Researchers and local stakeholders have explored a range of strategies, such as better routing algorithms, smaller or newer trucks, consolidated local delivery stations, alternative modes, off-peak deliveries, low emission zones and freight partnerships. The purpose of this paper is to consider the state of research and practice in the US context. There are many interesting and innovative strategies being developed in Europe and other parts of the world. The extent to which these strategies are transferable to the US context depends on the complex governance arrangements in which urban freight policy takes place in the US.

This paper is organized as follows. We begin with a brief review of the urban freight literature. We then describe the sources of our research synthesis. We summarize the key findings of our study and lessons learned from our investigation of experiments with various policy measures. We consider whether these experiments are transferable in the US and may be identified as best practices. We close with some recommendations and suggestions for future research.

3. BACKGROUND AND LITERATURE REVIEW

Although there is increasing experimentation in solving urban freight problems, the relevant literature is limited and fragmented. A major challenge for research is the lack of appropriate data; studies have addressed data availability and promote more comprehensive data collection (1-3). Data on truck and van movements in US urban areas is almost non-existent; consequently the extent of the urban freight problem remains unknown. There is an extensive literature in logistics, with studies on truck routing, network optimization, and related topics (4-6). This literature is not 'urban' in the sense of considering the urban context (freight/passenger conflicts, externalities), but rather addresses routing and allocation problems that are common in the urban environment. Transport economists have examined the economic structure of the drayage trucking industry, shipper behavior, and responsiveness to pricing policies (7-9). City logistics is an emerging field of study; it seeks to improve freight efficiency while minimizing both economic costs and social externalities, looking at city logistics in a broader sense than transportation (10). This is also the conclusion achieved by (3) in a recent review of city logistics in the academic literature. Researchers have examined spatial dynamics in freight activities, the transport geography of industry networks, and urban freight distribution systems (11-16).

There is a growing literature on the externalities associated with urban freight. The truck (17) and rail congestion (18) studies sponsored by USDOT show that freight bottlenecks are most prevalent in metropolitan areas, particularly where trade flows are concentrated, as in Los Angeles, Atlanta, Chicago and New York. Case studies document local congestion associated with truck parking and loading (19). There is a growing number of studies of the health impacts of small particulates associated with diesel truck emissions, notably the longitudinal children's health study in Los Angeles (20). Ports and intermodal terminals tend to be air pollution 'hot

spots_ due the concentration of truck traffic and the prevalence of older, more polluting trucks in local delivery fleets. Trucks are also significant contributors to GHG emissions, accounting for about two-thirds of emissions from freight sources (21).

There is an emerging literature on urban freight policy, much of it focused on environmental impacts and regulation (22). Studies of specific policy examples include off-hours deliveries in New York (7), low emission zones (23), and the container fee program in Los Angeles (24). These studies have not reached a point of synthesis or general understanding of what policies are effective, and what conditions are required for effective implementation (25).

4. METHOD

Our synthesis is based on a review of the domestic and international literature (25). Our review includes journal publications, government reports, consultant reports, and unpublished papers and materials, resulting in 261 references of which 108 are academic papers and scientific books. We believe this review to be fairly comprehensive regarding academic publications in English, as it results from a search in the main publication databases covering transport engineering, transport geography, transport economics and logistics as well as transport planning. It matches the recent literature review on city logistics by (3). Our review is focused more on local sources, such as freight data collection in specific cities or national reports from ministries and institutions. These sources were identified from various contacts or previous work. Our literature review was supplemented with communications from project sponsors and data collected from secondary sources. A full list of references is available in Giuliano et al, 2013 (25) and only the most significant ones have been referenced here. Our synthesis included: 1) an assessment of current knowledge on the impacts of freight in metropolitan areas; 2) a survey of mitigation strategies proposed, planned or implemented in metropolitan areas; 3) a discussion of the US governance and regulatory context; and 4) our evaluation of freight management strategies and their potential for implementation. In this paper we present an overview of mitigation strategies. We selected 63 practices based on their recurrence in the literature and, when available, their reported positive results. Half of them are from North America. The paper finally provides our assessment of the most promising strategies for broad implementation in the US.

5. RESULTS: BEST PRACTICES AND POLICY INITIATIVES

In response to growing urban freight problems, cities around the world have engaged in extensive experimentation. In this section we summarize findings, discuss effectiveness, and consider transferability to widespread implementation in the US.

We organize our discussion around three general categories of urban freight management problems: local last-mile/first-mile delivery and pick-up, environmental impacts, and trade node problems. Last mile strategies address local deliveries and pick-ups to or from urban businesses or residences (home deliveries). They aim towards making these trips more efficient. Strategies that reduce environmental impacts focus on reducing emissions and noise by regulation or offering incentives to use less polluting vehicles. Finally, we consider strategies related to trade nodes (i.e., cities that are hubs for national and international trade) where there are large flows to and from ports, airports, or intermodal facilities.

5.1. Last mile strategies

One-third of urban truck traffic is goods pick-ups. The last mile (or rather miles) represents the final haul of a shipment to its end receiver, be it a shop, a business, a facility or a residence in

case of home deliveries. (Collectively we will refer to these trips as the 'last mile.')

Serving local businesses and residences in cities is inefficient for several reasons. First, product is often delivered from vendor to establishment, so a given establishment (say department store) may receive multiple deliveries each day. Small deliveries across many destinations generate complex routing problems. If deliveries could be consolidated across vendors, more efficient routing and fewer trips would be possible (26). Second, deliveries may be restricted to certain routes or time periods, adding additional constraints on routing and scheduling. Restrictions on night deliveries, or the reluctance of urban business owners, force more trips to take place during peak hours, adding to congestion. Third, home delivery is inefficient due to the small size of products, the spatial dispersion of residences, competition within the local delivery industry, and the frequency of failed deliveries (27).

European cities face more serious local delivery problems than US cities because of their older built form, higher average density, and greater share of small and independent businesses. European cities also have the apparent advantage of more regulatory control over truck access and roads. It is therefore not surprising that the majority of last mile experiments have come from overseas - Europe in particular. In the US, the few domestic policy experiments that do exist (like clean truck programs and off-peak deliveries) come from either of the two largest trade node cities: New York and Los Angeles. Other North American cities' freight initiatives tend to center on new or improved infrastructure (such as grade separations, added highway capacity, or logistics parks) rather than operational changes

The main types of last miles strategies and some examples of each are presented in Table 1. The main sources of information are (7, 23, 28-30). Table 1 clearly illustrates the preponderance of examples coming from outside the US.

[TABLE 1]

5.1.1 Labeling or other certification programs

Certification and labeling programs are examples of voluntary regulation. The public sector negotiates with private industry to develop a set of voluntary targets or operating rules that confer either recognition or special benefits like flexible delivery hours. Certification and labeling programs include the various 'green' certification programs that promote use of cleaner vehicles, cleaner fuels, or operations during less congested periods of the day. Effectiveness depends on how much agreements change behavior. Certification programs that allow access to loading facilities, or extended delivery hours offer a significant benefit to shippers, and therefore make it easier to justify the purchase of new compliant vehicles. Certification programs are often the result of Freight Forums, or participatory processes including public and private stakeholders. Two well-known Freight Forums, in London and Paris, resulted in detailed Freight Plans.

The certification programs we reviewed were perceived as very successful both by the public sponsors and private participants. One potential problem is the buy-in and participation of all industry segments; for example the large shippers are more capable of negotiating program conditions with public sponsors, and hence programs may be designed to the advantage of larger shippers. Certification programs may increase trust and foster more collaborative relationships between industry and government. Shippers may also enjoy a competitive advantage when bidding for contracts, as more clients place value doing business with 'green' firms. Finally, certification programs are relatively low cost, with most of the costs in the form of transactions

costs – establishing and maintaining public-private relationships. They may also evolve: as targets are reached, new targets are negotiated, leading to significant improvements over time.

Voluntary regulation is a good fit with the US context of decentralized governance and dispersed regulatory authority. In cases where direct regulation is either impossible (due to lack of authority) or infeasible, voluntary regulation may be the best available alternative.

5.1.2 Traffic and parking regulations

City efforts to manage last mile problems have focused on local traffic and parking regulations, because these tools are clearly within local authority. In theory traffic and parking regulations are effective as long as they are enforced. However, cities have no control over demand for pickups and deliveries, and consequently traffic and parking regulations are limited tools for managing last mile problems. In practice, highly restrictive regulations are costly to enforce and may lead to other problems. Restricting truck parking areas may result in trucks double-parking in the roadway or using curb space reserved for other purposes. When the demand for truck pickup and delivery greatly exceeds supply of loading and parking areas, enforcement becomes costly and increasingly difficult, as the risk of being cited becomes less costly than the delays incurred in waiting for a parking spot.

Traffic and parking regulations have a mixed record of success. Restrictions on truck access or the limit of truck deliveries to certain days of the week tend to shift truck traffic to smaller vehicles (generating a net increase in truck VMT), or concentrate traffic into shorter time periods (generating more congestion). Regulations that seek to use road resources as efficiently as possible tend to be successful. Barcelona's policy of allowing use of traffic lanes for pickup and delivery during off-peak hours is an example. San Francisco's recent implementation of dynamic parking charges is another. The lesson drawn from both US and international examples is that local freight demand must be accommodated, hence strategies that *manage* rather than *restrict* freight deliveries tend to be more effective.

5.1.3 Local planning policy

Local jurisdictions have land use planning authority, and hence may set policies and guidelines for incorporating freight deliveries into new developments, for the design of loading docks, and for parking and loading standards. With increased development in city cores and more frequent deliveries for each business, freight demand has increased, while the scarcity of road and curb space, as well as ever higher land values, increase the cost of managing demand. New development or redevelopment offers the opportunity to implement planning standards for on-site freight facilities. Examples include Tokyo's and New York's requirements for new commercial developments. Barcelona goes further, adding a requirement for minimum storage areas for new restaurants and bars. On-site facilities lessen the need for on-street loading zones, reducing conflicts with passenger demands. On-site facilities also add to building costs, and hence may be resisted by the development community.

Cities may also develop freight loading and parking standards for off-site activities (e.g., in a public right of way). There are more opportunities in developing areas, where the road infrastructure is still being constructed. However, standards can have an impact over time even in already developed areas if they are tied to future development and redevelopment.

Experiences with on-site planning policies have been largely positive. Although such requirements add to development costs, they also add to commercial property value by assuring that freight deliveries are accommodated. Shippers and truck drivers clearly benefit from having

reliably available loading facilities. These policies are a good fit in the US context, where the authority of local governments to develop and implement planning and building guidelines is clearly established. The ability to negotiate through the zoning and approval process allows for flexibility in enforcement and is widely accepted.

5.1.4 City logistics and consolidation programs

Consolidation programs seek to reduce truck traffic by finding ways to combine pickups and deliveries of different shippers or different receivers. They often focus on changing the supply chain, rather than on the final (or initial) step of the chain. The simplest (from a supply chain perspective) consolidation schemes are those that focus on final delivery or pickup, e.g. on the end of the chain, such as pick-up centers for online purchases. These common pick-up points reduce home deliveries (truck trips) but their impact on private vehicle trips is unknown and depends on how consumers access these centers.

Another version of consolidation is shared logistics spaces, where multiple shippers use an in-town facility to consolidate loads (typically from different, out of town logistics facilities) before final deliveries. The intent is to reduce truck VMT by more efficient routing of final deliveries (or initial pick-ups). The most ambitious version is the urban consolidation center, where goods from multiple shippers or vendors are combined and delivered by third-party trucking firms. Although shippers may benefit from the lower costs of consolidated deliveries, whether these benefits would offset the rental and added labor costs of trans-loading is unclear. In the many European experiments, consolidation centers were not feasible without public subsidies and many have since closed.

The transferability of consolidation schemes to the US context is limited. The required subsidies to freight operators would be politically difficult, even if local jurisdictions had the funding to provide. Any effort to force consolidation in the US via regulation (as in several European cities) would be very difficult due to interstate commerce laws.

5.1.5 Off-hours deliveries

Off-hours deliveries seek to shift truck activity out of the peak traffic periods and hence reduce congestion and emissions, yet few examples of off-hours delivery programs exist. Constraints on the trucking side include federal hours of service requirements, shift premium pay for unionized drivers, and possible efficiency losses associated with spreading shipments out across more hours of the day. Constraints on receivers include having to open receiving facilities early and to operate loading terminals more hours of the day, shift premium pay for terminal workers, and local zoning codes that prohibit after hours truck activities in residential neighborhoods.

There is only one permanent off-hours program in the US, the PierPass program at the Los Angeles/Long Beach ports. It was implemented due to unique circumstances that do not exist in other US metropolitan areas. A New York City demonstration was the first and only in-city program. It has resulted in reduced congestion, energy consumption and emissions, and thus demonstrates the potential benefits of such programs. Off-hours delivery may have potential as a voluntary regulation. Shippers might be incentivized to purchase and use quieter trucks and handling equipment in exchange for being able to deliver off-hours.

5.1.6 Intelligent Transport Systems (ITS)

The use of ITS for monitoring or managing urban freight include technologies for providing real-time traffic (and parking) information, automated enforcement of parking or traffic regulations,

toll collection, or automated access control. Use of ITS for monitoring truck traffic via license plate readers and other devices is extensive outside the US. Automated monitoring systems involve high upfront costs, and tend to be used either as part of road pricing systems or limited access zones. Once implemented, automated systems make possible continuous, low cost enforcement of tolls or access zones, and thus can be very effective.

Transferability in the US depends on the perceived acceptability of the policies to be implemented. So far, security at limited access facilities has proven to be an acceptable justification for semi-automated monitoring. The use of tolls to manage congestion in metropolitan areas is not yet widely accepted. The New York City congestion pricing proposal is illustrative; it included truck tolls that could be discounted by using clean trucks, and studies indicated that congestion and emissions reductions would be substantial. However, we expect that tolls will become more acceptable as congestion increases and funding from traditional sources to support capacity expansion declines.

A second implementation challenge in the US is the general resistance to automated monitoring by public authorities. An illustrative case is the conflict surrounding cameras used to enforce red light violations at intersections. Monitoring could provide comprehensive data on truck movements, which is greatly needed for better analysis of urban freight problems. However, these data may be perceived as proprietary and resisted by trucking companies and shippers. Use of ITS for truck tolls or automated monitoring outside limited access facilities appears to have limited transferability to the US context.

5.2 Strategies to reduce environmental impacts

Strategies to reduce environmental impacts seek to reduce truck emissions and energy consumption by improving engine performance, shifting to cleaner (and quieter) conventional diesel trucks or alternative fuel trucks, or shifting freight to more energy efficient modes. Our review makes clear that strategies that address the entire commercial fleet have the most impact, even if the impact is small on a per vehicle basis. Strategies that impose substantial costs on private industry will not be adopted unless industry is forced to do so, and strategies that seek to shift freight from trucks to slower modes are not attractive to industry without large subsidies, and may have little impact on emissions or energy consumption. Strategies to reduce environmental impacts are summarized in Table 2. The main sources of information are (21, 23, 32-36).

[TABLE 2]

5.2.1 Truck fuel efficiency and emissions standards

Truck fuel and efficiency standards have been demonstrated to be one of the most effective tools for reducing emissions. The recent changes in light truck CAFÉ standards will have a significant impact on the light truck portion of the freight vehicle fleet. The shift to cleaner diesel engines and fuels is having a similar impact on heavy duty trucks. The Los Angeles/Long Beach ports' Clean Truck Program is by far the most ambitious emissions reduction program in the US, and in four years led to large reductions in diesel truck emissions. We expect fuel efficiency and emissions regulations to continue to be one of the most effective tools for reducing air pollution and CO₂ emissions in metro areas.

5.2.2 *Alternative fuels and vehicles*

Alternative fuel vehicles (AFVs) have been widely promoted in the US, but have achieved little market penetration due to higher capital and operating costs, the complexities of operating diverse fleets, limited range, and lack of fueling infrastructure. In Europe, even large subsidies have not prompted adoption of AFVs on any significant scale. AFVs are not yet sufficiently competitive with heavy duty diesel engines, and the progress being made in reducing diesel emissions may make it more difficult for AFVs to compete. However, the largest private delivery firms – FedEx, DHL, and UPS – are all experimenting with AFVs and have small numbers of electric and hybrid electric trucks operating in various cities.

In Europe we noted experiments with smaller AFVs, such as small vans and `cargo-cycles_ for local deliveries. Niche markets may exist in the most dense US city centers (New York, Chicago, Boston), depending on the costs (labor, new vehicles) relative to conventional vans or small trucks. Lack of a potentially large market suggests that these strategies would have little impact on emissions reductions.

5.2.3 *Low Emission Zones (LEZs)*

Low emissions zones (LEZs) limit the types of vehicles that may enter a given part of the city. The limitation is based on emissions and energy consumption characteristics. LEZs have been established in several European cities LEZs have some obvious advantages: to the extent that performance standards are imposed on all trucks, the entire urban fleet is affected, and emissions reductions could be large. LEZs may generate secondary benefits by forcing the re-organization of the local trucking industry into larger and hence more efficient operations (we note that whether LEZs generate net benefits is uncertain, as the elimination of small operators would eliminate jobs and small businesses.).

Although a potentially effective strategy, the transferability of LEZs to the US context is low. In the absence of jurisdictional authority, a LEZ would have to be established as a voluntary program.

5.2.4 *Alternative modes*

Efforts to shift truck freight to slower but more energy efficient and cleaner modes have not been successful. Experiments in Europe using the regional rail system to ship goods to central areas for delivery show that large public subsidies are required. Studies of using commuter rail for package delivery failed to result in demonstrations or experiments. Efforts to shift freight to water have been similarly unsuccessful, both in the case of coastal shipping and river transport. Waterborne freight in the US continues to lose market share.

Mode shifting has large impacts on the supply chain. In order to use a slower mode, cargo owners must hold the inventory longer, and these inventory costs tend to exceed the higher costs of using faster modes. In addition, mixing modes adds to the number of times shipments must be handled, further increasing labor and facility costs. The most promising segments for mode shifting are through freight traffic (port or airport imports/exports) in large volumes, as for example increasing on-dock rail facilities to eliminate short drayage trips, or large volume, longer distance deliveries (say to distant distribution and warehouse centers) where rail is close to competitive with trucking.

5.2.5 *Community environmental mitigation*

The US has taken the lead in the incorporation of environmental justice as a performance measure for new freight projects. In part this is due to the socio-geography of US cities, where poor and minority populations tend to be concentrated near major freight facilities. The environmental review process provides a venue for environmental justice concerns. More recent research on the relationship between emissions and health has created an imperative for industry to find solutions to problems that might otherwise prevent them from securing the needed support of elected officials and regulatory agencies. Environmental justice considerations are therefore widely institutionalized in the transportation planning process and often involve industry-government partnerships. Examples include SCAG's Toolkit for Goods Movement, New York City's truck impact study, and Baltimore's industrial overlay zone study.

US ports have been particularly proactive in addressing environmental justice concerns. In addition to the extreme case of Southern California, clean truck programs, freight rail investments, and elimination of at-grade rail crossings are part of programs in New York/New Jersey, Seattle, and Oakland, as well as Chicago and Atlanta, two major intermodal hub cities.

5.3 Trade node strategies

Trade hubs and gateways – places with large ports or airports, intermodal transfer points, or border crossings – are the focus of freight flow associated with national and international trade. Trade hubs share the same 'last mile' issues addressed in previous sections such as truck and van delivery and access issues, evening and weekend vehicle movements, and incompatible land uses. However, trade hubs are further defined by the scale and scope of operations that take place within them, particularly in the port, warehousing and distribution sectors. A combination of rising trade volumes, demand for larger facilities and the cost of land have pushed distribution centers (DCs) and warehouses to the periphery of metropolitan areas. These facilities generate freight-related activity that may pass through the urban core on their way from ports and airports to markets outside the region.

Unlike the last mile and environmental strategies outlined above, the majority of trade node strategies have been developed and tested in the US context. The largest trade nodes – in particular Southern California – have had the greatest influence in the development of strategies to address environmental problems. In the Southern California gateway, the threat of legislative mandates and rising trade volumes created a unique set of conditions that favored an industry-driven response to environmental pressures. The question is whether the same conditions exist in other places in the US. Both political pressure and competitive pressures exist in other parts of the world, but it is apparent from the research that the two in combination drive the environmental agenda in trade gateways. In the US, where good intermodal connections encourage the development of pass-through traffic transited through transload centers, the gateway plays a pivotal role in framing the debate surrounding the environmental impacts of trade. Trade node strategies are summarized in Table 3. The main sources of information are (7, 24, 37-45).

[TABLE 3]

5.3.1 Appointments and pricing strategies at ports

These strategies attempt to spread the flow of truck traffic passing through terminal gates across more hours of the day. Appointments have been implemented at several ports. They have the potential to increase the efficiency of port operations and therefore reduce truck turn times (hence reducing truck idling), but to date there is little evidence that such efficiencies are being realized. Appointments require operational changes by terminal operators, so they are likely to be used effectively only when yard congestion makes it worthwhile.

The sole example of pricing-based terminal gate operations is the PierPASS program in Southern California. PierPASS was intended to reduce road congestion and it proved successful at shifting a significant amount of eligible cargo to the evening (approximately 40%). No other US metro area has the severity of congestion and air pollution to motivate use of peak fees, and no other port is inclined to take the risk of losing business in response to a fee. Shifting truck traffic at the ports generates changes along the rest of the supply chain, including distribution centers and retail establishments which presumably also operate on more traditional work schedules. The net benefits at the system level are not yet proven.

5.3.2 Road pricing and dedicated truck lanes

Despite the demonstrated effectiveness of congestion pricing in the few places where it has been implemented, pricing strategies in the US continue to be difficult to implement. There is more use of pricing strategies in Europe and Asia compared to the US, and at least a few examples of truck pricing, notably the weight-distance fees in Switzerland, Austria and Germany, and the cordon pricing scheme in London. There are numerous proposals for truck tolls in the US, including the New York bridge toll plan, and proposed tolled truck lanes in Atlanta, and in Los Angeles, but none of them have even reached the stage of being part of an accepted project.

Truck pricing may be more difficult than pricing passenger cars because of the competition between trucking and rail. The trucking industry argues that they already pay their 'fair share' for using the roadways, and additional charges would reduce their competitiveness with rail. From an environmental perspective, if trucking generates more emissions per ton of freight carried, this shift would be socially beneficial despite the negative impact on the trucking industry. Despite their promise for managing congestion, implementation of pricing strategies will require extensive education and political leadership.

A second strategy (often linked with tolls to offer a funding mechanism) is truck-only lanes. They have been proposed in major metropolitan areas (most notably Atlanta) and included in regional transportation plans. They have failed due to lack of funding as well as a scarcity of land. Truck lanes are costly to build due to pavement and geometry requirements, and can rarely be justified on the basis of truck volumes. Given the fiscal constraints facing the US highway system, truck-only facilities do not appear to be a promising option for dealing with truck traffic.

5.3.3 Accelerated truck emissions reduction programs

Given the success in the US of national regulation to increase fuel efficiency and decrease emissions, a logical extension is to accelerate the introduction and use of cleaner vehicle at trade nodes. Several US ports have 'clean truck' programs, which are intended to accelerate the use of cleaner diesel and alternative fuel vehicles in drayage trucking. The most aggressive effort is the Clean Truck Program (CTP) at the Los Angeles/Long Beach ports (45). Seattle, Oakland, and New York/New Jersey have programs with more flexibility and less aggressive targets. These

programs are examples of voluntary regulation: the targets are reached via negotiation and are beyond regulatory requirements. As voluntary, negotiated programs, they are a good fit in the US context.

5.3.4 Equipment management

Another potential source of reducing truck VMT is to use port-related freight equipment – chassis and containers – more efficiently. Ownership practices result in many extra trips for truckers, because they are required to match containers with the same owner's chassis. If management practices are modified by the owners, it becomes possible to share containers and chassis, reducing VMT associated with these movements. Equipment owners are motivated to experiment with different models due to the growing standardization of equipment characteristics (and therefore the declining value of branding one's own equipment), the costs of owning equipment that is idle much of the time, and the costs of storing equipment at land facilities. Public sector assistance may be necessary to assist with land assemblage for shared equipment facilities, and to sponsor studies.

Shared equipment offers a promising way to reduce truck trips while increasing the efficiency of port-related freight operations. Since it is industry motivated, it is a good fit in the US context.

5.3.5 Rail strategies

Efficient rail and intermodal facilities are critical to international trade. High volume rail corridors conflict with surface road traffic at at-grade rail crossings, and conflict with passenger commuter rail traffic. The main trade node city strategy to address these problems is capital investment to increase rail capacity and to eliminate at-grade rail crossings.

The major challenge to capital investment strategies is the lack of an obvious funding source. Railroads have little incentive to incur costs to solve a problem for road transport, and hence are typically unwilling to pay. Local jurisdictions have no authority to force railroads to incur these costs. They also have little incentive to pay, as they view the rail traffic as a national responsibility. At the national level there is no specific funding source for such projects.

5.3.6 Border crossings

Border crossing regions are a unique subset of trade nodes. Like port regions, border crossings generate truck traffic destined for local distribution or transfer facilities as well as markets beyond the immediate metropolitan area. This means 'last mile' impacts as well as the pass-through impacts previously discussed. Border crossings provide a unique challenge with regard to managing regional freight capacity however because of the international context.

The US-Canadian border has provided a useful test bed for researchers investigating both the institutional and technological framework for freight flows across borders. In Washington State, the FAST Corridor was designed and supported by the USDOT, the state of Washington, the Puget Sound Regional Council, the three ports, three private freight carriers, 12 local cities and three counties. The FAST Corridor members identified highway/rail crossings as the most pressing concern, and proposed as a first phase, 15 projects: 12 grade separations and three truck access projects totaling \$470 million.

US-Mexico border crossings, in many ways, operate in a more complex and uncertain environment. While the North American Free Trade Agreement (NAFTA) and other institutional and regulatory reforms have been designed to improve cross-border freight flows for

the US, Canada, and Mexico, the lack of a truly open border results in further delays at crossings as goods are unloaded and reloaded on different vehicles on opposite sides of the gate. This has created a demand for technology-based solutions.

6. RECOMMENDATIONS

6.1 Urban freight management strategies

Our review and assessment suggests some promising options for better management of freight in US cities and metropolitan areas. Our findings are summarized in Table 4. The second column is our rating of effectiveness based on the literature as discussed in Section 5 above (25). The last column is our rating of applicability in the US context: given US institutional and governance structures, to what extent could such a strategy be implemented? The ratings for applicability were based on our judgment. The US context is quite different from that of Europe, and other developed parts of the world. For example, many aspects of urban freight are protected by interstate commerce, limiting the ability of local or state governments to regulate. There are also different perspectives on the extent to which private industry should be subsidized in order to achieve social benefits. Among the last-mile strategies, labeling and certification programs, land use planning (in the longer term), and off-hours deliveries are the most effective strategies. However, off-hours delivery programs are less transferable due to the many changes they require across the supply chain. Traffic and parking regulations are less effective, because they do not have an impact on the underlying demand for freight moves. We rate ITS strategies as medium due to their limited implementation feasibility and the need for more development of some of the most potentially beneficial applications, such as truck parking and loading information systems.

Within the category of environmental strategies, global fuel efficiency and emissions regulations have proven their effectiveness over several decades. Low emissions zones are the most effective to address local hot spots, but do not appear to be feasible under current national and state US policy. Alternative fuel vehicles may prove to be very effective long term, but the technology and market penetration are not sufficient to achieve significant reductions in emissions or energy consumption. Environmental justice efforts are more advanced in the US than in other countries; however environmental justice problems are challenging to solve.

Among the trade node strategies, pricing and accelerated emissions programs are among the most effective strategies. Despite the effectiveness of pricing, we rate it low on applicability because of the continuing strong political opposition from various stakeholder groups. Accelerated emission-reduction programs based on negotiation and voluntary targets have proven to be effective and are a better fit in the US context. Rail strategies can be effective, but involve high costs for which funding sources are not obvious.

[TABLE 4]

6.2 Future research needs

There are many opportunities for further research. First, most cities cannot answer the following questions: How many vehicles (be it a heavy-duty truck, a light-duty truck, a van, a car, or even, a bike) are engaged in freight transport activity? How many deliveries and pick-ups occur in a day, a week? Data accessible to planners and researchers on delivery characteristics is almost non-existent. Without these data it is hard to confirm or refute conventional wisdom such as, the rise of e-commerce means a net increase in commercial VMT.

Additionally, we find there is much research on system optimization, but little on how optimization methods work in practice. We need better data on, for example, real time route optimization that is based on actual fleet movements. Border crossings are a case in point. Similarly, the need for field tests in the area of technology deployment is great.

Second, one of the biggest problems associated with urban freight is truck emissions, and our review showed the many different approaches being taken to address this problem. We have limited information on the relative benefits and costs of certification systems or Low Emissions Zones (LEZs). Research is needed to better understand the effectiveness of these strategies. For example, in the case of LEZs, a) what are the costs associated both in terms of the government and logistics firms, b) what is the impact on trucking industry, c) are LEZs legally possible in the US, and if so, at what level of government?

Finally, there is a need for careful and systematic evaluation of existing policies and experiments. We are lacking analysis of the impacts of certification schemes, truck access restrictions, and requirements for alternative fuel trucks. Ongoing experimentation provides a rich resource for discovering whether these efforts have the expected results or have unintended consequences that reduce their benefits.

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TABLE 4 Summary of strategies, their effectiveness and applicability to the US

TABLE 1 Last mile strategies

Strategy	Location	Description
Consultation processes and certification schemes	London	Freight Quality Partnership
	London	Freight Operator Recognition Scheme
	Paris	Delivery Charter
	Netherlands, 25 cities	PIEK label program
Traffic and parking regulations	Paris	Daytime hours truck ban (over 29 square meters)
	Sao Paulo	Access two days/week/vehicle
	New York City	Commercial Vehicle Parking Plan
	Barcelona	Off-peak hours use of roadways for unloading/loading
	Los Angeles downtown	Increased enforcement of use of loading bays
	San Francisco	Demand dependent parking charges
Intelligent Transport Systems (ITS)	Several European and Asian cities	Automatic control systems for truck access regulation
	London	Transport for London Freight Website
	Europe	DHL Packstation and USPS Gopost: automated self-service parcel delivery lockers
Planning strategies	Tokyo	Loading/unloading facilities requirements for new commercial of > 2,000 square meters
	New York	Loading/unloading requirements for new commercial of > 8,000 square feet
	Barcelona	Minimum 5 sq. m. storage for new bars, restaurants
	Paris	Technical guide to delivery bays for the City of Paris design guide for on-street loading bays
Consolidation schemes and measures targeted towards urban supply chains	Paris	Urban Logistics Spaces: subsidized rental rates for freight storage in municipal parking garages
	Europe	Kiala network: pick-up points for home deliveries
	Bristol (UK), Motomachi (Japan), Cityporto (Italy)	Urban Consolidation Centers
	London	Construction Consolidation Center
Off-hours deliveries	New York City	2009-2010 experiment, focus on receivers
	Los Angeles/ Long Beach	PierPASS off-peak program

TABLE 2 Strategies to Reduce Environmental Impacts

Strategy	Location	Description
Truck fleet emission standards	California	CARB truck, diesel particulate filter standards
	US	EPA 2011 truck CO2 emissions and fuel efficiency standards
Low Emission Zones (LEZs)	Greater London	Low Emission Zone: access restrictions on old trucks and large vans
	Milan	Historic center truck regulations
	Swedish, Dutch and Danish cities	Regulations based on Euro standards
Alternative fuels, electric delivery vehicles	London, Milan	Congestion charge exemption for AFVs
	US cities	Delivery company use of alternative fuel trucks and vans
	European Cities	Electrically assisted Cargo Cycles
	France	Program to group purchases of electric vans for commercial fleets for public administrations
	Los Angeles/ Long Beach Ports	CAAP Technology Advancement Program (TAP)
Promotion of alternative modes/Cargo diversion	US	USDOT (MARAD) Marine Highways/Short Sea Shipping Grant program
	San Francisco Bay Area	FedEx BART pilot program
	Paris	Cargotram, Monoprix rail, and waterways deliveries projects
	Dresden	CargoTram
Restriction on truck idling	California	Five minute limit on diesel truck idling
	US	Truck-stop electrification
Delivery noise reduction	Netherlands	PIEK research, development and regulation program
	Atlanta	ASTROMAP
Environmental justice, community mitigation measures	Greater Los Angeles	SCAG Toolkit for Goods Movements
	County of Riverside	Truck Routing and Parking Study
	New York City	Truck Route Management and Community Impact Reduction Study
	Baltimore	Maritime Industrial Zone Overlay District
	Europe	Freight villages
	Atlanta	Regional Commission's Freight Studies
	US	EJ Guidelines Publications (NCHRP 320, NCFRP 13, 14)

TABLE 3 Trade node strategies

Strategy	Location	Description
Congestion pricing: Marine terminal gates	Los Angeles/ Long Beach Ports	PierPASS off-peak Program
	Vancouver	Off-peak gate program
	Busan	Evening gate program
Congestion pricing: Road pricing	New York City	Proposed pricing
	Europe	Truck VMT pricing
Truck reservation and appointment system	Ports of LA, Long Beach and Oakland	AB 2650
	Port of Vancouver	Reservation system
Lane separation/ Truck only lanes	Georgia	Statewide truck only lanes (proposed)
	South Boston, Southern CA, Port of New Orleans	Short distance/truck only access roads
Elimination of at- grade crossings	Los Angeles	Alameda Corridor
	Greater Los Angeles	Alameda Corridor East
	Chicago	CREATE
	Seattle	FAST program
Border crossing delays	Washington State	FAST Corridor
	US/Mexico Border Crossing	Pilot Program
Accelerated emissions reduction	Los Angeles/ Long Beach Ports	Clean Air Action Plan Clean Trucks Program
	Port of Vancouver	Truck Licensing Program
	New York and New Jersey, Seattle, Oakland	Voluntary truck emissions programs
Equipment management	New York and New Jersey, Oakland	Virtual Container Yards
	Worldwide	Industry driven Chassis Pools

TABLE 4 Summary of strategies, their effectiveness and applicability to the US

	Strategy	Effectiveness	Applicability to US
Last-mile	Labeling or other certification programs	High	High
	Traffic and parking regulations	Medium	High
	Local planning policy	High	High
	City logistics and consolidation programs	Low	Low
	Off-hours deliveries	High	Medium
	Intelligent Transport Systems (ITS)	Medium	Medium
Environment	Truck fuel efficiency and emissions standards	High	High
	Alternative fuels and vehicles	Low	Medium
	Low Emission Zones (LEZs)	High	Low
	Alternative modes	Low	Low
	Community environmental mitigation	Medium	High
Trade node	Appointments and pricing strategies at ports	Medium	High
	Road pricing and dedicated truck lanes	High	Low
	Accelerated truck emissions reduction programs	High	Medium
	Equipment management	Medium	Medium
	Rail strategies	Medium	Medium
	Border crossings	Medium	High