GLOBAL SOYBEAN TRADE, SUPPLY CHAIN AND TARIFFS

CHANGQIAN GUAN[1], SHMUEL (SAM) YAHALOM[2], LUKE GERMANAKOS[1], SAMUEL LAPAGE[1] & BRENDEN MCKEEVER[1]
[1]US Merchant Marine Academy, USA
[2]State University of New York Maritime College, USA

ABSTRACT
Soybean products are one of the main ingredients in Asian diets. In addition, soybeans are used as feed stocks and pressed to extract oil in food consumption. The Asian market place, namely China, Japan, and Southeast Asia, accounts for the majority of the world's soybean demand. The United States and Brazil are the world's largest producer of soybeans, followed by Argentina, representing a vibrant international market. China accounts for one third of the total worldwide demand for soybeans and 60% of the total seaborne import, the same percentage for US exports just a year ago. As most of the soybean productions are located in distant inland areas, an efficient multimodal transportation system is essential to facilitate the soybean export from origin to importing countries. For example, soybeans are produced and harvested in the agriculture heartlands far away from coastal ports for both the US and Brazil, the configurations of their respective supply chain to transport their soybeans from production to overseas ports at destinations provide a unique perspective to show how each country compete for the most important soybean market, China. The objectives of this paper are to exam the world soybean market and supply/demand relationship among major trade partners with emphasis on the US and Brazil export to China, identify major characteristics of the multimodal soybean supply chain in the US and Brazil, compare and contrast modal shares with regards to trucking, rail, barge, and ocean transport, and apply a total landed cost model to analyse cost competitiveness of the soybean supply chains both in the US and Brazil.
Keywords: agribulk transportation, soybean trade, supply chain, total landed cost, tariffs, multimodal transportation.

1 INTRODUCTION

According to the 2018 annual report of maritime transport by United Nations Commission on Trade and Development (UNTAD), global grain trade, including wheat, coarse grains and soybeans, reached 515.1 million tons in 2017, a 7.1% increase over 2016 [1]. The Asian market place, namely China, Japan, and Southeast Asia, accounts for 70% of the world's seaborne soybean demand, US and Brazil are the two largest producers, accounting for 80% of the world production. followed by Argentina, the majority of these nations' exports end up in China [2]. China alone accounts for 32% of the world soybean production and 60% of the global soybean trade, its soybean import has increased by 815% since joining the WTO in 2001, playing a dominant role in the market [3]. As soybean productions are located in distant inland areas from major seaports, an efficiency multimodal transportation system is essential to facilitate the soybean export from origin to overseas destinations. For example, soybeans are produced and harvested in the agriculture heartlands far away from coastal ports for both the US and Brazil, analysis of their respective supply chain to transport their soybeans from production to overseas ports provide an important insight into how each country competes for the most important soybean market, China. The objectives of the paper are to exam the world soybean market and supply/demand relationship among major trade partners with emphasis on the US and Brazil export to China, identify major characteristics of the multimodal soybean supply chain in the US and Brazil, compare and contrast modal shares with regards to trucking, rail, barge, and ocean transport, and apply a total landed cost

www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/MT190221

model (TLC) to analyze cost competitiveness of the soybean supply chains both in the US and Brazil. The paper starts with literature review. Next it provides a statistical analysis on the world soybean market and market shares of major importers and exporters, especially US, Brazil, and China. Applying a total landed cost model, the paper analyses cost components, production cost, modal configuration and cost variables of each mode (truck, barge, rail, and ocean) in the total costs. Furthermore, the paper assesses the robustness of the soybean supply chains in their responds to drastic changes in trade tariffs between countries. Lastly, the paper concludes that an efficient and responsive multimodal transportation system is critical to a sustainable agriculture supply chain and maintain international competitiveness. Although ocean transport is indispensable for products exporting to overseas market, an integrated domestic multimodal system with truck, barge, and rail is equally important for international competitiveness.

2 LITERATURE REVIEW

The literature covers global soybean trade, total landed cost model, and soybean supply chain. Due to the fact that soybean is an agriculture commodity, its products are main ingredient for feed stocks and for human consumption, cost is a major factor in terms of market competitiveness, given the absence of differentiating product features.

A generic global logistics cost model for electronics industry is comprised the following variables: raw material sourcing cost, manufacturing costs, transportation costs, warehousing costs, inventory holding costs, and taxes and duties. The model was applied to analyse various trade-offs between inventory and transportation costs [4]. From a buyer's perspective, a concept of total procurement price includes: traditional basic input costs (product or material cost paid by the firm), direct transaction costs (detecting, transmitting, and processing material flow), supplier relationship costs (costs of creating and maintaining relationships with suppliers), transportation costs, quality costs (costs of quality compliance), and inventory costs [5]. To analyse international supply chain, the TLC model includes three main cost components: product cost (manufacturing and packaging costs), trade related costs (import duties, documentation, and trade financing costs), and total distribution costs (TDC) (transportation cost, in-transit inventory carrying cost, and warehouse inventory cost). This model is applied to compare various alternatives of multimodal combination solutions for containerized consumer goods from Asia to the US It identifies TDC optimization parameters taking into account product value, transportation costs (different multimodal alternatives), and inventory carrying cost as trade-offs to achieve supply chain objectives [6]. Jansson and Nordh applied a TLC model comprised of two main components: purchase price and costs of bringing product to distribution centre, comprising of manufacturing costs and logistics costs i.e. packaging, customs, transportation, inventory, insurance, and taxes for the latter. Applying a method of integer programming with statistical distribution, the authors analyse different optimization solutions to achieve the goal of minimization of TLC for various product groups [7].

Nardi and Davis utilized a TLC method to assess the export competitiveness of US, Brazil, and Argentina soybeans to Rotterdam, the Netherlands between 1997/1998 and 2005/2006. In their TLC model, it is divided into two main components: total production cost (TPC) and total marketing cost (TMC) (inland transportation, storage, and ocean transportation costs). The findings of the analysis revealed that TPC is lower in both Argentina and Brazil, but higher in the US On the other hand, the US has lower TMC in particular in transportation cost. It clearly indicated the significance of the impacts of transportation costs especially domestic transportation costs on the TLC, export competitiveness. As both countries, in particular Brazil, improve their transportation infrastructures, their soybean export competitiveness have increased substantially, now Brazil has become the largest soybean exporter [8]–[10].

Several studies and government reports analysed the dynamic competitive nature of the soybean markets and the global supply chain involved multimodal transportation. Oliveira and Alvim used a spatial equilibrium model to assess the competitiveness of Brazilian agriculture export, mainly on soybean and maize, transportation and storage logistics costs remain a major barrier [11]. Dynamic econometric modelling and multivariate sensitivity analysis were applied in two comprehensive consecutive studies by Salin and Somaru on US soybean export supply chain, competitiveness and market share. The focus was on transportation modal share with respect to the impacts of infrastructure development on soybean export competitiveness between US and Brazil. The study results indicated that infrastructure costs were the main drivers impacting the total landed costs. Infrastructure development of highway, rail, and ports improved Brazil's soybean export competitiveness substantially. Though US would remain as one of the top players, but with declining market share and Brazil would become the top player in the global market [12]–[14].

Soybeans are the fourth leading crop produced in terms of volume, and soybeans and their derivatives are the most traded agricultural commodity, accounting for over 10% of the total value of global agricultural trade. The world soybean trade is projected to increase by 22% in soybean meal by 20%, and in soybean oil by 30%, according to USDA Agricultural Projections to 2024. There are many factors influencing the global soybean market, primarily population and income growth, as well as domestic and trade policies implemented by major agricultural importers and exporters [15]. Germanakos et al. analysed US soybean export supply chain and process, applying the TLC concept. However, recent trade conflict between China and US, soybean export to China has been seriously impacted with more than 65% reduction in 2018/19. However, due to its well-developed multimodal transportation infrastructure, US soybean industry was able to reconfigure its export supply chain quickly to the new European market, offsetting its loss of Chinese market [16]. Zhou et al. evaluated the potential long-term impacts of Chinese tariffs on US soybean, resulting in a possible shift of the global soybean flow and changes of price differentials that the US would export its soybean to Argentina and Brazil as China drastically increased its import from these two countries and their inability to meet the demand [17].

In summary, all the research on the global soybean market, its supply chain applied the TLC concept and demonstrated its how important an efficient multimodal transportation is for the exporting countries to gain competitive advantages. However, analysis on transportation costs did not provide sufficient details to gain further insight on the totality and dynamics nature of the supply chain.

3 GLOBAL SYBEAN TRADE AND TRADE ROUTES

The world soybean market is dominated by a handful of countries and regions, US and Brazil are the top producers, responsible for the majority of soybean supply and export, while China and European Union are the main importers. China alone is accounted for 60% of the global import. As most of soybean productions are located in the agriculture heartland regions far away from coastlines and sea ports, this implies the necessity of multi-stage and multimodal supply chain with the objective of optimization and export competitiveness.

3.1 Global soybean trade

Although originating in Asia, today's top three soybean producers are actually located in the Americas: the US, Brazil, and Argentina. US and Brazil are the top soybean producers with estimated 123.6 and 122 million metric tons respectively in 2018. The third largest producer is Argentina with 56 million metric tons [18], [19]. The growth in population and livestock in East Asian help drive the demand for more soybean imports. China and other Southeast Asian countries such as Korea, Taiwan, and Indonesia all have huge demands for grain, especially soybeans. In recent years, Europe has also become another demand area with growing import of soybeans. Fig. 1 shows the magnitude of major exporting and importing countries in the global seaborne soybean trade.

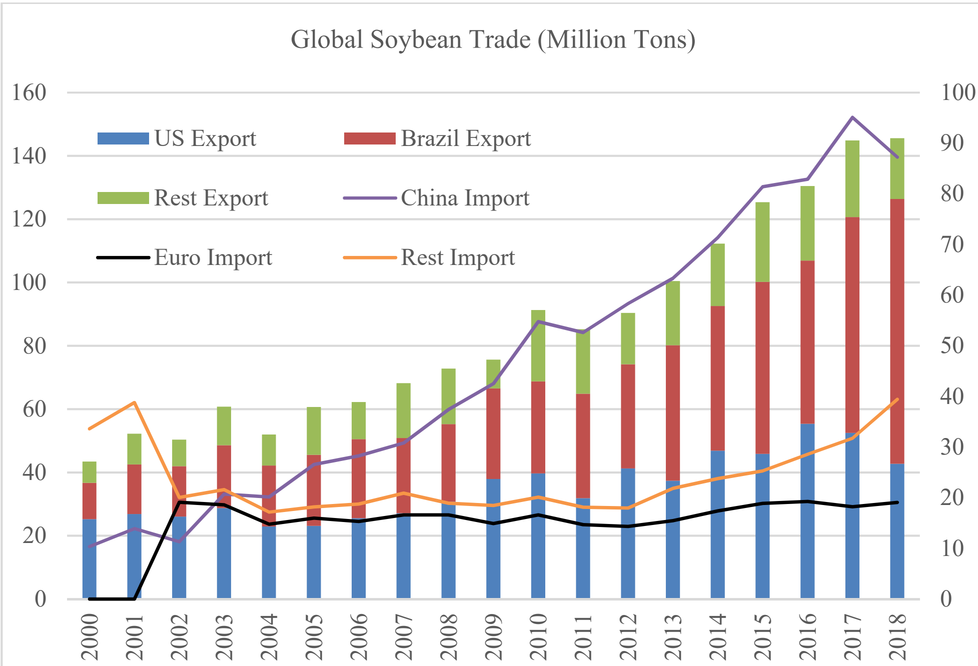

Figure 1: Global soybean market [2].

As result, the global seaborne soybean trade has experienced significant growth over the last two decades, mainly driven by China's import, its 2017 import of 95.1 million tons was a nine-fold increase from the 10.37 million tons in 2000. On the export side, the US, once held a dominant position in the first decade of 2000's, is overtaken by Brazil in recent years. In 2014, both countries exported the same volume of soybeans at 45.5 million each, but in 2018 Brazil exported almost twice the amount as the US, 82 vs. 42 million tons. This is a clear indication that Brazil has been gaining market share on the US Though the tariff war played a role here, A comparative analysis of supply chain and TLC in both countries will provide insight regarding this drastic change and how their respective supply chain functions.

Although a majority of the world's demand for soybeans comes from China, 20% of exported whole soybeans, soybean meal, and soybean oil is sent to other Asian countries. That is equivalent to a little over 14.6 million metric tons of the 70.4 million metric tons of exports. The US Soybean Export Council (USSEC) divides Asia into two general regions: North Asia and Southeast Asia. As trade tension rises, the US soybean industry started to establish better relationships with these nations will help US farmers better connect with their crops' destinations. The USSEC, the international marketer of US soybean products, focus a majority of their efforts on these expanding markets (Southeast Asia): Vietnam, Thailand, the Philippines, and Indonesia. This helps to reduce reliance on mature markets. In addition, the US is also looking to expand their markets to non-Asian countries like Europe, Middle East, and Africa [20].

3.2 Soybean trade routes

As stated earlier that the top two soybean producers are US and Brazil and their main market is China, based on their respective production regions, domestic freight transportation networks, and terminal facilities are of importance for market competitiveness (see Fig. 2).

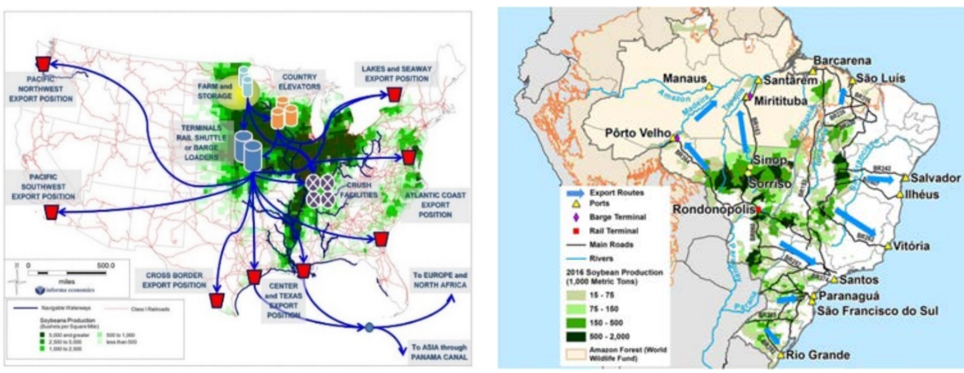

Figure 2: US vs. Brazil soybean logistics flows. *(Source: United Soybean Board, Informa Economics, 2016 and [14].)*

In Fig. 2 the US soybean trade routes and logistics flow for export markets. The production regions are concentrated in the central and northern territories, and along the Mississippi River and its tributaries. In the addition, there are extensive rail networks and inland waterways, especially the Mississippi River and its tributaries, connecting production, storage, and major seaports. Though not shown in this figure, the US also has a very comprehensive highway network covering every corner of the country connected to rail terminals and all seaports. Such a multimodal freight transportation system provides numerous logistics solutions for its agriculture and manufactured products for both import and export as well as domestic distribution. For soybeans, there are two main gateways in the West Coast for Asian markets, three along the Gulf of Mexico for Asian (via Panama Canal), European, and African markets, two in the East Coast and one in the Great Lakes mainly for European and African markets. In particular, its main inland waterway networks provide thousands of miles of navigable channels connecting its production regions to major highways, rail, and hub ports.

Brazil, on the other hand, does not have a comprehensive multimodal freight system, its soybean productions are concentrated in remote interior regions where the primary means of freight transportation is truck. Brazil's major gateways for soybean export are ports along its East Coast, in addition there are several main ports located in its northern coast and along the Amazon River. However, the primary means of moving soybeans from production to coastal ports for export is truck. Though there are several major rivers in the country, there are not well connected to major ports, except for Amazon River, and there is lack of efficient freight

www.witpress.com, ISSN 1743-3509 (on-line)

rail network as well. This is a disadvantage in terms of transporting bulk agriculture commodities like soybean, corn, etc. as rail and water transportation are low cost in comparison to trucking.

As soybean is a relatively low value agriculture commodity, total transportation costs account for large percentage of the TLC in global trade. Domestic freight infrastructure and its accessibility, capacity, modal connectivity, and efficiency are of importance impacting soybean logistics, supply chain system effectiveness, cost efficiency and ultimately export competitiveness.

4 GLOBAL SOYBEAN SUPPLY CHAIN AND TOTAL LANDED COSTS

There are multiple stages with different entities in a soybean supply. Using US domestic movement as an example to describe a generic soybean supply chain is shown in Fig. 5. After harvesting, soybeans are moved from the field to silos, the next step is to move the soybeans to exporter's grain storage facilities. From there, the soybeans are transported to an inland port facility for export via either truck, rail, or barge, whichever provides the lowest costs and the most efficient route. At the port of export, the soybeans are then loaded on to ocean going ships sailing to their destination ports overseas [16].

4.1 Characteristics of US and Brazil soybean supply chains

As mentioned earlier, there are two main routes, the supply chain for soybeans produced in the western part of the US are exported to Asia via truck–rail–ship intermodal route. The average distance for this westbound soybean movement is about 1,400 miles. Soybeans produced in the central region of US are exported to Asia and Europe via truck–barge–ship intermodal route, taking the advantage of the well-developed Mississippi River and its tributary system. The distance for this southbound soybean movement is about 1,350 miles. The five-year average modal share of soybean export is 20%, 30%, and 50% for truck, rail, and barge respectively [21].

On the other hand, Brazil's soybean export supply chain is quite different from the US There are 35 soybean export routes from production regions to major seaports, their lengths vary from 130 to 1,200 miles with an average of 587 miles. Since Brazil's freight rail network is still in its early stage of development, nor are there inland waterways connecting these production regions to seaports, the primary mode of transportation to move export soybeans is trucking. Its top three ports for soybean export by volume is Santos, Rio Grande, and Paranagua, accounting for about 60% of total [14].

4.2 Comparison of total landed costs between US and Brazil

US Department of Agriculture (USDA) publishes detailed reports regarding soybean trade for both countries on a regular basis. Using the data in those reports, a time series was developed for comparison [22]. A Since soybean is a raw agriculture commodity, the TLC model used by the USDA is quite straight forward as follows.

$$TLC = P + TC_D + TC_E, \tag{1}$$

where TLC = Total landed costs per ton for soybeans; P = Soybean price per ton at origin; TC_D = Total domestic transportation costs per ton; TC_E = Total international transportation costs per ton.

The soybean price P is the average market value at farms at origin. TC_D is summation of all the transportation costs, truck, rail, and barge when used in moving soybeans. TC_E is the shipping market freight rate covering vessel operating costs, bunker costs, and port costs.

Based on the weekly Grain Transportation Reports published by the USDA [22], comparisons of TLC, P, TC_D, and TC_E are made on two trade routes in the US vs. one from Brazil from origin to Shanghai, China: Minneapolis, Minnesota via US Golf; and Sioux Falls, South Dakota via Pacific Northwest vs. North MT via Santos (Brazil). These routes have similar distances of 1,200 to 1,400 miles in the domestic segment of their respective supply chains. Using quarterly data provided in the USDA's Grain Transport Reports from the 1st quarter of 2010 to the 1st quarter of 2019, the following graphs are plotted.

Fig. 3 contains two graphs: comparison of TLCs and comparison of production costs (farm prices). The comparison of TLCs shows that the TLCs at the destination of Shanghai, China, all three trade routes are quite competitive in today's market. The average TLC for these routes was $440 per metric ton the first quarter of 2010, it reached its peak at $640 per ton during the third quarter of 2012. From there on, it steadily declined. In the 1st quarter of 2019, it was $406 per ton, close to 33% reduction from the peak. From 2010 to 2013, the TLCs of the North MT via Santos route were higher than all the US routes, but from 2013 onwards, they have been more or less within narrow ranges with the US routes. This confirms that Brazilian soybean export has become quite competitive based on TLC. However, due to the fact that there are multiple stages in the soybean supply chain, it is important to analyse each cost variables in the TLC to gain further insight. On the other hand, the comparison of production costs shows soybean prices at origin; the overall production costs have been on a downward trend since 2012. The average farm price per ton dropped from its peak at $540 in the 3rd quarter of 2012 to $310 in the 1st quarter of 2019, a significant 42.6% decline. Most importantly, it demonstrates that Brazil has production cost advantage over the US, however, the gap is narrowing, indicating a more competitive market.

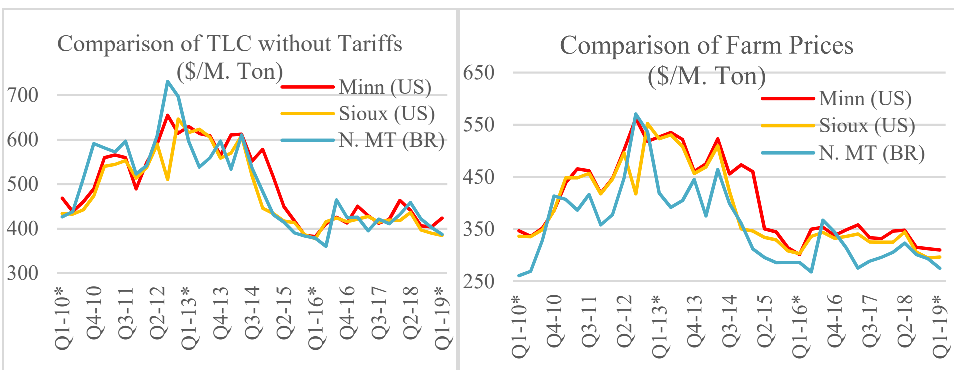

Figure 3: Comparison of TLCs and soybean price at origin. *(Source: Created by the authors.)*

The transportation costs have two parts: domestic and international (ocean). This is the most distinction between US and Brazil in domestic transportation system. US has a very comprehensive and efficient freight rail network, providing high capacity and low-cost solutions especially for bulk commodities.

In the route to Shanghai via Pacific Northwest, unit trains (single commodity and one pair of origin–destination) with over 100 railcars are used gain efficiency and lower transportation cost. In the route to Shanghai via the US Gulf, a multimodal solution is used: truck–barge–ship or truck–rail–barge–ship (where appropriate). The common theme is that since the distances for both routes from producing regions to seaports are quite long, about 1,400 miles, such as multimodal movement in which truck for short distance movement from harvest points to storage units/terminals and barge or rail for long distance movement from the storage units/terminals to seaports are very cost-efficient. However, such a multimodal solution is not available yet in Brazil due to lack of appropriate infrastructure or suitable inland waterways connecting producing regions and seaports as well as cargo handling equipment and terminal facilities, the domestic transportation for soybean is truck only.

Fig. 4 shows a comparison of domestic transportation costs of the soybean routes between US and Brazil. The Minneapolis route using truck–barge combined via the US Gulf has the lowest total costs, however, in the 1st quarter of every year, a truck–rail–barge combination is used due to poor weather condition during winter in the upper section of the inland waterways resulting in higher costs in comparison to other seasons, contributing to larger seasonable variation. The costs of domestic transportation in the Pacific northwest route (truck–rail) is higher than the truck–barge route via the Gulf, but is the most stable cost trend and it is much lower than the all truck route in Brazil. The costs of the all truck route in Brazil was very high, twice of the truck–rail route and almost three times of truck–barge route in the US in 2010 and 2011. Starting in 2012, there has been a steep decline from 2012 to 2016, to the same level as the US truck–rail route in the 4th quarter of 2016. But since then, there has been a rapid increase, rewidening the gap. Nevertheless, the reduction of domestic transportation in Brazil is very substantial, indicating significant improvement.

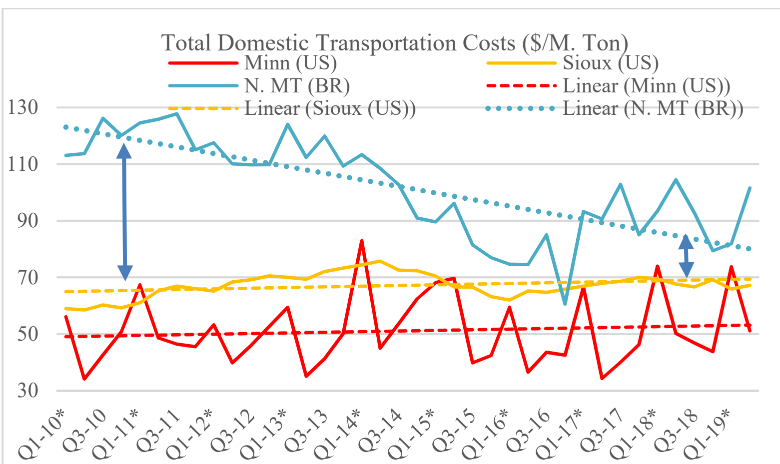

Figure 4: Comparison of domestic transportation costs. *(Source: Created by the authors.)*

For international transportation costs, all routes show a significant decline of 60% from 2010 to 2016, and steady increase since 2017, back to the level in 2012 or 2013. Among the three routes, the US truck–rail–ship route is the lowest one, followed by the Brazil truck–ship route, and lastly the US truck–barge–ship route is the highest (see Fig. 5).

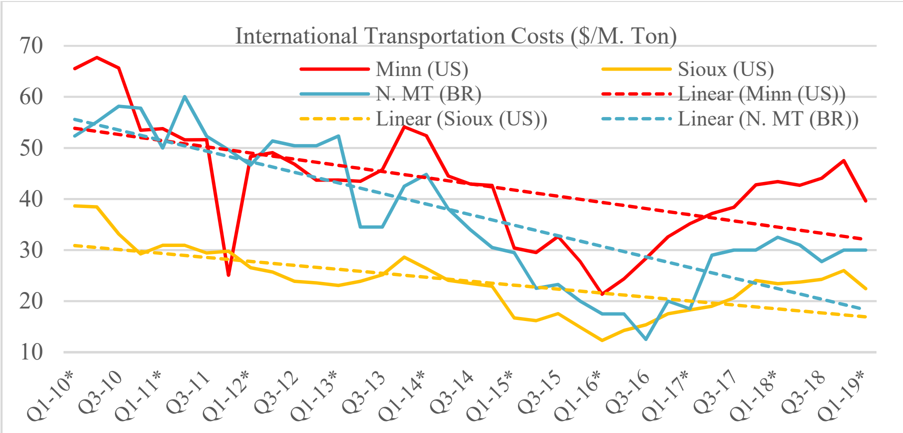

Figure 5: Comparison of international transportation costs. *(Source: Created by the authors.)*

For total transportation costs, Fig. 6 shows that the Brazil's route has the highest among the three routes, however, with the steepest decline from 2010 to 2016. The US northwest route is the most stable with slight downward trend. The US Gulf route fluctuates with a gentle downward trend from 2010 to 2016. Starting in 2017, the total transportation costs for all three routes increase. Overall, the gap of total transportation costs between Brail and US has narrowed significantly, greatly contributing to the competitiveness of Brazil soybean export.

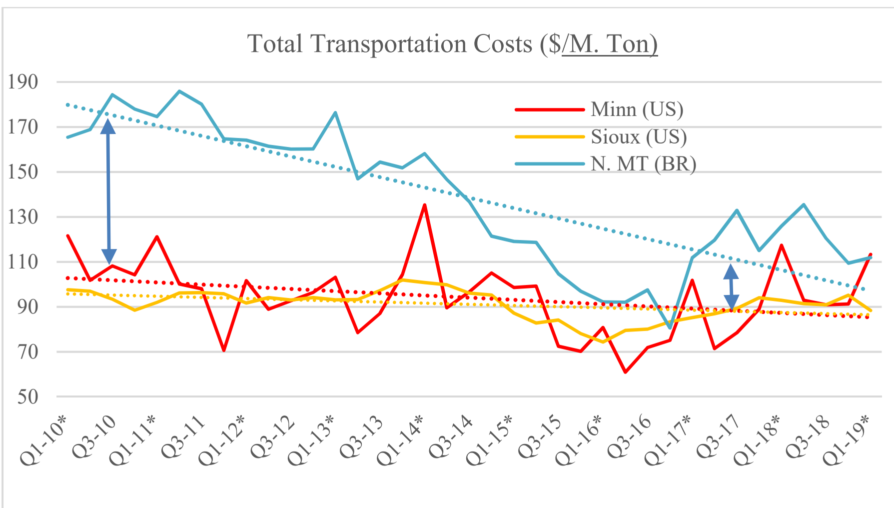

Figure 6: Comparison of total international transportation costs. *(Source: Created by the authors.)*

4.3 Soybean tariffs and the shift of the soybean supply chain

After imposing the soybean tariffs, China also stopped purchasing US soybeans and focused on Brazil and Argentina, meanwhile the US had a good harvesting year with much higher yield in 2018, resulting in excess of supply and causing a steep drop in price [23]. However, the demand for soybeans in China remains in place, and soybean productions in Brazil and Argentina were not be able to increase quickly enough to offset the supply from US, creating an artificial supply–demand gap. Given the fact that the distance to China's market is long, but the distance between Brazil and US is much closer than to China, and the US has a well-developed and functioning transportation infrastructure and supply chain facilities than Brazil. A new market dynamic was developed [24].

Because of the artificial supply–demand gap, a price spread was developed between US and Brazil soybeans. Brazil was able to increase their soybean price for China by 23% to stay competitive. But Brazil and Argentina were not able to increase their soybean productions to sufficiently meeting the demand and the price spread was big enough, Brazil ended up buying US soybeans to supplement the supply. In addition, soybean market in Europe also reacted quickly, European buyers took advantage of the drop in US soybean price and began purchasing the grain. Therefore, a new market for US soybeans was developed. Though the Chinese tariffs created many inefficiencies in the traditional soybean supply chain, the soybean and food commodity markets were quick to adjust to changes, Within a few days, the supply chain was able to alter its various routes to ensure that US soybeans were able to be transported to Brazil, Argentina, and the newly developed European market.

As the US soybean market switched direction, trade to China in the Pacific Northwest came to a grinding halt. Western soybean producers were forced to take a more expensive option of shipping their soybeans eastward to Saint Louis instead, railroads also adjusted their freight rates to accommodate for the longer travel times and distances, as soybeans volume being transported to Saint Louis increased. The Gulf of Mexico, which had traditionally always been the secondary market for soybean and other grain exports to Asia, has now become the primary export location for US soybeans and other grains. One unexpected, but positive change, to the US soybean supply chain was the creation of an East Coast export market to countries in Europe.

In summary, since the implementation of Chinese tariffs on US soybeans, the market was able to adjust quickly to the new demand pattern. Thanks to the robust US transportation infrastructure and supply chain facilities, the soybean industry was able to reduce the negative impacts. More importantly it is the close collaboration among supply chain stakeholders such as farmers, conglomerates, agriculture traders, trucking companies, railroads, barge lines, and ports to make this possible. It demonstrates the importance of a well-developed multimodal transportation system, enabling a highly competitive supply chain.

5 CONCLUSION

The paper analyses the global soybean trade, its supply chain, and the impacts of tariffs. The seaborne soybean market is comprised a handful of dominant players. On the demand side, China alone accounts for 62% of the global import, US and Brazil are the two biggest exporters. Over the past decade, US has ceded its dominant position as the biggest exporter to Brazil. Using TLC, the paper evaluates all cost variables in the model, statistical analysis demonstrates that besides product costs at origin, transportation costs accounts for large portion of the TLC and play a critical role and contribute significantly to export competitiveness. While international transportation market is beyond the control of any single entity, reduction of domestic transportation cost via infrastructure improvement will help enhance international competitiveness and efficiency. Brazil is able to reduce transportation costs for their soybeans as it has undertaking major transportation infrastructure investments in recent years. If fully developed, the use of railroads, to move their soybeans from interior region to seaport would provide further advantage to their soybean export as well as domestic markets. As for the US, it is hoped that trade disputes will be resolved, its soybeans will be directly shipped to China again, rather than to South America. Lastly, a well-functioning multimodal transportation system, as a backbone of the global supply chain, is essential for international trade, export competitiveness and overall economic efficiency.

REFERENCES

[1] United Nations Commission on Trade and Development, Dry-cargo trades: The mainstay of seaborne trade in 2017, Review of Maritime Transport 2018. https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf. Accessed on: 12 Apr. 2019.

[2] Clarksons Shipping Intelligence Network, World seaborne drybulk trade: World soybean seaborne trade. https://sin.clarksons.net/Timeseries?h=36560&p=20320. Accessed on: 9 May 2019.

[3] American Farm Bureau Federation, China uses one-third of world's soybeans. www.fb.org/market-intel/china-uses-one-third-of-worlds-soybeans. Accessed on: 10 Feb. 2019.

[4] Jearasatit, A., Using a total landed cost model to foster global logistics strategy for electronics. https://ctl.mit.edu/sites/ctl.mit.edu/files/library/public/2010_Jearasatit%20_ExecutiveSummary.pdf. Accessed on: 2 Apr. 2019.

[5] Coyle J., Langley, C., Novack, R. & Gibson, R., Sourcing materials and services. *Supply Chain Management: A Logistics Perspective,* 8th ed., South-Western Cengage Learning, pp. 559–585, 2009.

[6] Clancy, B. & Hoppin, D., Coping with uncertainties, Merge Global: Boston, 2008.

[7] Jansson, E. & Nordh, M., Cost comparison model on total landed cost for purchased items: A case study for an industrial company. Master's thesis, UMEA Universitet. www.diva-portal.org/smash/get/diva2:943344/FULLTEXT01.pdf. Accessed on: 9 Mar. 2019.

[8] Nardi, M. & Davis, T., Soybean landed cost competitiveness analysis for Argentina, Brazil, and the United States. *Proceedings of VI International PENSA Conference Sustainable Agri-food and Bioenergy Chains/Networks Economics and Management*, October 2007. https://researchgate.net/publication/271076552. Accessed on: 23 Mar. 2019.

[9] Friend, J., Lima, R. & Montevechi, J., Effect of soybean transportation costs in the US and Brazil: A logistical comparison. *Proceedings of XVI International Conference on Industrial Engineering and Operations Management*. www.abepro.org.br/biblioteca/enegep2010_ti_st_113_741_16677.pdf. Accessed on: 18 Feb. 2019.

[10] Fliehr, O., Zimmer, Y. & Smith, L., Impacts of transportation and logistics on Brazilian soybean prices and exports. *Transportation Journal,* **58**(1), pp. 65–77, 2019.

[11] Oliveira, A. & Alvim, A., The supply chain of Brazilian maize and soybeans: The effects of segregation on logistics and competitiveness. *International Food and Agribusiness Management Review,* **20**(1), 2017.

[12] Salin, D. & Somaru, A., The United States transportation dynamics in the world soybean market. US Department of Agriculture Marketing Services, 2014. DOI: 10.9752/147.08.08-2014. Accessed on: 23 Mar. 2019.

www.witpress.com, ISSN 1743-3509 (on-line)

[13] Salin, D. & Somaru, A., The impacts of infrastructure and transportation costs on US soybean market share: An updated analysis from 1992–2017. US Department of Agriculture, Agriculture Marketing Services, 2018. www.ams.usda.gov/sites/default/files/media/SoybeanMarketShare.pdf. Accessed on: 23 Mar. 2019.
[14] Salin. D., Soybean transportation guide: Brazil 2017, US Department of Agriculture, Agriculture Marketing Service, 2018. DOI: 10.9752/TS048.09-2019. Accessed on: 24 Feb. 2019.
[15] Lee, T., Tran, A., Hansen, J. & Ash, M., Major factors affecting global soybean and products trade projections. Amber Waves, Economic Research Services, US Department of Agriculture. www.ers.usda.gov/amber-waves/2016/may/major-factors-affecting-global-soybean-and-products-trade-projections/. Accessed on: 24 Feb. 2019.
[16] Germanakos, L., LaPage, S. & McKeever, B., Tariffs and the US soybean supply chain. *Annual Conference of Connecticut Maritime Association*, Stamford, 3 Apr. 2019.
[17] Zhou, Y., Baylis, K., Coppess, J. & Xie, Q., Evaluating potential long-term impacts of Chinese tariff on US soybeans. Department of Agriculture and Consumer Economics, University of Illinois at Urbana-Champaign, *Farmdoc Daily*, **8**, p. 179, 2018. https://farmdocdaily.illinois.edu/2018/09/evaluating-potential-long-run-impacts-of-chinesetariff-on-us-soybeans.html. Accessed on: 2 Mar. 2019.
[18] US Department of Agriculture, National Agriculture Statistics Service, Crop production 2018 summary. www.nass.usda.gov/Publications/Todays_Reports/reports/cropan19.pdf. Accessed on: 2 Apr. 2019.
[19] Merco Press, Brazil's 2018/19 soy crop estimated at 122m tons and Argentina's at 56.5m tons. https://en.mercopress.com/2019/01/07/brazil-s-2018-19-soy-crop-estimated-at-122m-tons-and-argentina-s-56.5m-tons. Accessed on: 2 Apr. 2019.
[20] Carmen, J.D., Beyond China: A closer look at Asia's other soybean markets. *Missouri Soybean Farmer*, pp. 10–14, 2018.
[21] Chang, K., Cafferelli, P., Gastelle, J. & Sparger, A., Transportation of US Grains: A modal share analysis. US Department of Agriculture, Agriculture Marketing Services, 2019. DOI: 10.9752/TS049.04-2019. Accessed on: 1 May 2019.
[22] US Department of Agriculture, Agriculture Marketing Services, Grain transportation reports, 6 Jan. 2011–30 May 2019. www.ams.usda.gov/services/transportation-analysis/gtr/archive. Accessed on: 30 May 2019.
[23] American Farm Bureau Federation, US soybean exports to China fall sharply, 2018. www.fb.org/market-intel/US-soybean-exports-to-china-fall-sharply/. Accessed on: 2 Dec. 2018.
[24] Francis, T. & Dawson, M., US soybean supply chain. Mutual Farmer's Association, Columbia, Missouri, personal interview, 28 Dec. 2018.