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Abstract: Freight Villages (FV) are logistics clusters in which all activities related with freight transportation are realized. Various operators conduct business under one roof in FVs. Coordination and collaboration are the essential part for creating harmony to achieve sustainability. The establishment of such facilities in Turkey has been realized in late 2000s. In this paper, the aim is to provide a broad overview of the FVs in Turkey and shed light into their potential for the future. To do so site visits to all existing operational public FVs and a private FV have been made, where interviews with the management units have been conducted and comparisons to global counterparts have been made. As a result of these, it has been observed that currently, FVs in Turkey are overwhelmed due to lack of coordination and collaboration. However, also light has been shed into possible alternative working principles for Turkish FVs, and it has been showed that if coordination and collaboration could be realized, significant positive effects can be achieved in terms of different aspects regarding sustainability and social equity.

*Title Page

Potential Effects of Logistics Clusters: The Case of Turkish Freight Villages

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Freight Villages (FV) are logistics clusters in which all activities related with freight transportation are realized. Various operators conduct business under one roof in FVs. Coordination and collaboration are the essential part for creating harmony to achieve sustainability. The establishment of such facilities in Turkey has been realized in late 2000s. In this paper, we aim to provide a broad overview of the FVs in Turkey and shed light into their potential for the future. To do so, we make use of site visits to all existing operational public FVs and a private FV, where interviews with the management units have been conducted and comparisons to global counterparts have been made. As a result of these, we observe that currently, FVs in Turkey are overwhelmed due to lack of coordination and collaboration. However, we also shed light into possible alternative working principles for Turkish FVs, and show that if coordination and collaboration could be realized, significant positive effects can be achieved in terms of different aspects regarding sustainability and social equity.

Keywords: Freight Villages, Logistics Clusters, Social Equity, Sustainability

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Response to Associate Editor

We are thankful to the Associate Editor and the anonymous reviewer for their time, effort, and constructive feedback regarding the revision and suggestions for further improvement of this paper. We believe that their inputs have improved the content of the paper. Our main edits to the Revision 1 of the manuscript include the following:

- More emphasis is given in SWOT methodology section; how the factors were found, why such an analysis is chosen and how this analysis can be turned into a application
- Takeaways for practitioners and potential researchers have been underlined in the conclusion.
- Overall wording of the text is simplified

Response to the Comments of the Reviewers

We are grateful to the editor and the reviewer for the following suggestions. Our responses to each of these suggestions are provided below.

Response to the Associate Editor:

**The manuscript should be written in third person singular or plural perspective. Please avoid the use of "we" or "our".*

Parts of the R1 manuscript that contains usage of “we” or “our” have been corrected accordingly.

**Kindly discuss how SWOT analysis was carried out for the case study examined. How did the authors determine the elements in SWOT.*

Information about the steps of the SWOT analysis and how the factors are found have now been added to Section 5. In the conclusion section, it has now been underlined that the outcomes of the analysis can be used for strategy formulation and thus can be turned into application.

**In the beginning, the authors have indicated that one of their objectives is to propose relevant indicators for FVs. It will then be useful if the authors can mention in the conclusions what the proposed indicators are based on their analysis. In addition, please discuss in the conclusions how the results of the work can be useful for other researchers who might be working on a similar research field but interested perhaps in a different case study.*

We are grateful for an important issue aroused by the editor. All the proposed performance metrics in Section 4 are indeed proposed indicators. In the conclusion section it has been highlighted that the future work on the area can be build up on these metrics.

**Although JCLP does not indicate a page limit to the submissions, the guide for authors indicates that the length for original articles should be 6000 - 8000 words in length. Please see https://www.elsevier.com/journals/journal-of-cleaner-production/0959-6526/guide-for-authors.*

As suggested by the associate editor, the authors have gone through the guide for authors document of the Journal of Cleaner Production and made necessary formatting and structural changes whenever necessary. We believe that in its current version, the paper is simplified and number of pages are decreased.

Response to Reviewer 6:

**Overview of individual strengths, weaknesses, opportunities and threats related to the Turkish FVs processed in chapter 5 still does not represent the proper SWOT analysis in the true sense of the word. So, my remark has not been taken into consideration and deficiency has not been eliminated (revised). Authors of the manuscript also did not taken into account my remark regarding the number of pages of the manuscript, nevertheless as a matter of fact, it is not normal to publish scientific papers of 30 pages in length. This fact should be known by the authors, even if no page limit restriction is specified by the journal. Furthermore, as noted in previous manuscript version, appropriate quantification (a research study calculation) in terms of the proposed performance metrics for Turkish FVs needs to be added in order to enhance the scientific value of the manuscript. Unfortunately, this shortage has not been removed as well, and thus manuscript does not include the required chapter with a research study; i.e. a scientific value of the manuscript is insufficient (poor).*

We are thankful to Reviewer 6 for this detailed and constructive feedback to the R1 manuscript. Firstly, to address the concerns of the SWOT analysis, three new references have been added to the current version of the manuscript:

1. Bell, G. G., Rochford, L., 2016. Rediscovering SWOT's integrative nature: A new understanding of an old framework. The International Journal of Management Education, 14, 310-326.
2. Ghazinoory, S., Abdi, M., Azadegan-Mehr, M. 2011. SWOT methodology: A state-of-the-art review for the past, a framework for the future. Journal of Business Economics and Management 12, 24-48.
3. Hill, T., Westbrook, R., 1997. SWOT analysis: It's time for a product recall. Long Range Planning 30(1), 46-52.

It is believed by the authors that Reviewer 6's comments and these new references have given more insight on the SWOT analysis. Information about the steps of the SWOT analysis and how the factors are found have been added to Section 5. Again, practitioners and interested have been guided on how to turn this analysis into application by strategy formulation.

As noted by the reviewer, the current study was the lack of available data and quantitative analysis. For this, a pioneer work has been carried out by conducting site visits and collecting data. In addition this shortcoming has been underlined in the conclusion section and turned into a future research direction.

Data in Brief

Click here to download Data in Brief: Baydar_et_al_2019_Datainbrief.docx

Highlights

- FVs are logistics clusters necessarily focusing on coordination and collaboration
- FVs have potential for sustainable freight transportation
- FVs in Turkey can significantly affect transportation
- Case studies and paradigm change are required for analyzing Turkish FVs
- Physical Internet is promising in FVs future

Potential Effects of Logistics Clusters: The Case of Turkish Freight Villages

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1. Introduction

Freight Villages (FV) are sites/areas hosting clusters of industrial, intermodal, distribution, and logistics infrastructure as well as supporting services dedicated to facilitating the flow of goods. Their main feature is to provide high-quality connections to intermodal and other transportation infrastructures (road, rail, air, and barge) to enable fast and flexible transportation of freight (Higgins et al., 2012).

The first FVs were established in late 1960s in continental Europe (near Paris) to reduce traffic and increase the effectiveness for freight transportation in urban areas by means of freight consolidation (Kapros et al., 2005). In Italy and Germany, the establishment of FVs in the early 1970s was directed towards the objective of extending the inland rail/road intermodal terminals. In 1980s and 1990s, with increased emphasis on supply chain management and increased competitiveness in the global business environment, the focus of FVs shifted to the reduction of transportation costs via economies of scale. By late 1990s and early 2000s, FVs were also made use of for facilitating coordination and collaboration among stakeholders. In recent years, FVs have arrived at a new stage where issues related to sustainability and social equity need to be addressed.

In Turkey, FVs are rather recent, with the first ones established in the early 2000s as public entities. Depending mostly on the infrastructure available from the Turkish State Railways (TSR), the expansion of the FV network in Turkey is still underway. As of the time of writing, six FVs have been established, with five more under construction and nine areas chosen for construction of further FVs by the TSR and the Ministry of Transportation, Maritime Affairs and Communication (MTMAC).

A cluster is defined as a "grouping of bodies with common attributes or a group of similar things or people positioned or occurring closely together" (Oxford Dictionary of English, 2010). In specific, industry clusters are horizontal or vertical agglomerations of firms. Clusters exist mainly due to the important merits they offer such as increased productivity, new technological and delivery possibilities, better access to information, and ease of new business formation (Porter, 1998). A few examples of clusters in supply chains include the city of Detroit for the automotive industry, and more recently, the Silicon Valley (Sheffi, 2012).

In the last two decades, logistics clusters have gained increased acceptance as a base for coordination and collaboration (Kumar et al., 2017). The main motivation behind this is to hedge against competition by providing increased productivity for the bodies inside the cluster, innovation speed, and an environment for new businesses to cherish. For the increased benefits of logistics clusters against supply chain competition, the interested reader is referred to the studies of Porter (1998), Sheffi (2012), and Baranowski et al. (2015). A FV is a special type of logistics cluster which can offer the above-mentioned benefits in terms of supply chain efficiency and effectiveness by its structure and by the services it provides.

Baydar et al. (2017) provide an extensive review of the literature on FVs from the sustainability and societal equity perspective, pointing to the impacts of FVs in logistics networks and underlining certain gaps in the literature, leading to potential research directions. Amongst the main motivations of this paper is to bridge the gaps pointed out by Baydar et al. (2017), including the proposal of tangible performance indicators to assess the effects of FVs in terms of sustainability and social equity, as well as the usage of both academic and non-academic resources and on-site observations to better understand the FVs in Turkey.

The study uses a case study approach to (i) give an overview of the FV concept and indicate the position of FVs within logistics clusters in general, (ii) analyze the specific FV applications in Turkey, (iii) assess the potential effects of FVs in Turkey from a sustainability and social equity perspective, and (iv) discuss the future of FVs in Turkey and provide potential research areas related with this topic.

The remainder of this paper is organized as follows. Section 2 gives insights about clusters, their formation, and logistics clusters, while defining the FV concept and its relation to logistics clusters. Section 3 provides an overview of freight transportation activities in Turkey and the Turkish economy. A detailed overview of FVs in Turkey and the outcomes of the site surveys in operational FVs are given in this section with analyses on their potential effects on sustainability. This section also focuses on the future of FVs in Turkey and provides assessments of the Turkish FVs (TFVs) in terms of sustainability and social equity. Section 4 focuses on the potential effects of TFVs and their evaluation. Section 5 provides a SWOT analysis, before the paper is concluded, and Section 6 discusses the future of TFVs.

2. Freight Villages as Logistics Clusters

A Logistics Cluster (LC) is defined as an area within which high volumes of logistics activities take place (Sheffi, 2012). Rivera et al. (2014) give an alternative definition where a LC is defined as a geographical concentration of firms providing logistics services, such as third-party logistics, transportation carriers, warehousing providers, and forwarders.

Different types of LCs have been formed with respect to different needs of the economies and the supply chains, as well as the eligibility of land. Their main common property is the existence of intensive logistics activities. The nomenclature and types of LCs differ throughout the world with different classification schemes (Higgins et al., 2012) such as geographical coverage, capacity and size (Wiegmans et al., 1999), different roles in supply chains (Rimiené and Grundey, 2007), and types of value-added activities performed (Notteboom and Rodrigue, 2009). Distribution Center, Distripark, Distriport, Dryport, Güterverkehrszentrum, Logistics Center, Platforme Logistique, Platforme Multimodal are alternative names for such logistics clusters.

Logistics operations and freight transportation contribute substantially to negative outcomes against the environment due to emissions (Kahn and Kobayashi, 2007). In addition, with globalization, the level of competition is higher than it has ever been before (Friedman 2005). LCs provide economically, environmentally, and socially sustainable logistics management entities to address these issues. Potential benefits of LCs include building trust between different bodies, creating an environment for education and research, exchanging knowledge more effectively, and becoming a focus point for supply (Sheffi, 2012). In addition, the advantages of co-location addressed by Rivera et al. (2016) are also present in LCs, which include increased productivity, new technological and delivery possibilities, easier access to information, and ease of new business formation. Such establishments also prove useful with higher service levels and in decreasing costs and carbon footprints of companies by increasing conveyance utilization (Rivera et al., 2016).

A FV is a logistics cluster within which all activities relating to transport, logistics, and distribution of goods both at the domestic and international level are carried out by various operators (EUROPLATFORMS, 2000). Established outside cities, FVs let their stakeholders perform value-added logistics activities not only by hosting them under the same roof, but also by creating a synergy between them, enabling coordination and collaboration (Baydar et

al., 2017). With the presence of coordination and collaboration, FVs are purposeful systems to aid with economical sustainability, environmental sustainability, and social equity. It is the coordination (common usage of offered services) and collaboration (acting together) aspects that distinguish FVs from other LCs.

FVs offer logistics services via their technological and organizational resources, in addition to supplying the necessary information and performing value-added activities. However, certain challenges arise in carrying out these activities. Higgins and Ferguson (2011) point out to these by underlining the coordination difficulties between different levels of government and conflicting political interests. There can be risks of oversupply as every jurisdiction strives to pursue the latest trend. On the private sector side, modern day supply chains are mostly vertically oriented, whereas the FV concept is inherently horizontal and at least partially depends on the cooperation among firms. In many FVs, firms have been observed to operate completely independently of others in the development. Concerns about cooperating for competitive reasons and a dependence on government subsidies have also led to difficulties in the urban consolidation/distribution potential of FVs.

As purposeful systems, FVs follow a well-structured vision. Along with increasing the efficiency of the activities related with freight transportation (a property shared by all LCs), FVs also aim to increase effectiveness of the country-wide supply chains. For developing countries, the motivation is more towards market penetration and increased competitiveness, whereas for a developed country sustainability is one of the major principles to consider. In any case, the effectiveness is related with the three pillars of sustainability (economical, environmental, and social).

There are numerous studies from different parts of the world focusing on the benefits of FV applications on different dimensions of sustainability. For example, Hanaoka and Regmi (2011), Altuntas and Tuna (2013), and Lättilä et al. (2013) show examples of decrease in negative environmental impact resulting from emissions, whereas Oláh et al. (2018), Wang et al. (2016), Moinos (2015a, 2015b) and Sainz et al. (2013) show how FVs can aid regional development. A more extensive review of these studies is provided by Baydar et al. (2017).

In line with the above-mentioned studies, this paper specifically performs a similar case study on the TFVs. There have been studies on FVs such as Özceylan et al. (2016a, 2016b) which approach the FV concept from a facility location problem point of view. In contrast, this study

aims to provide a holistic view by defining FVs as LCs and it also aims to assess the potential effects of FVs on sustainability and social equity using the case of TFVs. This is where novelty of this study lies; it fills the gap in the literature by approaching TFVs from a sustainability and social equity paradigm.

3. Overview of Freight Transportation and Freight Villages in Turkey

As depicted in Figure 1, in terms of ton-km, 89.5% of goods transportation is carried out by road transport in Turkey. Roads are followed by seaways and railroads, which account for 4.6% and 5.9% of the operations, respectively (Turkish Statistical Institute, 2015). When these figures are compared to the EU, of which Turkey has been striving to become a member and whose standards it aims to accommodate, there are major differences in the modal split. The percentage of goods transported by road is much less in EU (71.59%) whereas the railroad usage is nearly quadruple of Turkey (17.21%). Sea usage is similar (6.34%) and there is additional pipeline usage (4.86%), the amount of which is negligible. Figure 1 clearly shows that it is vital for Turkey to change to more *sustainable* modes of transport (Chiara et al., 2014) and decrease the usage of roads while making more use of railroads and pipelines in freight transportation. In addition, there is a positive correlation between transportation activities, employment and GDP. As shown in Figure 2, between years 2000 and 2017, freight transportation numbers (in ton-km), GDP, and employment numbers show similar trends.

Even though all three trends have been subject to similar phenomena including financial crises (such as those in 2008 and 2011), national disasters and social disruption, it is important to point out that in Turkey, the increase in freight transportation is an important indicator for the increase in employment, which is generally regarded as a source of achieving social equity in a region with relatively low income and employment numbers.

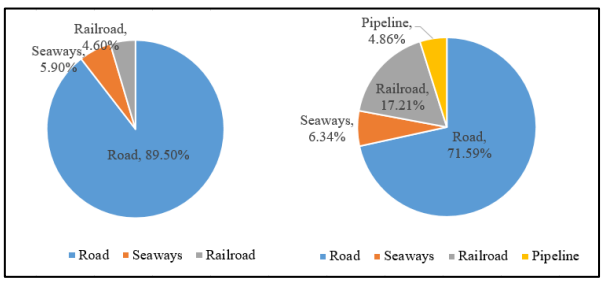

Figure 1 Percentage of transportation modes by ton-km in Turkey and EU-28 (Turkish Statistical Institute, 2015)

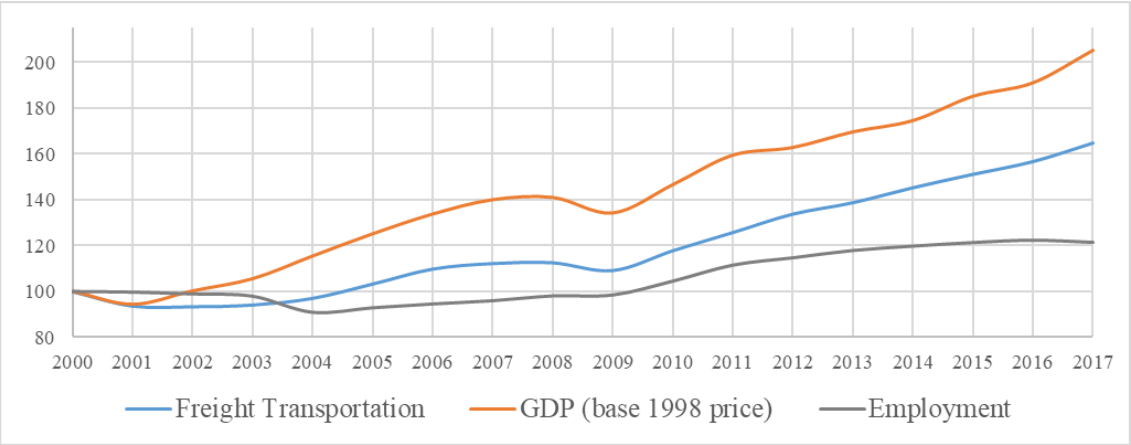

Figure 2 Relationship of freight, GDP and employment indices in Turkey in 2016, with year 2000 set as the base (at value 100) for all three (General Directorate of Highways, 2016), Turkish Industrial Development Bank (2018), The World Bank

Significant effort is spent by the authorities, namely the TSR and the MTMAC and establishment of FVs has been regarded as the main solution to overcome the disadvantages of depending on roads, which have detrimental financial and environmental effects. A project to establish FVs was started in the early 2000s in which the existing warehouses and loading docks are continuously modernized and new facilities are opened. Currently, 20 such facilities are regarded as logistics centers/villages by the TSR. In addition to these 20 facilities, there is a private sector investment in Kazan, Ankara. This facility will also be analyzed in the scope of this study. As of the end of 2017, six of the public FVs and the private FV were operational. The locations of these (logistics) complexes can be seen in Figure 3. It is important to state that there is no formal legal status and/or definition for the facilities that underlines their privileges.

In Figure 3, Yeşilbayır/İstanbul, Kayacık/Konya, Sivas, Boğazköprü/Kayseri, Türkoğlu/Kahramanmaraş, Kars, Tatvan/Birlis and Habur are the planned investment areas by the TSR. Gökköy/Balıkesir, Bozüyük/Bilecik, Yenice/Mersin, Palandöken/Erzurum and Mardin FVs were under construction by the end of 2017. Halkalı/İstanbul, Köseköy/İzmit, Hasanbey/Eskişehir, Uşak, Kaklık/Denizli and Gelemen/Samsun are operational (facilities marked with green). These operational facilities were former railroad warehouses and host certain number of loading docks. They have been modernized in order to meet the increased capacity demands. During the structured interviews (to be discussed in Section 4), two updates have been observed in comparison to those in Figure 3, where it was established that

an additional project has been started in Kemalpaşa/İzmir FV. Furthermore, Gelemen/Samsun, is currently not operational.

Typical flow of operations in the public FVs is as follows: First, firms learn the wagon availability for each of the upcoming trains. Then, TSR and firms negotiate on the price. After negotiations are complete, firms are given wagon information, which includes date and hours of availability. Firms then load onto or unload from the train with their own equipment.

Figure 3 Freight Village applications of TSR*

*Source: Courtesy of TSR (http://www.tcdd.gov.tr/Upload/Files/ContentFiles/2010/yurticibilgi/lojistikkoy.pdf), Accessed 26 November 2016

On the other hand, within the private FV located in Ankara, a different set of operations take place according to the destination of the freight. For domestic operations, firms rent an office inside the facility, which allows them to submit their available freight information in the facility's database. This freight information is continuously shown on screens inside the facility until an available truck driver contacts the firm inside facility. If, after the negotiations, an agreement has been made, the order is then deleted from the screens and the truck driver picks up the load and starts the route. Here, the FV is used as a meeting point for the freight distribution agencies (the tenants) and the available truck drivers. The different agencies are offered offices inside the FV.

The international operations in the Ankara FV are run in a separate part of the FV. Here, the main motivation is to consolidate the bureaucratic operations necessary for international freight transportation in one place. In addition to the shared services that are common for the

domestic and international parts of the FV, the Undersecretariat of Customs also holds an office in the international part of the FV to complete formal paperwork necessary for international freight transportation. The operations of an international shipment start when the loaded trucks arrive at the facility to complete formal paperwork. When all the bureaucratic operations are completed inside the FV, trucks continue their predefined route.

4. A Case Study on Turkish Freight Villages

This section presents the case study conducted by making site visits to all operational TFVs. First, the research methodology and why a case study method was chosen are discussed. In the second part, results of the case study are presented.

4.1 Research Methodology

The methodology in this paper is based on conducting field studies and collecting empirical data by making on-site visits to all operational FVs in Turkey at the time of the study. The reason for these site visits is the lack of available quantitative data on TFVs in the literature. A similar approach is taken by Bask et al. (2010) for seaport-dry port dyads in Europe. Later these sets of data are used for comparison of TFVs with their counterparts and to understand their impact. After analysing the position of FVs in logistics clusters, the outcomes of these site surveys are used to evaluate the performance of TFVs in terms of sustainability and social equity and to propose relevant performance metrics.

This study is the combination of a case study and a site survey. Case studies allow a holistic and meaningful explanation to the characteristics of organizational and managerial processes (Yin 2009). The case study is combined with a survey in order to convey an investigation in an explanatory and descriptive fashion. In addition, case studies provide benefits in evaluation research to explain relations between real life interventions (Yin 2009). Coordination of collaboration constitute the basis of the reason why FVs are special amongst other LCs and these concepts are too complex just to be explained by sole survey or experimental research strategies, which is another reason why this type of research strategy is preferred.

The site selection is based on the feedback from the TSR personnel so that all facilities with active freight transportation operations are selected. These are Balıkesir-Gökköy, Denizli-Kaklık, Eskişehir-Hasanbey, Kocaeli-Köseköy and Uşak. In addition to these public facilities,

a visit to the private Ankara Logistics Base located in Kazan, Ankara is made. During these visits, the form given in Table 9 in the Appendix is used. It includes the following questions:

1. **Location:** What are the criteria for selecting the location of the facility?
2. **Management Information System:** What management information system is used, if any?
3. **Employment:** What are the education and experience levels of your employees? Where are your employees located?
4. **Tenants:** Which firms can you state as your tenants in the facility?
5. **Vehicles:** What model and type are the vehicles that the facility offers to its users?
6. **Effect to Environment:** In which areas (noise, air or water pollution) does the facility affect the environment? Which metrics are being monitored for these areas?
7. **Certification:** Which quality system and/or environmental certificates does the facility hold? From which authority has that certificate been taken and what is the renewal rate?
8. **Business Volume:** What is the current business volume of the facility (monthly vehicle traffic, amount of freight handled, number of destinations in the last 6 months, weekly freight handled, and weekly vehicle traffic)?
9. **Evaluation:** How important are the following criteria: increase in employment, exhaust gases emissions, saving consumables, saving electricity and noise pollution?

Some of the questions given in Table 9 have similar answers; for example, the location selection of the FVs of TSR has been made by the Logistics Department of TSR, thus all answers are identical. The question on vehicles is not applicable to some extent, since apart from a few, the FVs in Turkey do not own material handling machines to serve the tenants. It is found that no performance metrics were available for the facilities, which deemed question 6 regarding the effect to environment out of use. In question 8, only a small amount of the information, namely the yearly freight traffic, has been shared by the FV administrations. Some photographs from the site visits can be seen in Figure 4 through Figure 6 with the loading/unloading docks and the warehouses in Balıkesir, Denizli and İstanbul-Halkalı FVs.

Using the answers from the sites visited for the questions in Table 9, Table 1 is constructed, which is simplified in order to project the effects of FVs on sustainability more easily. Since the TSR FVs did not host any tenants, the cells corresponding to those sections are not applicable to them (N/A). Likewise, Ankara FV refused to share yearly realized traffic numbers, which is the reason the corresponding cell is N/A.

Because of their available infrastructure, all TSR FVs have rail and road transportation modes. Ankara FV only supports road transportation. Nevertheless, Ankara FV is the largest operational FV in Turkey. With its 700,000m^2 of area, it also has the largest capacity and number of employees. Amongst the FVs with available data, İstanbul-Halkalı FV has the largest amount of realized freight traffic with around 355,000 ton/year. It is worth noting that Ankara and İstanbul-Halkalı FVs are also the only FVs that have hosted tenants inside facilities. The typical freight of the FVs is generally raw material and industrial products.

Figure 4 Balıkesir FV

4.2 Case Study Results

When the TFVs are compared to the best practices abroad (three examples given in Table 2), there is a major difference in terms of size. Along with the operational, planned and under construction FVs (including the FV in Ankara), the average size for Turkish FVs is around 540,000 m^2. When the FVs in the EU and US are considered, the smallest FV with available information is Roissy-SOGARIS in France with 538,000 m^2. The establishment schemes for FVs also differ; in Turkey, current FVs are sole government or private investments. Hybrid investments (public-private ownership) are common worldwide.

Figure 5 Denizli FV

Figure 6 İstanbul-Halkalı FV

Table 1 Overview of FVs in Turkey, based on the responses to the interviews

	Ankara	**Balıkesir-Gökköy**	**Denizli-Kaklık**	**Eskişehir-Hasanbey**	**İstanbul-Halkalı**	**Kocaeli-Köseköy**	**Uşak**
Size (in m^2)	700k	211k	120k	540k	220k	340k (including the second stage)	140k
AVT † (trucks/year)	730k	4k	19k	14k	18k	33k	8,5k
FTC ‡ (tons/year)	7.74m	500k	1m	1m	3,65m	1,5m	240k
RFT § (tons/year)	N/A	42k	204k	176k	355k	346k	90k
Mode	Road	Rail, Road	Rail, Road	Rail, Road	Rail, Road	Rail, Road	Rail, Road
# of Tenants	300	N/A	N/A	N/A	4	N/A	N/A
# of Employees	4000	7	2	34	30	10	5
Date Visited	August 2017	December 2017	May 2017	March 2017	January 2018	April 2017	December 2017
FV Representative	FV Manager	FV Manager, FV Warehouse Manager	FV Manager, FV Warehouse Manager	FV Manager	FV Manager, FV Logistics Manager	FV Manager, FV Warehouse Manager	FV Manager
Types of goods transported*	(1), (2), (3), (4), (5), (6), (7), (8), (9), (10), (11), (12), (13), (14), (15), (16)	(1), (2), (7), (9), (10), (11), (13), (14), (16), (17), (18), (19), (20)	(3), (9), (17), (18), (19), (20)	(2), (4), (5), (7), (9), (10), (11), (16), (18), (20)	(1), (2), (4), (5) (6), (7), (9), (10), (11),(12), (13), (14), (15), (16)	(1), (2), (3), (4), (5), (6), (7), (9), (10), (11), (12), (13), (14), (15), (16)	(1), (13), (15), (17), (18), (20)

† Average Vehicle Traffic (trucks/year)
‡ Freight Traffic Capacity (tons/year)
§ Realized Freight Traffic (tons/year)
*Agricultural Vehicles (1), Animal and Herbal Products (2), Cement (3), Ceramic and Sanitaryware Products (4), Chemical Products (5), Clinker (6), Construction Material (7), Consumer Products (8), Flammable and Explosive Material (9), Food Products (10), Fuel (11), Gypsum (12), Iron and Steel Products (13), Military Cargo (14), Various Minerals (15), Pipes (16), Coal (17), Lumber (18), Marble (19), Sandstone (20)

In terms of sustainability and social equity, the authorities seem to believe the scale economy created by the FV would directly lead to economic and environmental sustainability and

social equity. FV management struggled to form a basis for performance evaluation due to the absence of performance metrics and certification related with the effects to environment. This can also create a situation where it is not possible for the authorities to compare different FVs. Nevertheless, in the following sections, focus is on the potential of the FV applications in Turkey and their potential benefits on different dimensions of sustainability, by making estimations using the data from the site surveys. The increase of intermodality in Turkey and the capacity utilization of FVs is the basis of assumptions on the potential benefits of FVs. The cases in which the FV organizations are properly established; how the base for coordination and collaboration and the necessary regulations and by-laws are set, and how producers and logistics service providers have access to FVs and they use these facilities are also considered.

Compared to their worldwide counterparts, the main differences of the Turkish FV applications are (1) their size, which is relatively small, (2) their investment structures, which depend on a sole public or private investment, (3) modal split, which is generally road/rail, and (4) the lack of infrastructure. Most importantly, the analysis given in Section 3 points out that none of the FVs in Turkey possesses a business process that enables coordination and collaboration. This is evident, since the relationships between the stakeholders of these facilities have limited relations with the FV administrations, involving only rental contracts (for warehouses and/or offices) and the usage of trains (in TSR FVs). However, there is no scheme that is designed for the stakeholders to collaborate or coordinate their actions under FV administrations' supervision.

This lack of coordination and collaboration is also reflected in the freight volumes for the TFVs. When the examples in Table 2 are considered, even for a relatively small FV, Centro de Transportes de Irun in Spain, there is a relatively larger amount of freight transportation. If the ton of freight transported/m^2 is compared with the TFVs, these three FVs average 1.79 ton/m^2, as opposed to 0.63 ton/m^2 for TFVs. The highest performance is by Denizli-Kaklık FV, which has typical freight consisting of coal, lumber, sandstone, cement, marble, and flammable/explosive materials.

Table 2 Selected FVs and respective freight volumes (Higgins et al., 2011)

Country	FV	Size (in m^2)	Realized Freight Transportation (in tons)	Available Transportation Modes
Italy	Interporto Bologna	4,269,433	4,027,000	Road, Rail
France	Roissy-SOGARIS	538,231	2,500,000	Road, Rail, Water in the vicinity
Spain	Centro de Transportes de Irun	400,639	2,800,000	Road, Rail in the vicinity, Water in the vicinity

Although Roissy-SOGARIS and Centro de Transportes de Irun have access to water transport; which can be considered as a reason for high tonnage, Interporto Bologna does not have such access. In addition, the products that are transported range from consumer electronics to raw materials; unlike the typical freight of TFVs, which is mainly bulk materials.

The main reason behind the high freight transportation volumes is the coordination and collaboration activities are being realized in these FVs (Higgins et al., 2011). Tenants have a predefined legal basis for their interaction with the each other and the FV administration. Thus, the FV administration acts as a coordinator among its users. This legal basis lets users conduct shared planning and usage of the FVs' infrastructure in harmony and exhibit collaborative action.

Public FVs in Turkey, which have lower freight traffic than their estimated capacity, persuade their users to create "block train" orders, in which a single user should at least supply 200 tons of freight. Below this amount, certain amount of penalties and increased price/km is applied. The rationale behind this policy is to cut the amount of material handling activities for trains and decrease the possible stops for a train to avoid maneuvers. This clearly does not lead the goods transported by the railways in Turkey to be diversified as in the FVs elsewhere. The reason is that the stakeholders of the TFVs tend to use railway transport only if there is bulk cargo to be transported.

The lack of coordination and collaboration also removes any chance of multiple users of a facility to come together and prepare a shared delivery. The average freight volume for a truck in Turkey is around 10 tons and requires nearly 20 trucks of freight at minimum to be able to use TSR's trains and facilities. Accumulating this much freight may not be realistic for a logistics service provider or a producer that deals with a time frame and service standards. Even if such collaboration is realized, because of the lack of a well-defined, systematic governance, shared planning, storage and the terms between the users are left out of the

control of the FV; the only legal connection between the FVs which host tenants under their roof and their tenants are the rental contracts for the usage of the facilities.

The users of the FVs must be subject to certain performance criteria which should be monitored by the FV administration and corrective action must be taken in case a certain performance metric cannot be satisfied. These corrective actions should include penalties in terms of monetary terms in order to create awareness for the firms. Government subsidies in terms of taxes for firms with high scores should also be considered. The weights of these metrics, along with the metrics themselves, are subject to change, since FVs are purposeful systems and they should address different problems in different regions of Turkey

Table 3 proposes such metrics for TFVs, which are not limited to those given in this study. The proposed performance metrics are classified in relation with the different dimensions of sustainability and the way they should be evaluated. First group of the classification consists of metrics related to economic sustainability; increase in freight transportation (1) in an efficient way (4) with increased modal split and collaboration (2-3). The second group relates to environmental sustainability with traffic and engine efficiency metrics (3-4) and less material and energy usage (1-2). Last group is related with social equity with increased investment in the region (4) and employment (1) with the split of sexes favoring women (3) which would result in increased welfare and decreased turnover for a peaceful work environment.

Table 3 Proposed performance metrics for Turkish FVs

	Economic Sustainability	**Target Evaluation**	**Period**	**#**	**Environmental Sustainability**	**Target Evaluation**	**Period**	**#**	**Social Equity**	**Target Evaluation**	**Period**
1	Amount of freight transported	Higher the Better	Monthly and Yearly	**1**	Amount of consumables used	Lower the better	Monthly and Yearly	**1**	Number of employees	Higher the better	Monthly and Yearly
2	Amount of freight transported in shared deliveries	Higher the Better	Monthly and Yearly	**2**	Energy usage (water and electricity)	Lower the better	Monthly and Yearly	**2**	Employee turnover ratio	Lower the better	Monthly and Yearly
3	Percentage of modal split	Higher the Better	Monthly and Yearly	**3**	Average age of truck fleet	Lower the better	Monthly and Yearly	**3**	Ratio of different genders amongst employees	Minimum 50% or favoring women	At all times
4	Freight transported per m^2	Higher the Better	Monthly and Yearly	**4**	Truck-km	Lower the better	Monthly and Yearly	**4**	Amount of infrastructure investment in the region	Higher the better	Yearly

4.2.1 Potential Benefits on Environmental Sustainability

One important potential benefit of FVs is the decrease in emissions, resulting from fewer hauls by truck. The collaboration activities in a FV would lead to the shared use of resources and this would reduce LTL (less-than-truckload) trips for a company. According to the data from the General Directorate of Highways, the total freight transported in Turkey in is 253.1 billion ton-km in 2016. The total vehicle-km value for the heavy and light duty vehicles, including all kinds of trucks used for freight transportation is 28.3 billion vehicle-km (General Directorate of Highways, 2017). These two figures indicate that on the average, 8.95 tons/truck is realized in freight transportation.

In comparison to this, a comprehensive study on the freight transportation activities on Turkish Highways that includes technicians, mathematicians, statisticians and administrative personnel, from a large sample of heavy-duty vehicles (67,205) which travel in separate regions of Turkey for freight transportation, the average freight number has been calculated as 10.6 tons/truck (General Directorate of Highways 2016). Hence, there is a minimum gap of 15.5% between an FTL (full truckload) and the average truck used for freight transportation in Turkey. This 15.5% should be considered as a minimum gap, since some of the trucks taken in the sample of the study were also empty.

As mentioned before, goods transport by road has an important negative impact to the environment in terms of emissions. The main emissions from a diesel engine are carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter. The average emissions of these by each Euro standard can be seen in Table 4.

When the average ages of the trucks operating in Turkey for freight transportation are analyzed, it is observed that 75% of all heavy vehicles with Turkish license plates and 95% of all heavy vehicles with non-Turkish license plates are manufactured after the year 2000. Even though there is a decrease in all emission types between years 1992-2000 (53% in carbon monoxide-CO, 40% in hydrocarbons-HC, 38% in nitric oxide and nitrogen dioxide-NOx and 84% in pollutant materials-PM), still there is a significant number of trucks (25% of all heavy vehicles) with high emissions.

The LTL deliveries can be decreased by a shared planning of trucks to the same end destination in case there is no special requirement for that delivery such as cooling, safety,

hazardous material, etc. At the same time, shared usage of the same train could be possible if separate firms plan together and make their corresponding train and wagon arrangements accordingly. This shared planning would be possible only if the coordination and collaboration is maintained between the tenants using the same FV. As depicted in the beginning of this section, current situation in the Turkish Supply Chain results an underutilization of at least 15% of the overall deliveries, which are conducted by heavy duty vehicles, 25% of which still possess high emission values.

Table 4 EU Emission Standards (g/km)*
* Source: http://www.transportpolicy.net/standard/eu-heavy-duty-emissions, Accessed 01 November 201

Tier	Date	CO	HC	NO_x	PM
Euro I	1992, <85 kW	4.5	1.1	8.0	0.612
	1992, >85 kW	4.5	0.25	8.0	0.36
Euro II	Oct 1996	4.0	1.1	7.0	0.25
	Oct 1998	4.0	1.1	7.0	0.15
Euro III	Oct 1999	1.0	0.25	2.0	0.02
	Oct 2000	2.1	0.66	5.0	0.10
Euro IV	Oct 2005	1.5	0.46	3.5	0.02
Euro V	Oct 2008	1.5	0.46	2.0	0.02
Euro VI	31 Dec 2013	1.5	0.13	0.4	0.01

TSR has efforts on converting the current locomotives from diesel to electrical ones, which means an increase of around 70% in horsepower. This would directly affect the amount of freight that can be transported on a train. In addition, electrification of the locomotives would mean a centralized energy source for the freight transportation activities, which is a more sustainable option compared to the decentralized energy usage options (Chiara et al., 2014). However, it has been observed that environmental acts have been neglected, since there are no concrete measures for assessment of environmental impact.

4.2.2 Potential Benefits on Economical Sustainability

The major potential benefit of FVs to economical sustainability lies underneath the economies of scale offered by the FVs and the capabilities in terms of increasing intermodal transportation. Whilst the stakeholders of the supply chain could benefit from this scale economy, there is also a chance to improve the performance of the Turkish economy, since the energy usage habits could change as well. During the interviews, it has been observed that

the effects to economical sustainability have been perceived as crucial for the interviewees for the future of FVs in Turkey.

When the cost figures for logistics activities in Turkey are analyzed, they can be grouped under five general categories as administrative, customer support and order management, stock keeping, storage, and transportation. When the distribution of the costs for freight transportation in Turkey is analyzed, as can be seen in Table 5, the majority of the costs (more than 80%) are due to storage, transportation, and stock keeping activities.

Table 5 Distribution of Logistics Costs for Turkey*, EU-28 [†] and US [‡]
Sources: *Tanyaş (2013), [+]EU Commission (2015) [†]U.S Department of Transportation (2002)

Country	Transportation (%)	Stock Keeping (%)	Storage (%)	Customer Support and Order Management (%)	Administration (%)
Turkey	47	23	19	6	5
EU-28	44	22	24	6	4
US	63	24	9	-	4

For the European Union countries (EU-28) and the US, the distribution of costs among various items is summarized in Table 5. EU-28 countries show a very similar distribution in logistics costs to Turkey, in that the majority (>80%) of the costs are due to storage, transportation and stock keeping activities. For the US, transportation costs have a much higher share than those of Turkey and EU-28, accounting for 63% of the overall logistics costs. The next highest cost figure is stock keeping costs.

In Turkey, transportation and storage costs, which, on the average, account for 66% of the overall logistics costs, are the areas where the FVs' broad functions, contemporary and value-added logistics services could be of substantial use. For an individual firm, the current conventional freight transportation scheme that requires multiple layers of transportation brings the requirement of different infrastructure investments and the regulations to run that operation in the designated area. FVs' warehousing and cargo divisioning, barcoding, palletizing, packaging/repackaging and labeling abilities and free trade zone opportunities offered to their tenants would have significant effects in terms of money and time by decreasing the resources (time and funds) spent on storage and transportation activities. This is because the usage of an FV would cut the burden of a firm of making a warehouse investment in a strategic location or having to make partial deliveries (and thus paying the fixed cost of freight transportation in each delivery). Coordination and collaboration inside an FV would bring together multiple firms that have a delivery to the same end destination

together. The shared warehouse usage means both decreased storage costs for the firms and higher utilization for the FV. The estimation for LTL freight transportation is valid for the economical sustainability, as in the case of environmental sustainability. The average low utilization of 85% in truck deliveries can be increased by full train deliveries and/or combined and turned into FTL deliveries.

Amongst these cost figures, administrative, customer support and order management, and stock keeping costs are currently beyond the reach of sphere of influence of FVs, since the current structure of FVs fails to aid companies in terms of these cost figures. The amount of stock is an outcome of firms' planning efforts. The total capital bound by the inventories would be the same in any case. Administrative and customer support costs are not the figures where a significant decrease would be expected; because even if the current structure of the FVs in Turkey is to change, the amount of effort spent on these areas are related with organizational schemes and marketing strategies of the firms.

Subsequently, intermodality capability of the FVs would have potential effects on the addiction to energy. As shown in Figure 7, Turkey has been dependent on imported energy for the past decades. The energy production has increased by 38% from 1990 to 2016, whereas energy consumption has increased by 157%. Much of this increase is also related to the increase in the industrialization and the sectoral shift in Turkey. By the end of 2016, energy consumption is nearly four times of energy production with 136.2-thousand-ton petroleum equivalent units (TTPEU). Around 20% of this energy consumption in Turkey (26.8 TTPEU) is related to the energy spent in transportation (freight and people combined).

Freight transportation affects energy consumption, and thus energy production, in three ways. First, most of the freight transportation is dependent of imported diesel fuel. Secondly, as also given in Figure 1, around 90% of the freight is transported on highways by trucks (including light duty vehicles such as pickup trucks and heavy duty vehicles), which are run by diesel fuel. Lastly, when the vehicle-km numbers for Turkey are considered, around 24% of the overall vehicle-km is a result of truck movements. Consequently, the usage of FVs may lead to more efficient energy consumption by preparing block trains and/or more FTL deliveries. In turn, this would result in a significant decrease in the energy consumption in Turkey, eventually resulting in a decreased dependency on energy imports.

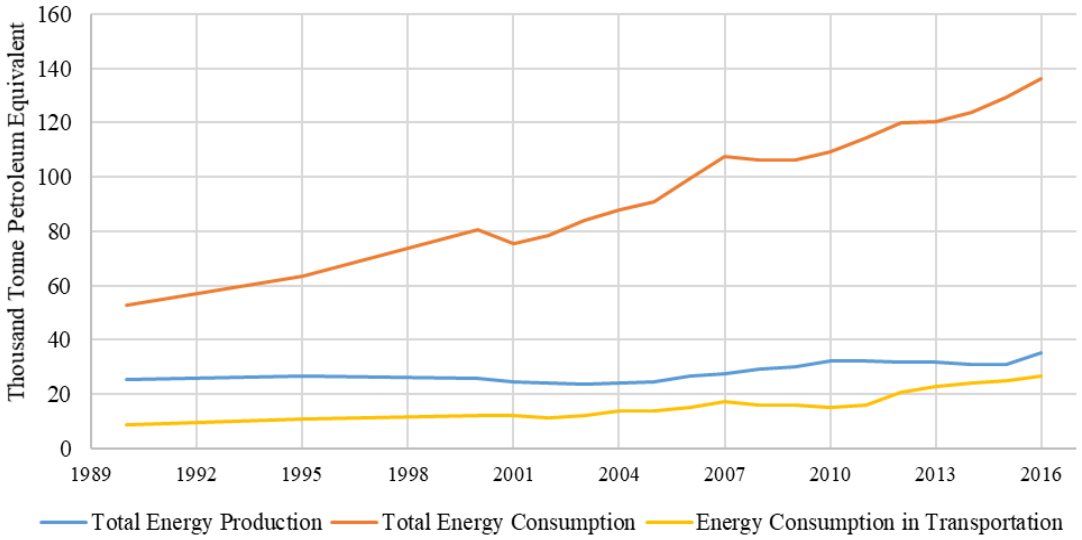

Figure 7 Total energy production, consumption and energy consumption in transportation in Turkey*

* Source: Republic of Turkey Ministry of Energy and Natural Resources (2016)

4.2.3 Potential Benefits on Social Equity

Potential benefits of FVs on social equity are by far the hardest and most controversial amongst the other dimensions of sustainability. This is because the social equity concept itself is open to deep discussion and a straightforward assessment measure is not available. The focus is generally on the job creation abilities of FVs. Even in Turkey, where proper grounds for coordination and collaboration are still missing and the FV utilizations are low (Table 1), the existence of FVs results in new job opportunities.

It is important to point out that none of the FVs in Turkey uses a metric for jobs created. However, Table 6 shows the importance of this issue for the administrators. Only for the Uşak FV, due to its unique structure, this question was not applicable. However, for the public FVs, it was pointed out that there has not been any formal planning for jobs to be created in the vicinity of the facilities. On the other hand, the Ankara FV administration forecasts a certain number of jobs to be created, since the number of offered services inside the FV and the personnel required are well-defined.

Table 6 FV administrations' answers for Question 3 in Table 9

FV	Importance of increase in employment
Ankara	Very important
Balıkesir-Gökköy	Semi important
Denizli-Kaklık	Important
Eskişehir-Hasanbey	Very Important
İstanbul-Halkalı	Very Important
Kocaeli-Köseköy	Very important
Uşak	N/A

If logistics activities are realized within the FV, an increase in the employment in the settlements of any size (cities, villages or towns) is inevitable, since the firms need to conduct material handling activities by their own means, thereby creating demand for available work force. Currently, the new jobs created after the establishment of FVs can be grouped into two as those (i) directly created inside facility by the FV governance (be that TSR or the private sector in the Ankara FV case) to accommodate the increased business volume, and (ii) supporting the users of the FV with material handling activities. Overall, the potential new jobs in the first group can be classified as administrative positions and services (restaurants, repair shops, facilities for accommodation and healthcare offered to users of the FV), whereas jobs created in the second group as the rental of material handling vehicles (forklifts, cranes, etc.) and blue collar jobs for loading/unloading operations and services (if not applicable inside the FV) such as restaurants, repair shops, facilities for accommodation offered to users of the FV.

When different regions are considered, income inequality is apparent. Table 7 shows the gap; as the richest region having a GDP per capita more than three times of the poorest region. The regions used in this graph are NUTS (Nomenclature of Units for Territorial Statistics) regions that are used by EUROSTAT; the responsible body for statistic for EU and candidate countries.

Table 7 GDP per capita for different regions in Turkey (EUROSTAT, 2016)

Region	GDP per capita 2017 (in €)	% with respect to EU-28 average
İstanbul Region	25,500	82.5
East Marmara Region	23,300	77
West Anatolia Region	20,300	67

Region	GDP per capita 2017 (in €)	% with respect to EU-28 average
West Marmara Region	19,600	65
Aegean Region	18,300	60
Mediterranean Region	14,850	49
West Black Sea Region	13,000	43
Central Anatolia Region	12,400	40
East Black Sea Region	11,700	39
Northeast Anatolia Region	9,100	31
Southeast Anatolia Region	8,500	28
Central East Anatolia Region	8,050	26.5

When the FV applications in these regions with the GDP per capita in decreasing order are analyzed, the situation is as shown in Table 8.

Currently, out of the eight operational FVs, seven are placed in the top five regions in terms of GDP per capita and the establishment of such facilities to the regions with higher GDP figures may be viewed as a source of inequity itself. However, this is mainly because the current facilities are placed in regions with higher industrial output and/or locations with better coverage.

Table 8 FVs in different NUTS-level regions of Turkey

Region (NUTS level-1)	Region (NUTS level-2)	Region (NUTS level-3)	Number of FVs
İstanbul Region	İstanbul Subregion	İstanbul Province	2 (1 operational, 1 planned)
East Marmara Region	Bursa Subregion	Eskişehir Province	1 (operational)
		Bilecik Province	1 (under construction)
	Kocaeli Subregion	Kocaeli Province	1 (operational)
West Anatolia Region	Ankara Subregion	Ankara Province	1 (operational)
	Konya Subregion	Konya Province	1 (planned)
West Marmara Region	Balıkesir Subregion	Balıkesir Province	1 (operational)
Aegean Region	İzmir Subregion	İzmir Province	1 (planned)
	Aydın Subregion	Denizli Province	1 (operational)
	Manisa Subregion	Uşak Province	1 (operational)
Mediterranean Region	Adana Subregion	Mersin Province	1 (under construction)
	Hatay Subregion	Kahramanmaraş Province	1 (planned)
West Black Sea Region	Samsun Subregion	Samsun Province	1 (operational)
Central Anatolia Region	Kayseri Subregion	Sivas Province	1 (planned)
East Black Sea Region	-	-	-
Northeast Anatolia Region	Erzurum Subregion	Erzurum Province	1 (under construction)
	Ağrı Subregion	Kars Province	1 (planned)

Region (NUTS level-1)	Region (NUTS level-2)	Region (NUTS level-3)	Number of FVs
Southeast Anatolia Region	Mardin Subregion	Mardin Province	1 (under construction)
Central East Anatolia Region	Van Subregion	Bitlis Province	1 (planned)
		Hakkâri Province	1 (planned)

With the current modal split of Turkey heavily favoring highways and as a candidate country for EU, the employment numbers in Table 8 are far from satisfactory. Using the EU-28 as a benchmark where the railway usage is around four times of that in Turkey (Figure 1), even a small change in the percentage of the modal split with the usage of FVs should be expected to result in significant increases in employment numbers.

The planned FVs and FVs under construction are spread along the entire country by the TSR; covering all different regions except East Black Sea Region. This approach of the TSR is likely to increase the employment levels at least with the formation of small-sized establishments to support the FVs in terms of social services and the material handling activities.

5. A SWOT Analysis of Turkish FVs

A SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis is presented in this section to address the current condition the FVs in Turkey and to interpret their future. SWOT analysis is a strategic decision-making method for strategic planning and management (Gürel et al., 2017). The merit of this type of analysis lies in giving a synthesized view of the current

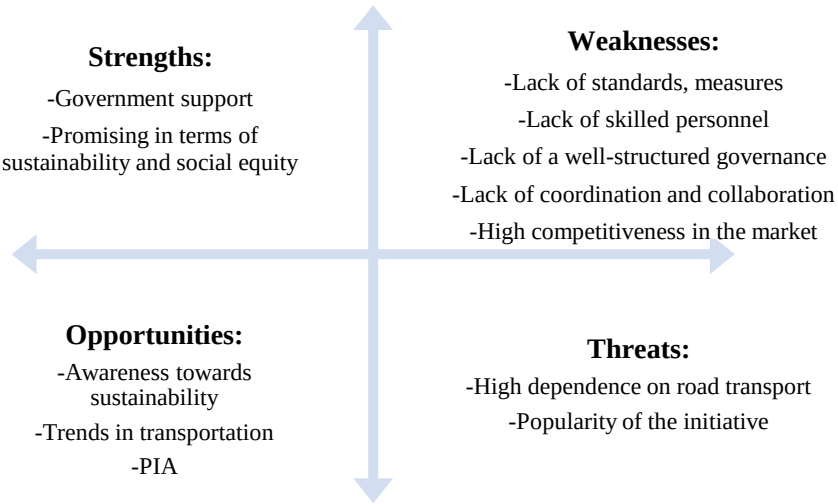

Figure 8 A SWOT analysis for Turkish FVs

situation in complex decision-making environments. The motivation behind the SWOT analysis in this study is to point out the necessary development areas for Turkish FVs, benefit from its simplicity (Ghazinoory et al., 2011) to quickly aid decision makers and help improve their effectiveness this way. Since SWOT the process includes the agreed outputs of different individuals (Hill et al, 1997) it is crucial to note here that the factors are not the sole observations of the researchers. Instead they appeared as a joint effort of the FV managers and the researchers and the factors evolved during the interviews made in site visits.As shown in Figure 8, TFVs have relative strengths in two major aspects. Although there is a private FV, the majority of the FVs are government initiatives. This results in a privileged position for the FVs in terms of infrastructure investments and gives them an increased chance of promotion. The importance of such endowments has also been underlined by Porter (2009). Most importantly, FVs facilitate sustainability in all three dimensions of sustainability, in that they decrease emissions, help respond to ever increasing energy prices, and act as business generators by creating direct and indirect jobs in their vicinity.

Since SWOT analysis is a tool that helps improve decision making while reducing magnitude of information (Prasad et al. 2018), it would be of great aid to practitioners in Turkey. Because the analysis provides a basic framework for the practitioners and can help authorities to turn threats and weaknesses in to opportunities. As depicted by Bell et al. (2016), SWOT analysis is integrative that it exposes unseen relationships. Here, if the current strategy is evolved with a sustainability point of view, following the trends in transportation (formation of FVs) then, there lies the possibility of eradicating all of the current threats since modal split will change (favoring road transportation less) and the initiative would become more popular with new job opportunities.

The weaknesses of TFVs include lack of standards, skilled personnel, well-structured governance, and coordination and collaboration. It has been observed in the site visits that the FVs in Turkey do not have any well-structured performance metrics for their operations. Interestingly, it has also been observed in these visits that FV management lacks an announced vision, strategy and road maps for the operations. Without performance metrics, it becomes hard for FV management to run and improve the system. The closure of the occupational schools for railways might be a major cause for the lack of skilled personnel. To cope with the ever-increasing competitiveness in the freight transportation market, skilled

personnel is indispensable for FVs. Similar weaknesses about personnel has also been noted in a different developing country by Nguyen et al. (2016).

The first opportunity for the TFVs lies in the increasing awareness towards sustainability and social equity. If a perception for the capabilities of FVs can be created in the public opinion, this would increase the popularity of these clusters and result in increased investments from government and public initiatives. Another opportunity is the current trend in the transportation sector. According to Speranza (2018), transportation sector is moving toward a systematic, collaborative and dynamic direction. With their capabilities, FVs are necessary facilities for moving toward these directions. As will be discussed in the following section, FVs allow possible accommodation to Physical Internet Applications (PIA). PIA, which are promising for a breakthrough soon, are a crucial opportunity for FVs. If suitable integration can be achieved, then it can be expected that nearly all weaknesses can be overcome. Since PIA demand openness and information sharing; well defined governance, performance measurement, and skilled personnel will become mandatory for any player in the sector. From this point of view, this is both a threat and an opportunity at the same time, because if a suitable environment for PIA cannot be achieved by the FVs, this might have a devastating affect for these cluster; pushing them out of the competition.

Lastly, the two identified threats towards TFVs are the increasing popularity of passenger transportation and the high dependence of freight transportation on trucks. Railways are still developing in the eastern parts of the country and the popular approach is towards passenger transportation because of its higher individual impact. This is a threat for TFVs, since it may result in altering freight transportation investments and/or projects. Even without this alteration, since current railway infrastructure is not capable of spanning the whole country (although there are still ongoing FV projects), there is high dependence on freight transportation by road; which stands as a threat towards FVs as it decreases their usage.

When compared to an example in the literature regarding Lithuanian FVs, Juozapaitis et al. (2017) provide a SWOT analysis for logistics clusters; underlining that the main strength of a logistics cluster as its geographical location. Apart from this, it is worth noticing that the weaknesses such as the lack of legal regulations, technology, political backing, opportunities including use of sustainable fuels, and threats, such as the negative attitude towards LC establishment in Lithuania are somewhat similar to those for Turkey.

6. Future of Turkish FVs

The future of TFVs lies in finding appropriate answers to overcome the threats and weaknesses given in Section 5. One such promising answer is PIA.

The urge for starting the Physical Internet Initiative is parallel to that of establishing FVs; the way physical objects are handled is no longer efficient or sustainable, neither economically, environmentally, or socially (Montreuil, 2010 and 2011). PIA have the potential to play a crucial role in the future of FVs by enabling the interaction between stakeholders in a supply chain more than ever before by its innovative approach. Its basic idea is to have a similar topology in material handling activities as in the internet's virtual world, namely *interconnectivity* and *encapsulation* properties of the transportation of data in the virtual internet.

PIA aim to eradicate the burden from current applications and propose a packaging where there are a limited number of modular containers which would fit in each other perfectly, resulting in fully utilized containers. These *π containers* also store precise information about themselves to be acknowledged universally. Anyone with this information is able to reach everything to be known about that container.

This containerization is followed by advances in material handling applications in which the effort for transporting these containers is minimized. As opposed to racks, containers can be stored as in ports which eases handling and decrease the need for complex storage systems. Since the containers are unimodular, the facilities previously dedicated to a single user no longer need to be so and can serve as a hub in the supply chain. Lastly, there is no need for the freight to be stuck at a single position, since there is a certain transportation option for it on its direction. Since unimodular containers can fit any such option, freight will always be moving towards its destination.

This innovation is dependent on advanced infrastructure and information sharing between the stakeholders of the supply chains. Like the Internet, information sharing system should be open and connected, as opposed to today's closed systems. When the coordination and collaboration capabilities of the FVs are considered, these concepts can surely be enhanced by the unimodular π containers and open information sharing of PIA. This is because the PIA let stakeholders in a supply chain use standard measures, procedures and infrastructure while conducting their operations.

It is worth noting here that in contrast to the centralization focus of a FV, PIA tend to decentralize freight transportation. For social sustainability, it is shown that PIA facilities significantly decrease the effects of shift work and lead to a decrease in mileages (Fazili et al., 2017). However, there may be lost jobs because of the vanished need for material handling. Furthermore, because of the conventional paradigms in Turkey and most of the developing countries, majority of the work force in the logistics industry may have problems accommodating to knowledge sharing required by the PIA. Data transfer maybe troublesome for Turkey at first; since an advanced information technology infrastructure is required. Nevertheless, as Montreuil (2011) states, PIA are visionary and open to development and enhancement, and it may evolve to fulfil different needs (Baydar et al., 2017). PIA themselves may create the solutions for such problems with its aid in economical sustainability, resulting in higher infrastructure and education investments from the stakeholders of the supply chain for both white and blue-collar personnel.

For Turkey, PIA are a promising area for FVs. Albeit the infrastructure needs and the vision to embrace the paradigms of PIA, it may help the country catch up with the developed world in the logistics sector. PIA are important, because they would push the logistics sector in to fully integrate with higher standards than today (Schwab et al. 2015). Furthermore, instead of covering longer distances and making fewer deliveries, trucks working in freight transportation would face an increased number of deliveries, which would bring increased collaboration, business volume and decreased lead times (Fazili et al., 2017). If PIA are to take place in Turkey, the necessity of a workforce with higher skills would rise the demand from the logistics sector for this new personnel type; resulting in higher skilled individuals (at least in the logistics sector) than today and the institutions to train them. The chances for catching this new trend is still alive and there is still time for the stakeholders of the Turkish supply chain to learn, understand and embrace this new era.

7. Conclusions and Potential Research Directions

In this study, the potential benefits of TFVs on sustainability and social equity are analyzed. The lack of value adding work and the data for TFVs led to the necessity of site visits to operational FVs and a case study approach. As a result, a broader view from a different paradigm is given for TFVs; placing them in the supply chain as a special set of LCs.

Seven site visits have been realized to operational TFVs. It has been observed that the current status of TFVs does not comply with the definition of a FV, since there is very little coordination and collaboration and the services are very limited. In terms of size and business volumes, FVs are relatively smaller and under-utilized compared to the selected counterparts in Europe and North America. When the locations of the FVs are considered, two of them, Uşak and İstanbul-Halkalı, are already surrounded by residential buildings and by no means divert freight transportation activities out of the city perimeters. Currently, neither performance metrics nor legal status is present for the FVs to lead to proper evaluation of these facilities. Besides, since the investments and developments in passenger transportation are more popular in Turkey, it is evident that the focus on FVs has decreased which is a reason for the decreased focus on these facilities.

Most importantly, TFVs fail to fulfill coordination and collaboration. For different dimensions of sustainability, FVs still possess a potential for Turkey if their usage is increased, and if the stakeholders act together in shared planning, shared usage of capacity and infrastructure and share knowledge. Only then can the positive effects to sustainability be achieved.

In terms of economical sustainability, it has been observed that namely transportation and storage costs in Turkey can be decreased with FV usage. This is because TSR FVs are intermodal terminals which all have railroad connections, which provide more a means for cost-efficient transportation. For environmental sustainability, significant decreases in emissions can be achieved with the increased number of FTL deliveries and the usage of TSR trains, which will become fully electrified in the following years. FVs also can act as a tool that can be used for increasing employment in regions they are established. It is vital to remark again that these benefits are possible only if the current structural properties of FVs are changed; creating and enhancing the coordination and collaboration between the FV users.

PIA appear to be prominent in terms of aiding the FVs in achieving all different dimensions of sustainability. If a move towards PIA is made, then the logistics industry standards must change towards a more sustainable way of conducting business. PIA demand for a highly developed infrastructure and skilled workforce. This by itself leads to a more sustainable and equitable future for Turkey.

This paper also aims to help practitioners in the decision-making steps of planning or managing FVs with the comprehensive SWOT analysis to address the current situation of FVs in Turkey and gives guidance for a proper strategy formulation for the authorities in order to overcome weaknesses and eradicate threats. Performance metrics and data from sites are offered, which are a great aid for future researchers in this area.

One limitation faced in this study is the absence of data for the FVs in Turkey for proper comparison. A joint work including the academia, government and the industry would be of importance to eradicate any limits related to gathering data. For future research, industry should be incorporated in the context of FVs. Their perceptions of the concept of FV, the effects of FVs on sustainability, and the connection to PIA is an interesting research direction. Measuring the degree of collaboration and coordination between the stakeholders of FVs in Turkey and in other FVs in the world poses another important direction. Lastly, it would be interesting to measure the metrics proposed in the current study and analyze them, although this would require significant effort as such measurements are not readily in practice.

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APPENDIX

Table 9 Question form used in site visits

	Describe the criteria used for determining facility	
m (MIS)	*Write down the type of MIS currently used in the facility and its integration with th*	
	Write down the number of personnel working the facility that f	
	Elementary School – Highschool Graduate	
	College Gradute	
	0-5 years	
	5 years or more	
	Lives out side of town	
	Lives in the same city as the facility	
	Write down the names and activity start dates and the type of contract(s)	
	Activity Start Date	Ty
	Write down the information used for facility ac	
	Model year	
	Write down the measured fields in which the facility effects the environment alon	
Field		

Table 9 Question form used in site

	Write down the quality and/ or environmental certificates the facilitiy h		
?	*Related Authority*		*Las*
e	*Write down facility's current business vol*		
ances + Exits)			
ths (City-Province)			
dled			
aces + Exits)			
	Rank the below for their importance to y		
	Less Important	**Semi Important**	**Ir**
nent			
ion			
bles			
ity			