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Contents

INTRODUCTION 6

GRITSENKO S.I. Doctor of Economics, Professor, Professor of Logistics Department National Aviation University (Ukraine), **KARPUN O.V.** PhD of Economics, Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine)
CREATION OF AVIATION TRANSPORT AND LOGISTIC CLUSTERS NETWORK 7 – 15

KOSTYUCHENKO L.V. PhD (Economics), Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine), **KOSTIUCHENKO A**.V. lieutenant-colonel Armed Forces of Ukraine, Kyiv, (Ukraine)
THE LOGISTICAL SUPPORT SYSTEM ELEMENTS FOR THE PREPAREDNESS FOR MILITARY OPERATIONS 16 – 31

MARCHUK V.Ye. Doctor of Engineering, Associate Professor, Professor of Logistics Department National Aviation University (Ukraine), **HARMASH O.M.** PhD (Economics), Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine), **OVDIIENKO O.V.** PhD student, Assistant at Logistic Department at National Aviation University (Ukraine)
WORLD TRENDS IN WAREHOUSING LOGISTICS 32 – 50

PATKOVSKYI Sergii Business practitioner; Business development manager, emerging markets Kuehne + Nagel Inc., Chicago, IL (USA), **LYTVYNENKO S.L**. PhD (Economics), Associate Professor, Associate Professor of International Economics Department National Aviation University (Ukraine)
THE WAYS OF SUPPLY CHAIN RESPONSIVENESS INCREASE AT TIME OF PORT INFRASTRUCTURE AND TRANSPORTATION ASSETS PRODUCTIVITY DISRUPTION 51 – 64

POPOVYCHENKO I.V. Doctor of Economic, Professor, Head of Economics and Entrepreneurship Department State Higher Educational Establishment "Prydniprovs'ka State Academy of Civil Engineering and Architecture", Dnipro, (Ukraine), **SPIRIDONOVA K.O.** PhD (Economics), Associate Professor, Associate Professor of Economics and Entrepreneurship Department State Higher Educational Establishment "Prydniprovs'ka State Academy of Civil Engineering and Architecture", Dnipro, (Ukraine)
APPLICATION OF FUNCTION COST ANALYSIS AND NETWORK SCHEDULING IN LOGISTICS COST MANAGEMENT 65 – 77

KOLOSOK V.M. Doctor of Economic, Professor, Head of the Department of Transport Management and Logistics Department Priazovsky State Technical University (Ukraine), **LAZAREVSKA Yulianna.** PhD student Donetsk National Technical University (Ukraine)
EFFICIENCY OF DIGITAL COMMUNICATIONS IN THE LOGISTICS BUSINESS: EVALUATION INDICATORS .... 78 – 87

CHORNOPYSKA N.M. PhD (Economics), Associate Professor, Associate Professor at department marketing and logistics at Lviv Polytechnic National University (Ukraine), **BOLIBRUKH L.I.** Student at department marketing and logistics at Lviv Polytechnic National University (Ukraine)
THE INFLUENCE OF THE COVID-19 CRISIS ON THE FORMATION OF LOGISTICS QUALITY .... 88 – 98

KOPISHYNSKA K. O. PhD (Economics), Senior Lecturer of Department of Management, National Technical University of Ukrainen "Igor Sikorsky Kyiv Polytechnic Institute" (Ukraine)
CURRENT STATE AND PROSPECTS OF DIGITAL TRANSFORMATION OF THE TRANSPORT AND LOGISTICS SECTOR OF UKRAINE .... 99 – 110

HRYHORAK M. Yu. ., Doctor of Science in Economics, Associate Professor, Head of Logistics Department of National Aviation University (Ukraine), **KARPENKO O.O.,** Doctor of Science in Economics, Professor, Professor by Water Transport Management and Economics Department, State University of Infrastructure and Technologies (Ukraine), **SEMERIAHINA M. M.,** Senior Lecturer of Logistics Department of National Aviation University (Ukraine)
FORMATION OF THE MULTIMODAL TRANSPORT ECOSYSTEM IN UKRAINE 111 – 130

The History of Science.
MIROTIN Leonid Borysovych– the Doctor of Technical Sciences, Professor 131 – 135

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THE WAYS OF SUPPLY CHAIN RESPONSIVENESS INCREASE AT TIME OF PORT INFRASTRUCTURE AND TRANSPORTATION ASSETS PRODUCTIVITY DISRUPTION

Sergii Patkovskyi, Sergiy Lytvynenko "The Ways of Supply Chain Responsiveness Increase at Time of Port Infrastructure and Transportation Assets Productivity Disruption". *The article determined that the delivery of goods by sea to the United States has its peculiarities and nuances. Specific trends over the last few years which have led to a number of supply chain disruptions have been described. An analysis of previous research has shown that the issue of increasing of the supply chain responsiveness in terms of reducing port infrastructure and transportation assets has been studied insufficiently. The volumes of traffic through US ports for the last three years were analyzed. It was identified that inefficiency in operation leads to an increase in inventories and immobilization of cash flows, as well as increased transportation, storage and demurrage costs. The complexity of the processes requires a systematic approach to reducing the main risks and building a multi-scenario model of operation with a flexible supply chain. The system of strategic and tactical measures for US shippers has been developed to reduce key risks. At the strategic level, it was proposed to implement a system of 3-4 distribution centers linked to supply chains on both coasts of the United States; ability of capacity variation; availability of 1-2 intermodal distribution centers; availability of alternative routes and ports of arrival, as well as various vehicles; maximum reliability of the last mile; real-time process management including the use of outrunning indicators to trace shifts. It was proposed to implement the tactical level through operations planning and increase in time of placing seafreight bookings and inland transport allocation; realization of the opportunity to choose alternative services by balancing actual supply and demand; reducing capacity constraints by using multiple routes and ports of arrival; active use of services for accelerated full container load for goods that are sensitive to time fluctuations; preventing container dwells. The dynamics of containers dwell time served in the port Los Angeles in 2018 during the trade war between the US and China was analyzed and the impact of new tariffs on imports of steel and aluminum products imported from abroad, as well as a wide range goods made in China was determined. A case study of 6250 shipments from China ports to the port of Los*

Angeles was conducted, dividing them to containers terminated at port of arrival and containers moved intermodally to inland terminals (dry ports) by rail. Storage periods peaked in the fourth quarter, when the number of containers that spent over 10 days and over 20 days doubled in each consecutive month.

***Keywords**:* supply chain, responsiveness, seaport, trade war, cargo, disruption, transport assets productivity.

Сергій Патковський, Сергій Литвиненко «Шляхи підвищення стійкості ланцюга поставок при перебоях в продуктивності морських портів та транспортних активів». *У статті було визначено, що доставка вантажів морем до США має свої особливості та нюанси. Було охарактеризовано специфічні тенденції за останні кілька років, які призвели до ряду перебоїв у ланцюгах поставок. При аналізі попередніх наукових досліджень виявлено, що проблема підвищення стійкості ланцюга доставки за умов скорочення транспортних ємностей та зменшення пропускної спроможності морських портів вивчена недостатньо. Проаналізовано обсяги перевезень вантажів через порти США за останні три роки. Визначено, що неефективність роботи призводить до збільшення інвентарних запасів і іммобілізації грошових потоків, а також збільшення витрат на перевезення, зберігання, демередж та детеншн. Складність процесів вимагає системного підходу до зниження основних ризиків та вибудовування багатосценарної моделі роботи із гнучким ланцюгом постачань. Розроблена система стратегічних та тактичних заходів для вантажовідправників США з метою звуження ключових ризиків. На стратегічному рівні запропоновано реалізацію системи із 3-4 дистрибуційних центрів, які пов'язані з ланцюгами постачань на обох узбережжях США; можливість варіювання ємностями; наявність 1-2 розподільчих центрів; наявність альтернативних маршрутів та портів прибуття, а також використання різних класів транспортних активів; максимальна надійність останньої милі; керування процесом у реальному режимі часу, в тому числі і шляхом використання випереджаючих індикаторів для відстеження змін. Тактичний рівень запропоновано реалізовувати шляхом операційного планування та збільшення термінів розміщення замовлень на морські перевезення і розподіл по внутрішньому транспорту; реалізації можливості вибору альтернативних сервісів морських ліній виходячи з фактичного балансу попиту і пропозиції; зменшення обмежень транспортних ємностей шляхом використання декількох маршрутів і портів прибуття; активного використання послуг з прискореного хендлінгу контейнера для товарів, які чутливі до часових коливань; унеможливлення простою контейнерів. Було проаналізовано динаміку часу затримки для контейнерів, які були обслужені в порту Лос-Анджелеса у 2018 році під час торговельної війни між США та Китаєм та виявлено вплив нових тарифів на широкий асортимент товарів, вироблених в Китаї. Проведено дослідження 6250 відправок з портів Китаю в порт Лос-Анджелес. Вони були розділені на контейнери, що термінуються в порту прибуття, і контейнери, що переміщуються в інтермодальних сполученнях на внутрішні термінали (сухі порти) залізницею Періоди зберігання досягли свого піку в четвертому кварталі, коли кількість контейнерів, які провели більше 10 днів і більше 20 днів, подвоювалося в кожному наступному місяці.*

Ключові слова: ланцюг постачання, стійкість, морський порт, торгівельна війна, вантаж, збій, продуктивність транспортних активів

Сергей Патковський, Сергей Литвиненко «Пути повышения устойчивости цепи поставок при перебоях в продуктивности портов и транспортных активов». *В статье было определено, что доставка грузов морем в США имеет свои особенности и нюансы. Были охарактеризованы специфические тенденции за последние несколько лет, которые привели к ряду перебоев в цепях поставок. При анализе предыдущих научных исследований выявлено, что проблема повышения устойчивости цепи доставки в условиях сокращения транспортных емкостей и уменьшение пропускной способности морских портов изучена недостаточно. Проанализированы объемы перевозок грузов через порты США за последние три года. Определено, что неэффективность работы приводит к увеличению инвентарных запасов и иммобилизации денежных потоков, а также увеличение расходов на перевозку, хранение и демередж. Сложность процессов требует системного подхода к снижению основных рисков и выстраивания много-сценарной модели работы с гибкой цепью поставок. Разработана система стратегических и* *тактических мероприятий для грузоотправителей США с целью сужения ключевых рисков. На стратегическом уровне предложено реализацию системы из 3-4 распределительных центров, которые связаны с цепями поставок на обоих побережьях США; возможность варьирования емкостями; наличие 1-2 интермодальных распределительных центров; наличие альтернативных маршрутов и портов прибытия, а также различных классов транспортных активов; максимальная надежность последней мили; управление процессом в режиме реального времени, в том числе и путем использования системы опережающих показателей для отслеживания изменений. Тактический уровень предложено реализовывать путем операционного планирования и увеличения сроков размещения заказов на морские перевозки и аллоцирования транспортных емкостей для наземной перевозки; реализации возможности выбора альтернативных сервисов морских линий исходя из баланса фактического спроса и предложения; уменьшения ограничений по емкостям путем использования нескольких маршрутов и портов прибытия; активное использования «экспресс» сервисов доставки товаров в полных контейнерах, которые чувствительны к временным колебаниям; предотвращения простоя контейнеров. Была проанализирована динамика времени задержки для контейнеров, которые были обработаны в порту Лос-Анджелеса в 2018 году во время торговой войны между США и Китаем и выявлено влияние дополнительных пошлин на широкий ассортимент товаров, произведенных в Китае. Проведено исследование 6250 отправок из портов Китая в порт Лос-Анджелес. Они были разделены на контейнеры, которые следовали до порта прибытия, и контейнеры, которые перемещались в интермодальных сообщениях на наземные терминалы (сухие порты) по железной дороге. Периоды хранения достигли своего пика в четвертом квартале, когда количество контейнеров, провели более 10 дней и более 20 дней, удваивалось в каждом следующем месяце.*

Ключевые слова: цепь поставок, устойчивость, морской порт, торговая война, груз, сбой, продуктивность транспортных активов.

Introduction. Over the past decade increasing the sustainability and reliability of supply chains has become key issue for all participants in the delivery process. Even a slight deviation in a certain part of the supply chain can cause catastrophic consequences for the whole chain. The key criterion of delivery efficiency is the just-in-time logistics principle. Although maritime shipping involves longer delivery times, especially compared to air transport, transit time parameters are also highly important given the planning of the entire supply chain.

Cargo shipping to the United States has its own characteristics and nuances. In addition, it should be noted that there are specific trends in this market. Last several years brought a number of disruptions to seafreight based supply chains in the US:

- Union strikes 2015;
- ELD (Electronic Logging Device) regulation implementation Q1 2018;
- emerging Trade War with China in H2 2018 when Section 301 Import Tariffs were imposed against wide variety of Chinese goods;
- COVID19 unprecedented vessel capacity removal by steam ship lines from the main trade lanes.

So, it is necessary to study in more detail the characteristics of this market and develop effective proposals to increase the sustainability and reliability of supply chains.

Literature and research review. The deepening of globalization and integration processes, the widespread use of modern information technologies determines the need to find ways to increase the sustainability of the supply chain while reducing existing risks. This is especially relevant in direction of ensuring sustainability in the face of business environment complexity and uncertainty. The issue was studied by many researchers, namely Mota B., Gomes M.I., Carvalho A., Barbosa-Povoa A.P., Lee H.L., Shen Z.-J., Lee H., Gillai B., Chen Y., Rammohan S. Mota B. et al. [1] focused on creating an appropriate decision-making support tool to provide sustainable supply chain designing and planning taking into account economic, environmental and social aspects. The application of the offered tool was considered through a case-study of the company with a head office in European region.

Lee H. et al. [2] devoted their research to global supply chain and logistics improvement for better service and customer satisfaction, in particular through deregulation, trade liberalization, e-commerce development, formation of multinational logistics alliances and networks targeted to the development of the U.S.-China B2C sector. Lee H.L. and Shen Z.-J. [3] studied innovations introduced into supply chains and logistics in the framework of the Belt and Road Initiative in China. Implementation of such a project contributed to the improving interaction between business representatives and providing better value. The authors analyzed international cooperation and supportive adjustments in carrying out supply chain improvements. Also risk management in supply chain is essential for optimal operational performance, that was noted by Munir et al. [4]. Authors offered the decision-making framework considering the links and dependencies between supply chain risk management and integration. Xu M. et al. [5] designed the framework for evaluating risks in supply chains based on economic, social, and environmental sustainability dimensions.

Peculiarities of improving supply chains and providing sustainable operation of seaports are considered by a number of researchers and practitioners. Hossain N.U.I. et al. [6] analyzed the interconnection between waterway port infrastructure and adjusting supply chain causing failures in the system. The evaluation model can be used as a tool for decision-making in eliminating critical risks in performance. Oh H., Lee S.-W., and Seo Y.-J. [7] conducted analysis of South Korean port sustainability indicators in terms of its competitiveness, optimization of resource allocation and operational improvement. The authors, like most other researchers, identified economic, social, and environmental dimensions of sustainability. Baert L. and Reynaerts J. [8] devoted their study to aspects of factors competition between ports, outlining port charges and congestion as main factors in decision making of port users. Based on this, optimal logistics can be ensured.

Identification of port hinterlands and their overlapping was done on the example of Chinese foreign trade container ports for perspective seaport development and operation planning in terms of infrastructure improvement by Wan S. et al. [9]. The paper reveals the features and importance of interconnection and cooperation between international hub ports, regional hubs, and feeder ports. Han C.-H. [10] also highlighted the importance of integration to ensure port supply chain effective and quality performance (case of Busan container ports). Ascencio L.M et al. [11] concentrated their study on proposals on introducing modern supply chain management practices based on multilateral collaboration for the port development.

Another aspect of port community system development was considered by Moros-Daza A. et al. [12]. Authors conducted multivariate analysis for the purpose of developing specific IT tool that will help to reduce seaport costs and increase its competitiveness. Essential components of seaport sustainability are environmental factors. In this direction, research was carried out by Notteboom T. et al. [13], giving comprehensive study of perspectives and methods of interaction between port actors in the region in terms of green supply chain management. Sustainability of the seaport cannot be provided without elimination of critical risks in supply chain. Thus, the appropriate tool for risk management should be used. In particular, Jiang B., Li J., and Shen S. [14] offered an AHP method for this issue to increase port efficiency.

Despite the significant amount of research and their importance, the issue of increasing the supply chain responsiveness in terms of port infrastructure and transportation assets productivity reduction has been insufficiently studied.

Aim and objectives. The purpose of this article is to identify ways to increase the responsiveness of the supply chain at time of US ports infrastructure and transportation assets productivity disruption using systematic approach in main risks mitigation, strategical and tactical measures.

Results, analysis and discussion. Events that cause disruptions for inbound seafreight emerge in cycles fashion and can be recognized as systematic risks exposures for supply chain going forward. One of the fundamental reasons for this is natural constraints of further US ports infrastructure development. There is simply no lots of land available to build and put new sea port terminals in operation. Present bandwidth can cover normal case operations volume and encounters congestion or clogging at time of inbound containers volume spike.

US inbound seafreight volume developments were determined by quite strong consumption and retail sales 2017 through 2019 (Table 1). Growth pace accelerated by mid of 2018 driven by US shippers advancing their cargo and outrunning actual demand. This was caused by 301 Import Tariff Section imposed by White House administrations as of Jan 1 2019. Cargo advances resulted in 8.48% growth year over year according to 20 largest US ports study conducted. However, with gradual decline in 2019 it is obvious that previous year increase was rather reflected in inventory stocks than in actual sales numbers.

Table 1.

Volumes of traffic through US ports (2017-2019 years)

PORT OF ARRIVAL / QUARTERS	2017 Q1, TEU	2017 Q2, TEU	2017 Q3, TEU	2017 Q4, TEU	2018 Q1, TEU	2018 Q2, TEU	2018 Q3, TEU	2018 Q4, TEU	2019 Q1, TEU	2019 Q2, TEU	2019 Q3, TEU	2019 Q4, TEU	Total, TEU
PORTS TOTAL													
LOS ANGELES,CA	1 066 891,803	1 145 150,31	1 231 091,469	1 233 260,699	1 058 064,691	1 150 753,034	1 262 219,423	1 365 775,284	1 062 653,666	1 173 507,012	1 302 693,478	1 128 073,736	14 180 134,604
LONG BEACH,CA	769 342,221	984 343,24	1 070 916,882	984 162,133	930 153,13	1 069 932,885	1 046 615,138	1 061 397,754	845 600,309	931 688,675	998 163,157	935 527,936	11 627 843,461
NEW YORK/NEWARK AREA NEWARK, NEW JERSEY	747 946,11	832 459,029	891 552,783	869 034,214	849 390,474	873 291,266	950 646,209	965 073,171	883 149,145	926 594,496	973 681,703	938 083,552	10 700 902,151
SAVANNAH,GA	431 035,327	461 206,579	492 784,337	480 490,632	482 173,631	507 194,312	537 653,182	553 246,812	543 933,024	531 751,445	600 881,08	541 637,752	6 163 988,114
NORFOLK,VA	288 927,102	296 495,456	323 867,882	329 695,471	305 762,006	305 652,615	337 212,344	337 445,417	312 701,934	339 662,478	348 826,076	317 747,069	3 843 995,849
HOUSTON,TX	235 771,906	265 352,026	278 650,443	282 286,465	263 233,556	287 067,046	319 284,839	310 412,506	293 369,755	315 964,412	329 200,768	303 223,745	3 483 817,466
CHARLESTON,SC	231 210,408	240 839,102	237 204,57	241 140,137	236 095,082	252 916,057	256 796,134	269 075,773	256 512,719	262 082,28	286 946,659	261 707,417	3 032 526,337
OAKLAND,CA	194 037,508	225 810,133	237 140,12	223 636,605	207 327,511	240 915,417	249 964,285	247 241,595	222 715,954	244 564,643	259 983,952	235 077,624	2 788 415,346
TACOMA,WA	224 779,65	201 862,653	195 220,065	199 989,339	176 218,842	201 832,998	211 634,466	222 722,867	183 640,073	204 077,199	224 274,337	209 049,403	2 455 301,891
SEATTLE,WA	121 628,218	158 002,763	173 020,535	171 715,904	155 064,898	178 249,582	195 606,708	206 104,225	163 345,681	161 378,457	163 404,68	129 015,754	1 976 537,405
PORTS TERMINATED													
LOS ANGELES,CA	798 280,022	845 559,348	920 891,332	928 481,27	779 079,687	839 716,435	963 154,756	1 022 909,315	793 535,265	865 821,486	992 311,508	848 111,557	10 597 851,981
NEW YORK/NEWARK AREA NEWARK, NEW JERSEY	648 132,874	709 843,117	762 052,381	735 303,962	714 036,795	724 884,904	796 097,631	812 930,71	740 004,867	775 899,682	821 434,813	787 403,093	9 028 024,83
LONG BEACH,CA	554 936,125	721 290,535	796 846,345	741 375,684	680 841,442	779 381,026	806 270,814	828 687,897	648 956,758	727 319,997	794 741,191	748 119,489	8 828 767,302
SAVANNAH,GA	380 332,881	403 889,961	434 413,515	422 284,307	417 055,813	434 052,44	460 625,121	474 136,608	463 546,996	453 895,448	520 194,785	466 526,598	5 330 954,474
HOUSTON,TX	220 829,441	248 434,847	262 371,402	266 107,794	249 067,367	270 422,89	301 867,937	293 043,201	275 457,566	297 961,826	310 644,204	285 728,414	3 281 936,889
NORFOLK,VA	214 939,609	220 843,693	243 864,599	253 178,538	234 035,047	226 173,043	256 059,363	258 693,396	234 390,69	250 606,909	267 155,118	243 154,627	2 903 094,632
CHARLESTON,SC	194 137,113	205 393,83	200 836,951	207 050,198	201 221,403	216 733,364	219 806,827	229 572,868	217 603,088	220 453,865	243 390,76	221 895,075	2 578 095,344
OAKLAND,CA	178 304,661	207 172,00	217 847,722	205 665,528	190 506,724	222 875,44	232 608,807	231 507,622	207 227,979	226 817,158	240 799,682	215 447,569	2 576 780,891
TACOMA,WA	136 225,851	131 790,118	133 596,839	138 146,266	120 962,621	137 927,016	142 066,405	151 270,526	121 080,797	132 463,066	151 122,447	144 731,778	1 641 383,73
SEATTLE,WA	96 964,907	120 017,418	131 871,478	125 436,747	114 175,789	125 877,098	136 852,492	146 116,374	119 588,996	118 003,946	123 594,992	100 016,089	1 458 516,327
CY TERMINATED CARGO													
CHICAGO,IL	222 968,012	242 281,99	249 824,15	250 243,402	241 489,261	268 457,731	251 621,625	254 726,54	224 930,31	238 404,129	234 998,728	207 869,222	2 887 815,10
DALLAS/FT. WORTH,TX	80 214,412	106 018,204	103 233,72	103 916,532	91 918,772	115 928,363	106 804,005	121 638,427	91 944,824	111 950,111	107 258,619	101 517,873	1 242 343,862
MEMPHIS,TN	56 799,197	64 943,618	67 514,345	61 448,216	63 311,564	73 313,105	67 003,545	72 036,092	60 603,282	64 853,62	63 377,011	58 692,003	773 895,599

End of Table 1.

ATLANTA,GA	42 222,417	48 370,697	45 145,443	45 240,799	47 433,847	56 534,703	57 295,082	64 298,934	51 427,091	53 116,233	54 217,049	51 084,501	616 386,798
KANSAS CITY,MO	39 666,212	45 598,081	46 392,294	47 356,593	48 863,577	54 074,141	50 131,839	54 181,029	47 689,032	53 041,588	51 200,931	49 504,164	587 699,481
COLUMBUS,OH	39 115,487	39 803,008	42 774,178	41 328,275	40 550,357	46 126,342	45 764,755	48 310,895	41 044,935	42 973,236	47 739,038	45 605,91	521 136,416
CLEVELAND,OH	31 593,811	34 428,694	35 259,844	34 821,652	33 793,116	37 228,337	35 494,465	37 963,026	32 045,043	34 757,239	34 282,201	31 864,642	413 532,07
ST. LOUIS,MO	22 748,315	25 688,339	28 366,328	25 973,564	25 680,874	27 701,158	29 076,485	30 438,563	25 444,84	29 324,122	28 965,217	25 894,587	325 302,39
DETROIT,MI	22 661,67	23 757,052	23 847,699	23 985,345	25 520,769	28 831,145	25 676,798	25 775,194	23 536,388	24 275,102	21 908,774	19 520,766	289 296,70
CINCINNATI-LAWRENCEBURG,OH	20 629,541	22 449,142	23 532,726	23 113,613	21 308,236	25 360,218	24 848,511	25 526,957	21 457,976	23 250,654	25 060,751	24 562,242	281 100,568

Source: US Customs and Border Protection AMS data

Volumes of traffic between the largest US ports of containerized cargo present in Table 2.

Table 2.

Volumes of traffic between the largest US ports of containerized cargo (2017-2019 years)

PORT OF ARRIVAL / QUARTERS	2017 Q1, TEU	2017 Q2, TEU	2017 Q3, TEU	2017 Q4, TEU	2018 Q1, TEU	2018 Q2, TEU	2018 Q3, TEU	2018 Q4, TEU	2019 Q1, TEU	2019 Q2, TEU	2019 Q3, TEU	2019 Q4, TEU	Total, TEU
CONTAINER YARD CHICAGO													
LOS ANGELES,CA	64 862,742	64 311,18	67 847,137	71 802,669	68 126,528	72 186,972	64 045,978	71 435,235	60 896,416	63 831,223	65 536,909	56 872,15	791 755,14
LONG BEACH,CA	56 121,793	74 643,22	80 015,611	67 657,60	72 203,056	79 488,857	62 170,198	58 697,977	53 174,683	54 298,748	51 483,542	45 551,463	755 506,748
NEW YORK/NEWARK AREA, NEWARK, NEW JERSEY	30 782,454	35 472,566	37 019,986	41 095,082	40 831,023	45 764,65	45 107,45	46 742,467	44 287,915	47 145,237	44 032,672	44 109,021	502 390,521
TACOMA,WA	35 895,744	24 531,999	20 934,246	22 221,793	19 655,30	23 450,732	26 298,602	27 422,449	22 711,777	25 799,559	31 409,23	27 194,97	307 526,401
NORFOLK,VA	23 359,446	25 296,384	24 744,989	24 184,706	21 425,078	24 486,783	26 174,954	24 651,606	25 677,103	30 547,274	25 108,985	22 069,412	297 726,719
CONTAINER YARD DALLAS													
LOS ANGELES,CA	46 026,715	62 070,427	57 953,344	61 767,833	49 805,734	65 760,752	63 310,366	79 697,382	57 015,878	73 281,736	65 123,477	62 706,526	744 520,172
LONG BEACH,CA	29 444,07	38 902,445	40 129,714	37 597,019	37 588,391	45 431,357	38 704,815	36 376,266	30 054,647	34 599,582	37 132,72	34 604,171	440 565,198
HOUSTON,TX	3 898,873	4 285,382	4 235,177	3 766,332	3 601,912	3 603,30	3 744,70	3 735,131	3 679,372	2 237,702	1 908,948	2 448,925	41 145,755
SAVANNAH,GA	476,00	323,026	423,673	386,589	462,132	696,942	629,953	618,96	691,11	611,97	571,01	469,05	6 360,414
NEW ORLEANS,LA	125,25	102,75	158,25	119,00	156,50	148,50	165,03	1 018,97	294,00	974,25	2 041,51	992,50	6 296,51
CONTAINER YARD MEMPHIS													
LOS ANGELES,CA	25 883,643	25 212,176	26 952,997	24 336,64	24 478,578	27 840,134	26 049,102	31 405,239	23 653,908	25 851,435	26 076,299	23 778,828	311 518,979
LONG BEACH,CA	19 993,699	27 541,313	26 901,729	21 913,222	24 648,883	31 198,368	24 784,646	23 037,201	18 503,157	20 335,417	18 249,656	16 985,087	274 092,377
SAVANNAH,GA	5 922,117	7 001,16	8 389,877	9 397,09	9 031,46	8 598,424	9 364,227	8 734,955	10 505,945	9 829,226	11 366,682	10 830,423	108 971,585
CHARLESTON,SC	2 692,639	2 396,481	2 206,502	2 724,752	2 437,246	2 637,975	2 765,724	3 357,075	3 555,442	3 932,652	3 297,576	2 906,273	34 910,337
SEATTLE,WA	0,00	183,00	308,257	413,00	217,49	351,00	2 214,82	3 408,404	2 237,614	2 589,839	1 972,347	1 315,707	15 211,477
CONTAINER YARD ATLANTA													
SAVANNAH,GA	25 753,189	28 297,988	26 020,48	26 216,358	31 482,295	38 374,017	37 439,303	41 619,292	38 195,381	38 462,181	38 987,17	36 471,237	407 318,89
LOS ANGELES,CA	6 316,425	7 462,494	6 582,996	7 486,195	6 053,981	7 109,501	7 822,072	9 698,523	5 710,056	8 232,301	8 285,925	7 102,066	87 862,534
LONG BEACH,CA	5 962,20	7 883,218	7 441,39	6 638,987	6 037,451	6 551,865	7 403,723	8 263,484	3 450,807	2 410,293	2 520,301	2 620,21	67 183,929
CHARLESTON,SC	1 996,129	2 185,368	2 493,42	2 302,652	1 927,968	2 778,569	3 396,63	3 582,528	3 032,582	2 941,682	3 398,218	3 907,64	33 943,387
NEW YORK/NEWARK AREA, NEWARK, NEW JERSEY	759,189	1 146,826	1 014,983	1 018,053	1 034,485	1 262,753	1 000,23	902,067	900,015	1 003,441	972,435	962,349	11 976,826
CONTAINER YARD KANSAS CITY													
LOS ANGELES,CA	15 071,67	16 389,019	18 108,177	18 785,31	18 536,045	19 371,081	19 424,616	21 595,214	18 578,013	21 349,184	21 198,735	19 147,907	227 554,972
LONG BEACH,CA	14 093,156	18 193,511	17 135,654	16 268,698	17 564,497	22 259,116	17 930,876	18 782,838	15 857,201	18 316,894	16 723,18	18 335,831	211 461,454
NEW YORK/NEWARK AREA, NEWARK, NEW JERSEY	5 673,935	6 666,781	6 751,941	7 449,747	8 284,738	8 082,745	7 993,007	7 874,972	8 297,308	7 461,735	7 359,962	7 340,26	89 237,132
NORFOLK,VA	2 885,01	2 634,239	2 660,201	2 827,46	2 571,497	2 605,453	2 586,493	3 140,23	3 287,48	3 819,29	3 972,30	3 233,547	36 223,20
TACOMA,WA	1 685,69	1 130,77	894,07	959,117	965,55	945,247	1 058,317	1 528,266	1 068,78	1 415,984	1 403,00	1 146,627	14 201,417

Source: US Customs and Border Protection AMS data

Distribution of inbound container volumes that moved intermodally from main US ports of arrival to 5 largest inland container yards (CY) is shown in Fig 1. Percentage stated represents port of arrival contribution to entire CY inbound volume.

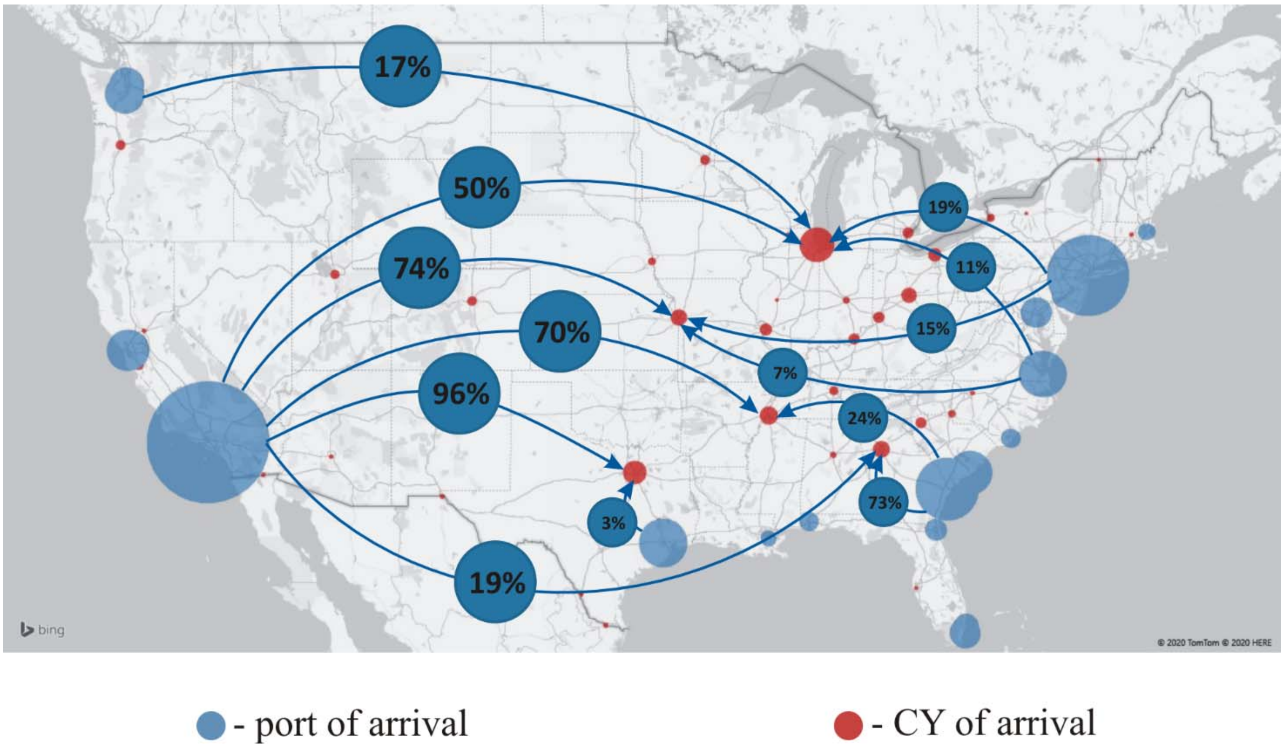

Fig. 1. Distribution of inbound container volumes that moved intermodally to inland CY

There is dual effect for US shippers caused by operational inefficiency and transport assets productivity drop. On one hand they result in increased safety inventory stocks and immobilized cash-flow, or non-satisfied ultimate customers demand usually accompanied by contract penalties. On the other hand inefficiencies produce sizeable losses for the shipper as far as extra freight charges required to get freight moving; storage, demurrage, detention charges due to increased dwell time inside and outside the terminals. Large number of various factors requires conscious and systematic approach in main risks mitigation. US shipper has to build resilient and responsive supply chain that has several operational scenarios for the goods to reach final destination in a timely fashion.

There are strategical, long term, and tactical, short, term planning implemented by US shippers in order to narrow down key risks. Seafreight delivery chain has rather long response time hence not just operational risk acknowledgment is vital but availability of tools that allow to collect and interpret data. This helps to recognize shifts and make preventative decisions in advance. Inventory stock increase possibility is removed for the purpose of subject study.

Strategical measures:

a) *3-4 DC (Distribution Centres) locations widespread across the market, linked to both US coasts routed chains.* Planning DC locations shipper considers not just bottom-line numbers and unit economy but supply risk resilience as well. Best case scenario - each main distribution regions has to be symmetrically covered by 2 out of 4 DCs. Main requirement is that each DC has to be independent and different route wise from other DCs within the network. Obviously, such model creates additional burden of overheads, operations set up and extra day to day efforts. On the other hand operating with several DCs enhance ease of inventory re-distribution within the network and reversal shipments settlement. Also decentralized operational model allows to diversify the risk of disaster impact.

b) *Ability to contract additional buffer capacity with the DC or 3rd party warehouse.* At time of fluctuation, seasonal goods or rapid stock inventory replenishment company strives to have extra capacity buy up possibility with existing DC landlord or in the same area. As practice shows limited warehouse capacity or systematic conflict between inbound and outbound became a main problem of operations productivity and generates sizeable transport assets detention charges for the shipper.

c) *1-2 intermodally connected DCs within supply chain.* Circumstantially intermodal operations are becoming more resilient a time of arrival port disruption; hence it is important for the shipper to have at least 1 intermodally connected DC in the network. Located within large US inland CY area this DC can be reached intermodally from the ports of both coasts, also from Canadian ports of arrival like Vancouver/Prince Rupert on the West and Halifax/Montreal on the East.

d) *Multiple routes and multiple ports of arrival.* Intermodally connected DCs allow utmost flexibility on ports of arrival selection and intermodal connection. This protects the company from possible chain interruptions due to port strikes and congestions, allows to utilize vast majority of steam ship lines and rail-roads in case of operational glitches of any kind.

e) *Various classes of transport assets contracted for deliveries execution.* Ability to cover most reliable services, different ocean vessel rotations and ports of transship. Large size Beneficial Cargo Owners (BCO) are in the position to distribute sufficient volumes directly with the carriers. Midsize and small size shippers typically operate through freight forwarders to benefit from existing basket deals.

f) *Highly manageable last mile based on several reliable contractors.* Resilient last mile has to be organized through several asset own contractors and a 3PL in order to maximize pool of possible dray agents. ELD implementation in mid Jan 2018 showed that assets own truckers can commit for the workload that exceeds bandwidth of their fleet that eventually makes them selective. So when contractual and spot markets are inflating lower paid cargo can make the company less attractive. Typically US based truckers have high level of debt and upon cashflow gap are forced to go out of business. Keeping 3PL in the contractors' network helps to make a smooth switch when needed.

g) *Clean data for real time visibility. Outrunning indicators to trace shifts in transport capacity supply.* Understanding and acting towards quality data became the cornerstone of prompt decision making for any decent size shipper these days. US shippers work with own and 3rd party data to trace key disruption phenomena and seek for the triggers of switching from one operations flexible to another. Re-active companies with all strategical measures encounter significantly higher losses comparing to pro-active.

Tactical measures:

a) *Operations planning, lead time of placing seafreight bookings and inland transport allocations have to go from standard 2 weeks to 4 weeks in advance.* Upon capacity tightening for both seafreight and drayage first step to accomplish is becoming forecast horizon increase from 2 to 4 weeks. Seafreight bookings placed 4 weeks in advance with steam ship lines significantly increase probability of prompt departure of goods from port of loading. Reasonable number of bookings 10-15% can be amended and pushed back for later departures. Shipper has to ensure that ration of cancelled bookings remains low, so trust is retained. Drayage moves along with key requirements have to be forecasted 3-4 weeks in advance upon cargo departure from Origin. Depending on projected warehouse bandwidth at time of cargo arrival special handling requirements: pre-pull, yard storage, drop/pull have to be aligned so no gaps on assets utilization occur.

b) *Blank sailings monitoring, alternate services selection.* Circumstantial blank sailings are becoming a powerful tool of balancing actual demand with capacity supply. This is fair especially for direct call strings of Transpacific Eastbound trade lane that is being operated with the ocean vessels of medium size, up to 10-12 thousand TEU. Steam ship lines can easily remove by blanking (canceling) departures at a certain week. During Apr-May 2020 up to 30% of overall Transpacific capacity was removed (Fig 2). Typically this information is known several weeks in advance, that makes shippers to seek for alternate steam ship line option or alternate routing of cargo from the port of loading.

c) *Multiple ports and DCs are feed on a weekly/monthly basis.* When recognized timely, capacity tightness has to be mitigated by utilizing multiple routes and ports of arrival feeding all DCs from the network. Each DC has to have a safety stock replenished on a regular basis that would allow cargo owner to be backed up in case of demand fluctuation on downstream side. Safety stock also serves possible losses and penalties from the ultimate customers in case shipments got delayed.

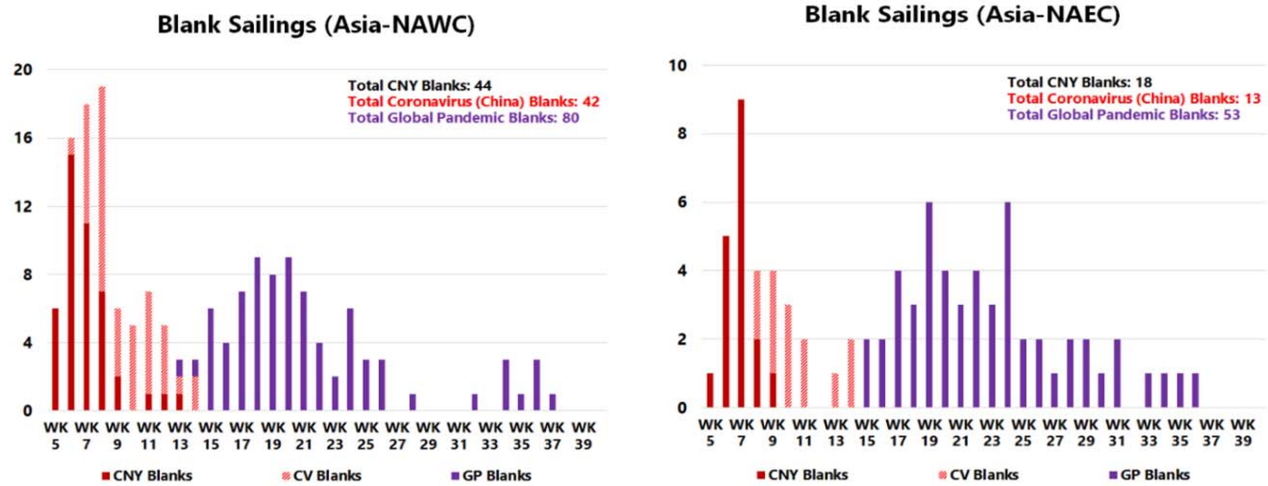

Fig. 2 Blank sailings

Source SeaIntelligence Jul 19, 2020

d) *Expedited full container load (FCL) services considered for time sensitive goods.* Shippers from automotive segment are utilizing so-called expedited FCL services for Transpacific trade lane on a systematic basis. Those yield faster transit time by 30%-45% on average and priority in port handling at origin and destination, no roll-overs at departure. They are being operationally traced in the manner that allow minimum dwell time at port and rapid connection with rail-road or release to a dray agent. These services operate smaller capacity vessels of 2-3 thousand TEU and require valid service contract and proved track record to get required space allocation at time of peak season or overall capacity tightness.

e) *Full container load (FCL) vs less than container load (LCL) transportation mode selection in conjunction with inventory stock replenishment requirements.* Less than container load freight rates are typically less sensitive to a fluctuations and can yield sizeable cost advantages for shipments up to 12-15 cbm in measure at time of FCL market peaks. LCL containers pay higher freight amounts in general and has higher priority in handling at both departure and arrival ports. Those are still consider general shipments if not shipped through one of expedited services. Shipper can partially mitigate cost increase by streamlining some of consignments through LCL. Cargo has to be seaworthy packed to prevent damage due numerous handling operations. Overall transit time will be 14 days longer on average but increase probability of in-time departure.

f) *Containers dwell time increase at time of Trade War between US and China.* Starting early 2018 a number of proclamations have been issued that imposed tariffs on steel and aluminum products imported from overseas as well as wide variety of goods manufactured in China. Tariffs implementation was set in phases and most impactful 301 Tariff Section was due to go into force Jan 1 2019. Shippers were advancing their cargo in order to create necessary inventory margin earlier on. Larger volumes of goods were shipped and customs cleared outrunning actual demand by 90-120 days. That means that outbound pace for distribution became considerably lower than inbound pace. Consequently this created additional loading on warehouse space projected for normal case operations. In order to understand relative impact of Tariffs imposed study of 6250 shipments from China ports into port Los Angeles has been conducted. Those were divided to containers terminated at port of arrival and containers that are being moved intermodally to the inland terminals (dry ports) by rail-road.

Dwell time is a good indicator of overall delivery chain productivity, warehouse and drayage capacity states. Increasing dwell time mea
ns that either port is congested, and containers can't be processed timely or shipper made a conscious decision to keep arrived cargo at port until warehouse has enough space for in-storage.

For the purpose of the study dwell time (port terminal storage time) was segregated in ranges: 1-5 days, 5-10 days, 10-20 days, over 20 days. Port storage of 1-5 days can be considered as normal for the goods terminated at port towards existing business practices and actual dray operations timings for majority of US ports. Typically steam ship lines honor 5 days free at port that are being used as a grace period to arrange last mile delivery. Port dwell time is the main source of hard dollar losses that cannot be mitigated operationally. 1 Day of storage outside of grace period costs USD 265/day per container. So containers that spent 5 extra days at port encounter USD 1 325 in storage fees per container, that equals 50% of seafreight charges at that time, those encounter 15 days would pay USD 3 975 per container. In Fig. 3 chart of dwell time dynamics from March through Dec is shown.

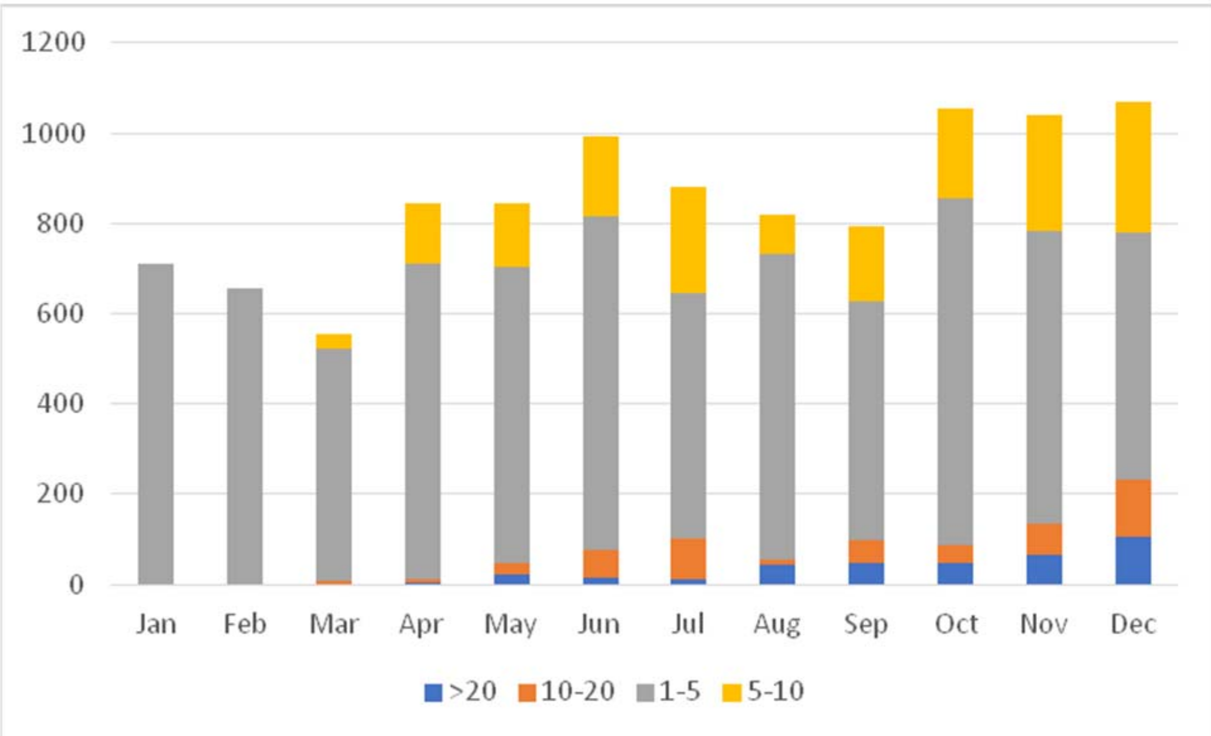

Fig. 3. Port terminated containers dwell time chart 2018

Source https://www.oocl.com/eng/ourservices/eservices/cargotracking/Pages/cargotracking.aspx

With normal case operations in Jan through March dwell time started to increase significantly by June. Partially this is caused by Christmas and New Year inventory being brought in and partially by seasonal cargo advances imported to outrun 301 Tariff Section. Storage periods reached their peak in Q4 when number of containers that spent over 10 days and over 20 days were doubling in each consecutive month.

Dwell time dynamics for the containers that were moved intermodally from port of Los Angeles are shown in Fig. 4.

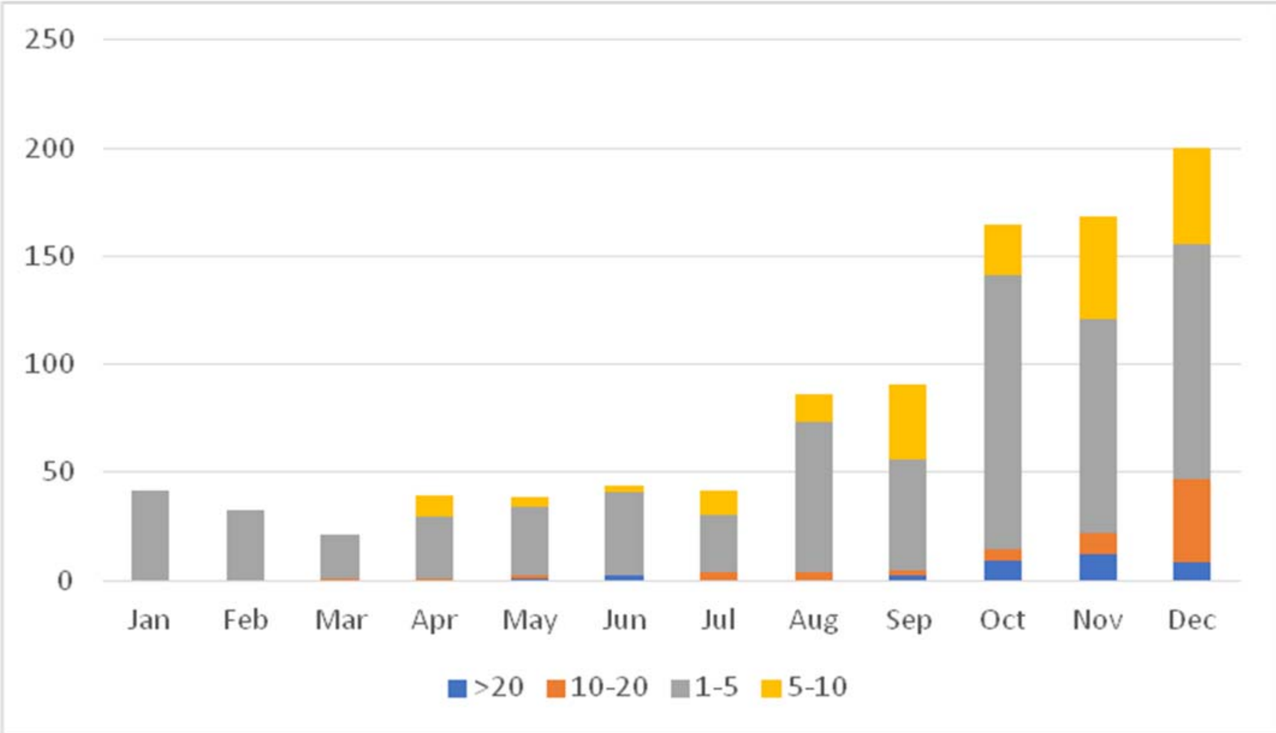

Fig. 4. Intermodally moved container dwell time

Source https://www.oocl.com/eng/ourservices/eservices/cargotracking/Pages/cargotracking.aspx

Comparison results of dwell time for port terminated containers vs moved intermodally is shown in Table 3.

Table 3

Dwell time comparison

	Total	1-5 days	5-10 days	10-20 days	Over 20 days	1-5, %	5-10, %	10-20, %	Over 20, %
Port terminated	3163	1964	748	234	219	62.1	23.5	7.4	6.9
Moved intermodally	534	335	116	54	30	62.7	21.6	10.1	5.6

Source https://www.oocl.com/eng/ourservices/eservices/cargotracking/Pages/cargotracking.aspx

Considering comparison results show that dwell time difference is insignificant. The main fact to keep in mind that intermodally moved containers do not encounter port storage charges since based on business practices steam ship lines remain liable for the storage charges.

Containers street dwell time, time spent by the inbound container outside port terminal is shown on Fig. 5.

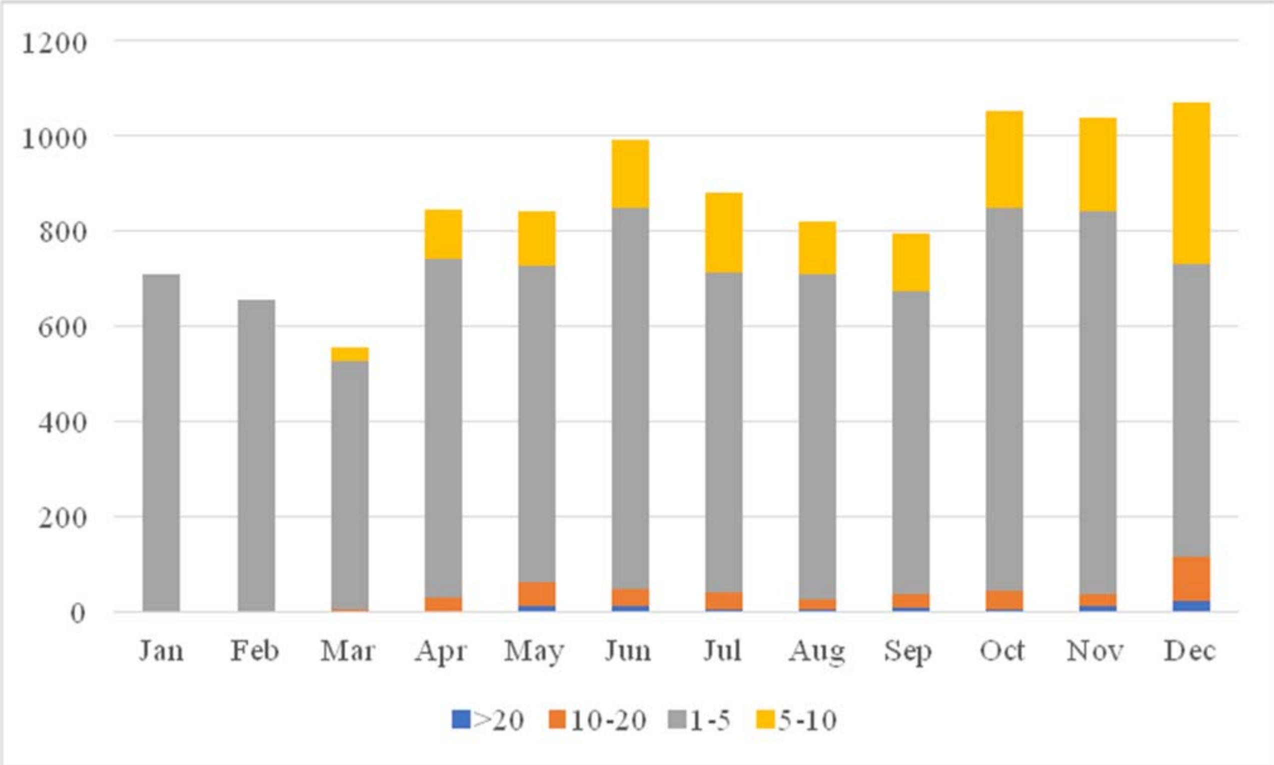

Fig. 5. Street dwell time outside of Los Angeles port

Source https://www.oocl.com/eng/ourservices/eservices/cargotracking/Pages/cargotracking.aspx

In Q4 2018 warehouse space in Los Angeles area became exhausted and inbound container flows were exceeding outbound port terminated container. Containers quantity that required extended dwell time of over 10 days went from average 33 in Oct and Nov to 93 in Dec, those quantity that were hit by 20 days outside the port increased twice from 10 in Nov to 21 in Dec.

A detailed description of ways to reduce the risks when shipping cargo to the United States is described in [15]. In particular, it was noted that the organization of a stable and reliable system of supplying products on time within the allotted budget plays a leading role.

Conclusions. In the article detailed study of the strategic, long-term and tactical, short-term planning carried out by US shippers was presented. Strategic and tactical measures to increase the sustainability of the supply chain were identified. The relative impact of tariffs imposed was analyzed through the case study of 6250 shipments from Chinese ports into Los Angeles port.

Majority of the studies that have been conducted by the time being are often based on the assumptions that foreign supply is unlimited or that inventory stock at destination can be increased to the level that prevents unfulfilled domestic orders. Reality is different though. Supply at origin is rare to be unlimited. Typically purchase orders size increase is caused by uncertainty factors or scares financial recourses that didn't allow to retain production and supply pace. There are many business cases when vendors overseas can recognize destination market developments and increase goods prices, increase lead times or request advance payments to prioritize and satisfy additional demand. This might also create some lag that will be required to negotiate acceptable conditions, so naturally time between minimum stock inventory achieved and goods shipped will be significant. Safety inventory might be of help, but market environment change can create inventory imbalance by populating the shortage for the most demanded goods. Having said that main potential of the further research is:

- elaboration of the system of outrunning indicators that would help the shipper to recognized emerging trends that could lead to a disruption or at least significantly increase supply chain vulnerability

- assessment of digital technology and real time visibility tools to increase operations and transport capacities planning in order to partially mitigate losses at time of supply chain disruption.

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