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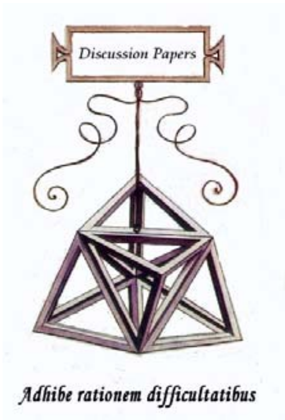

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A cost – transit time choice model: monomodality vs. intermodality.

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Discussion Paper
n. 47

Alga Danila Foschi

A cost – transit time choice model: monomodality vs. intermodality

Abstract

A cost – transit time choice model: monomodality vs. intermodality.

The Mediterranean and Italy are scenarios suited to consolidation of hub and spokes networks. The question is: are terrestrial spokes serious competitors of maritime spokes?

This paper highlights the limits of the Italian rail system and favourably considers the development of short.sea-shipping.

In this context, the final user's point of view may be crucial.

We therefore propose a 'cost-transit time choice model' for choice of the best intermodality for the final user, considering the differences in unit costs, transit time, final user's opportunity costs and the value of commodities transported in the container.

The model is tested on several legs from the Gioa Tauro hub port to various Italian destinations.

If suitably complicated, the model can be utilized for regulatory purposes.

Classificazione JEL: L100

Keywords: unit transport costs, transit time, choice model, feeder, intermodal, immobilisation cost, Mediterranean, Italy

3. Application to transport of various types of freight, differing in volume and value

A COST - TRANSIT TIME CHOICE MODEL:
MONOMODALITY VS.VS. INTERMODALITY 1

1. Reference scenario: Hub and spokes networks, longitudinal and transverse intermodality, strengths and weaknesses of the container transport industry in Italy

1.1. Transhipment

In the study entitled "The impact of hub and spokes networks in the Mediterranean peculiarity" by Cazzaniga Francesetti and Foschi (2002 a) about the better organization of container shipping services in the Mediterranean, it can be seen that transport services organized according to hub & spoke systems are advantageous in terms of unit cost of transport compared with the unit cost of point to point services.

This study

- shows the interest of the large liner shipping companies in using post – Panamax ships on the routes that cross the Mediterranean in view of the existence of scale economies linked to their increasing size;

- notes that there are very few ports in the Mediterranean that these large ships can call in at, both on account of sea depth, and because of diversion from the main route;

- constructs a model that compares unit costs of point to point services with those of hub and spokes network services comparing fleets of various sizes (mother ships from 4000 to 10000 TEU and feeder ships from 1000 to 2500 TEU) on the Western Mediterranean – Far East route The results of the model simulations

- indicate that the unit costs are lower when transport services are organized by hub and spokes systems;

- show that the advantage increases between 4000 and 5000 TEU then starting to diminish to almost disappear around 10000 TEU;

- emphasize the importance of technology used in the transhipment ports (number and productivity of cranes), the impact of variable transhipment costs on the unit cost and of the quantity of containers unloaded onto the hub port (which, for example, is what made Contship choose Gioia Tauro in Malta);

- emphasize the advantage for liner shipping companies to control terminals in hub ports so as to ensure more efficient times and lower costs in the movement of containers (strategic alliances and vertical integration between liner shipping companies and terminal companies).

Tailored to the Mediterranean, the study confirms the results obtained in "A new economic evaluation on the hub port versus multiport strategy" by Baird (2001) that refers to an itinerary that goes from ports of the Northern Range (from Hamburg to Le Havre) to the Far East.

In addition to the advantages in terms of cost the establishment of this logistic organization on shipping routes encourages the growth of local shipping services, both in terms of feeder service (maritime spoke), short sea shipping, and coasting trade.

The creation of large specialized transhipment ports (for example offshore transhipment hubs (Baird, 2002 – Foschi, 2003) attracts large volumes of containers from ocean liners using the main pendulum routes, by also causing a considerable contribution to the inclusion of small – medium ports (national and regional gateways) in the circuit of international traffic (Forte, 1999 – Baird, 1997 – Haralambides et al., 2000) and the increase of local traffic with consequent dimensional growth of the large liner shipping companies themselves (to which mention should be made of both the ocean liners and dedicated feeders), and those that manage the common feeders.

The Mediterranean in general, and the Western Mediterranean in particular, has benefited greatly from this particular organization. With the creation of specialized hub ports such as Algesiras, Marsaxllok, Gioia Tauro, Taranto, Port Said and with the expansion of other gateway ports, the volumes of containers dealt with in Southern Range ports as a result of connections with extra-Mediterranean areas, have increased greatly, taking traffic away from the Northern Range ports (Rotterdam, Hamburg, Antwerp, Bremen) for containers bound for Southern Central Europe (Switzerland, Bavaria, Austria) and to that of the South East (Hungary, Czech Republic, Slovakia, Bohemia, etc), by means of the use of different methods.

1.2. Intermodality and door to door.

On account of the special geographic position and efficiency of transhipment terminals and the good longitudinal and transversal connection potential with the above-mentioned markets, Gioia Tauro and Taranto are the ports predicted to become the Mediterranean super hubs, Gioia Tauro for the Western Mediterranean by means of the Tyrrhenian corridor and Taranto for the Eastern Mediterranean, using the Adriatic corridor (if the analysis made by Wijlnost and Waals (2001) for Gioia Tauro is also extended to Taranto).

Containers handled in these ports can continue their journey north either by using the feeder ships to the gateway ports closest to the final freight destination (Genoa for Milan; La Spezia for Munich in Bavaria; Trieste for Vienna; etc)[1], or by using intermodal (road - rail) systems, but especially by using block trains to cover inland areas with heavier road traffic[2].

The analysis of transport times, often the foundation of claims in favour of Southern Range ports compared with those of the Northern Range, clearly shows that once the ship has arrived in the Western Mediterranean times of delivery to the final destination are from 8 to 14 days less if delivery occurs using land – maritime (spoke) intermodality rather than the monomodal one (Albertini, 2000).

It must be stressed that this comparison was intentionally carried out on rail and not road modality, independently of the unquestionable greater speed of road transport compared with that of rail. By now many studies show that road transport is preferable to rail for within 150 to 200 kilometers (TTT, 2002). Apart from the greater cost, beyond this distance it must be born in mind that the problem of traffic congestion of the main stretches of European and Italian motorways is such that, even if road transport were preferable, it would in any case be discounted.

Europe is very sensitive to the various problems connected to the sustainable growth of transport. Preference is already beginning to be given to reliable transport time, monitoring of freight and just in time deliveries. An example of this is the great increase of river transport that occurs between the ports of Rotterdam and Antwerp to Basle that is usually considered as the land hub of Europe being at the intersection of important water and land routes.

Therefore, while in some areas, as in Italy, resort to internal waterways (rivers and canals) is probably not feasible, resort to trains must surely exceed that of road transport in order to reduce external costs that society must bear. Unfortunately rail transport still suffers from many bottle-necks (see § 2.), that slow productivity (Cazzaniga Francesetti – Foschi, 2002 b; Italfer, 2000 – Forte, 1999), and that explain the resort to modality on road and to support that

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[1] We will use the terminology "via feeder" to indicate the following type of:maritime – terrestrial intermodality : 'feeder – train – truck '

[2] We will use the terminology "via intermodal" to indicate the following type of exclusively terrestrial intermodality: 'train- truck'

the EU gives to short sea shipping implementation (COM, 1995; Musso, **1987 etc**; Forte, 1978 **etc.**)

The large liner shipping companies (see for example MSC, Maersk – Sealan, P&O N) have for a long time resorted to door to door rather than to port to port. The reasons are to be found in the need to increase their demand that in the meanwhile has become increasingly demanding and typified by brand-oriented customers (Cazzaniga Francesetti – Foschi, 2000); to some extent they are seeking to increase their demand by also diversifying their services. It is true that freight forwarders may perform the same global function, that is, to give final clients the impression of dealing with an 'only one company' by dealing with the entire chain of transport, or by intervening on land route, but recently however the habit of presenting the company as an 'only one' has been used by shipping companies as a market penetration strategy.

In this type of strategy, what sort of service could be more cost effective for a liner shipping company? The expansion of sea – sea connection, or integrated land – sea transport? Or rather, to use feeder ships on maritime spokes, or block trains on terrestrial ones?

This is the problem that this study seeks to address by using the construction of a model for deciding on a particular choice; in this text the model will be defined as the 'cost-time transit model' which aims to describe the conditions under which the terrestrial spokes can substitute the maritime spokes (i.e. transshipment hub port-block train, rather than transshipment hub port –feeder vessels – block train) and viceversa.

The model will be implemented by considering trains, or feeder ships departing from Gioia Tauro to the final market of north Italy.

1.3. "Bottle necks" in the Italian and European rail system for container transport.

The inadequate condition of the Italian and European railway network for freight transport has been analyzed for almost a decade and it has often been pointed to as being the cause of excessive development, from the viewpoint of environmental sustainability, of road transport. Obviously, at least in the case of Italy, there are also other explanations linked to the interest of the policy maker in supporting the growth of the motor industry in the country and, therefore, in this instance the development of freight transport by road might also be explained by this choice of industrial policy. But it is undeniable that in a logistic system that increasingly aims at speed, safety and punctuality, rail transport is outmoded. The "bottle-necks"- that the European Union call attention to in the white book "European Transport Policy up to 2010" (2002) - existing in all rail transport sectors become even more evident in the case of combined transport. This happens even in the north west of Europe where the rail network is better developed, around the important port systems of Rotterdam and Antwerp. In these areas rail transport is even an important substitute for barge transport where there are always slots available and punctuality of loading and unloading is always guaranteed (Cisco, 2003). Indeed the large freight forwarders complain that even on essential routes, such as from Rotterdam to Basle, the most important European intermodal hub center, there are no more than two trains a day available.

In "Mediterranean versus Northern range ports" by Cazzaniga Francesetti – Foschi (2002 b) the main weaknesses of the rail network are listed in the following points: "………, absence of distinction between ownership of the infrastructure, of the traction and the services, inadequate investment, infrastructural weakness, excess manpower and high prices, gauge incompatibilities, lengthy journey times,………" In the same article it is emphasized how the lines of intervention put forward by the European Union, that should have produced the first important, visible results starting in 2001 were in fact ignored. Indeed: "….in 1998 the European Commission proposed a common pricing framework for use of infrastructures, including roads. This agreement was due to come into force in 2001, but so far it has not been implemented and nothing has been done, as is also the case for all Community policies designed to shift traffic from roads to other "modes of transport"

In "Future of hub – and – spokes systems in liner shipping" by Haralambides et al. (2000) the work of the E.U. was emphasized "the existing inefficiences and discordances" towards "a more balanced model development of transport".

With special reference to Italy, for example the Project ARC SUD Ferrovie, a study on the railways funded by the EU in the framework of the Interreg II C programmes, underlined the urgent need to modernize the Italian lines, dwelling in particular on the congestion affecting certain legs in Northern Italy (eg. the Ventimiglia-Genoa line) as well as the terrible bottle-necks affecting the lines in Southern Italy. As an example of the latter, the case of the Rome-Reggio Calabriua line was cited: this line is extremely important for freight transport as it is the line that connects with Gioia Tauro, at the junction of Battipaglia.

1.4. Further paragraphs.

Within the reference scenario delineated in §§ 1,1, 1.2, 1.3 we build a model for choice between utilization of the "via feeder" modality and the "via intermodal" modality (see notes 1 and 2), and we evaluate their possible use as regulations in terms of industrial transport policies. In particular: the second paragraph is about the hypotheses of the model; paragraph three simulates the results of the model applied to transport of diversified freight, i.e. freight differing in volume and value (examples: notebook PCs, desktop PCs, snowboard boots, Nike trainers, Barbie dolls); paragraph 4 presents a generalization of the model and in paragraph 5 some conclusions are drawn.

The calculation that is made below is based on real times of current transport (given the state of available infrastructures) but does **not** take into consideration any queuing problems or traffic congestion from which delays could result in the standard of route planned by the suppliers of rail service (Italfer in the Italian case).

2. *The model*

2.1. Unit transport costs and transit time on some legs of the Gioia Tauro leg to final destinations in Northern Italy.

2.2.1 *Legs*

The legs considered are:

TABLE 1: LEGS CONSIDERED FOR THE PURPOSES OF THE ANALYSIS OF THE ADVANTAGEOUSNESS OF EITHER THE TWO ALTERNATIVES: 'VIA FEEDER' - "VIA INTERMODAL"

VIA FEEDER	VIA INTERMODAL
Gioia Tauro – Padua (via Trieste)	Gioia Tauro - Padua
Gioia Tauro – Milan (via Genua)	Gioia Tauro - Milan
Gioia Tauro – Milan (via La Spezia)	Gioia Tauro - Milan
Gioia Tauro – Modena (via Genua)	Gioia Tauro - Modena
Gioia Tauro – Bologna (via Genua)	Gioia Tauro - Bologna
Gioia Tauro – Naples (via Salerno)	Gioia Tauro - Napoli
Gioia Tauro - Catania	Gioia Tauro - Catania

FIGURE 1: THE HUB PORT OF GIOA TAURO; THE PORTS OF CATANIA, SALERNO, GENOA, LA SPEZIA AND TRIESTE; THE FINAL DESTINATIONS OF PADUA, MILAN, MODENA, BOLOGNA, NAPLES AND CATANIA

2.2.2. *Transit time*

Table 2, shown here below in the text, compared transit time in the case of containers that continue their journey from Gioia Tauro via feeder or via intermodal

TABLE 2 : COMPARISON OF TRANSIT TIME - FEEDER AND RAIL CONNECTION (in hours)

GIOIA TAURO – PADUA (via Trieste)			
Discharge mother vessel to load	98	Discharge mother vessel to load rail	72
Feedering from MCT to La Spezia	120	Shuttle+dwell time in hub	24
Feeder vessel discharge to exit train	96	Rail transit to inland terminal	27
Local delivery	5	Discharge train to exit gate	5
Total transit time	**319**	**Total transit time**	**128**
GIOIA TAURO – MILAN (via La Spezia)			
Discharge mother vessel to load	98	Discharge mother vessel to load rail	72
Feedering from MCT to La Spezia	108	Shuttle+dwell time in hub	24
Feeder vessel discharge to exit train	120	Rail transit to inland terminal	25
Local delivery	6	Discharge train to exit gate	5
Total transit time	**332**	**Total transit time**	**126**
GIOIA TAURO – MILAN (via Genoa)			
Discharge mother vessel to load	74	Discharge mother vessel to load rail	72
Feedering from MCT to Genova	120	Shuttle+dwell time in hub	24
Feeder vessel discharge to exit train	96	Rail transit to inland terminal	20
Local delivery	6	Discharge train to exit gate	5
Total transit time	**296**	**Total transit time**	**121**
GIOIA TAURO – MODENA (via Genoa)			
Discharge mother vessel to load	74	Discharge mother vessel to load rail	72
Feedering from MCT to Genova	120	Shuttle+dwell time in hub	24
Feeder vessel discharge to exit train	96	Rail transit to inland terminal	20
Local delivery	4	Discharge train to exit gate	5
Total transit time	**294**	**Total transit time**	**121**
GIOIA TAURO – BOLOGNA (via Genoa)			
Discharge mother vessel to load	74	Discharge mother vessel to load rail	72
Feedering from MCT to Genova	120	Shuttle+dwell time in hub	24
Feeder vessel discharge to exit train	96	Rail transit to inland terminal	20
Local delivery	6	Discharge train to exit gate	5
Total transit time	**296**	**Total transit time**	**121**
GIOIA TAURO – NAPLES (via Salerno)			
Discharge mother vessel to load	89	Discharge mother vessel to load rail	72
Feedering from MCT to La Spezia	12	Shuttle+dwell time in hub	24
Feeder vessel discharge to exit train	72	Rail transit to inland terminal	7
Local delivery	4	Discharge train to exit gate	5
Total transit time	**177**	**Total transit time**	**108**
GIOIA TAURO - CATANIA			
Discharge mother vessel to load	106	Discharge mother vessel to load rail	72
Feedering from MCT to La Spezia	36	Shuttle+dwell time in hub	24
Feeder vessel discharge to exit train	72	Rail transit to inland terminal	6
Local delivery	5	Discharge train to exit gate	5
Total transit time	**219**	**Total transit time**	**107**

Source: Author's elaboration of MCT, Italcontainer, CDC-Livorno data

2.2.3. *Unit costs*

TABLE 3 shown here below in the text compared the unit cost (per TEU) for containers continuing their journey from Gioia Tauro “via feeder” or “via intermodal”.

TABLE 3: DIFFERENCE COST ANALYSIS FEEDER VS RAIL CONNECTION

VIA FEEDER			VIA INTERMODAL		
Action	20 TEU	40 TEU	**Action**	20 TEU	40 TEU
GIOIA TAURO (Terminal Container) – PADOVA (Inland Terminal) (via Trieste)			GIOIA TAURO (Terminal Container) – PADUA (Inland Terminal)		
Discharge mother vessel to load feeder vessel	83	83	Discharge mother vessel to load rail wagon	83	83
Feeder from MCT to Trieste	161	322	Rail transit MCT to Padua inland terminal	473	764
Feeder vessel discharge to exit train	88	88	Discharge train to exit gate		
Train connection Trieste – Padua IT	95	130			
Discharge train to exit gate					
Unit cost connection via feeder	**427**	**623**	**Unit cost direct train connection**	**556**	**847**
GIOIA TAURO (Terminal Container) – MILAN (Inland Terminal) (via La Spezia)			GIOIA TAURO (Terminal Container) – MILAN (Inland Terminal)		
Discharge mother vessel to load feeder vessel	83	83	Discharge mother vessel to load rail wagon	83	83
Feeder from MCT to La Spezia	131	262	Rail transit MCT to Milan inland terminal	553	712
Feeder vessel discharge to exit train	88	88	Discharge train to exit gate		
Train connection La Spezia –Milan IT	90	115			
Discharge train to exit gate					
Unit cost connection via feeder	**391**	**547**	**Unit cost direct train connection**	**636**	**794**
GIOIA TAURO (Terminal Container) – MILAN(Inland Terminal) (via Genoa)			GIOIA TAURO (Terminal Container) – MILAN (Inland Terminal)		
Discharge mother vessel to load feeder vessel	83	83	Discharge mother vessel to load rail wagon	83	83
Feeder from MCT to Genoa	**131**	**262**	Rail transit MCT to Milan inland terminal	553	712
Feeder vessel discharge to exit train	**88**	**88**	Discharge train to exit gate		
Train connection Genoa – Milan IT	90	115			
Discharge train to exit gate					
Unit cost connection via feeder	**391**	**547**	**Unit cost direct train connection**	**636**	**794**
GIOIA TAURO (Terminal Container) – MODENA (Inland			GIOIA TAURO (Terminal Container) – MODENA (Inland		
Discharge mother vessel to load feeder vessel	83	83	Discharge mother vessel to load rail wagon	83	83
Feeder from MCT to Genova	131	262	Rail transit MCT to Bologna inland terminal	614	729
Feeder vessel discharge to exit train	88	88	Discharge train to exit gate		
Train connection Genova – Bologna IT	90	115			
Discharge train to exit gate					
Unit cost connection via feeder	**392**	**548**	**Unit cost direct train connection**	**697**	**812**
GIOIA TAURO (Terminal Container) – BOLOGNA (Inland Terminal -via Genoa)			GIOIA TAURO (Terminal Container) – BOLOGNA (Inland		
Discharge mother vessel to load feeder vessel	83	83	Discharge mother vessel to load rail wagon	83	83
Feeder from MCT to Genova	131	262	Rail transit MCT to Bologna inland terminal	614	729
Feeder vessel discharge to exit train	88	88	Discharge train to exit gate		
Train connection Genova – Bologna IT	90	115			
Local delivery					
Unit cost connection via feeder	**391**	**547**	**Unit cost direct train connection**	**697**	**812**
GIOIA TAURO (Terminal Container) – Naples (Inland Terminal) (via Salerno)			GIOIA TAURO (Terminal Container) – Napoli (Inland Terminal)		
Discharge mother vessel to load feeder vessel	83	83	Discharge mother vessel to load rail wagon	83	83
Feeder from MCT to Salerno	131	262	Truck transit MCT to Napoli	NA	NA
Feeder vessel discharge to exit train	88	88			
Truck connection Salerno and Naples Market	114	129			
Discharge train to exit gate					
Unit cost connection via feeder	**415**	**561**	**Unit cost direct train connection**		

Source: Author’s elaboration on MCT, Italcontainer, CDC-Livorno data[3] [4]

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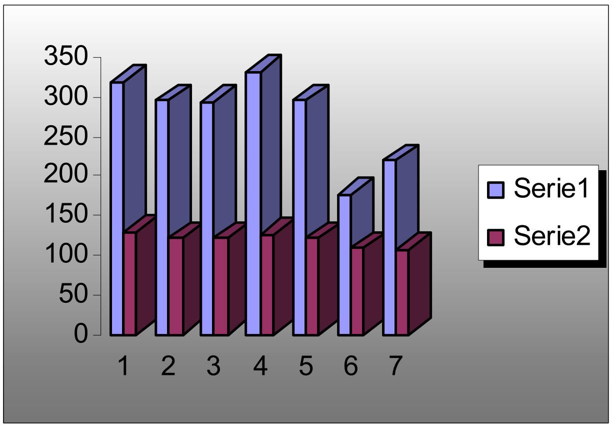
[3] The unit costs pertaining to the maritime and terrestrial legs refers to full containers.

2.2. Aims of the model

The two time and cost differentials show, for the 5 legs considered:

- transport "via feeder" is more economical, in terms of unit cost per TEU, than 'via intermodal' transport
- 'via intermodal' transport is more efficient in terms of transit time compared to transport via feeder

FIGURE 1: TRANSIT TIME DIFFERENCE



The histograms of Figures 1 is based on the data taken from Tables 2

Source: Author's elaboration on MCT, Italcontainer, CDC-Livorno data

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[4] **NOTE ON CALCULATING THE UNIT COSTS**

The "via feeder" modality: involves:

- handling of transshipment (unloading from mother ship and loading onto the feeder)
- maritime leg from the transhipment port to the gateway port (costs at sea)
- port call (costs at port)
- handling in the final port (including loading/unloading on the train)
- rail terrestrial leg to the interport (inland terminal)
- handling in the inland terminal.
-

The "via intermodal" option involves: rail option includes

- handling in the transhipment port (including loading/unloading on the train)
- rail transport
- handling in the inland terminal

Furthermore:

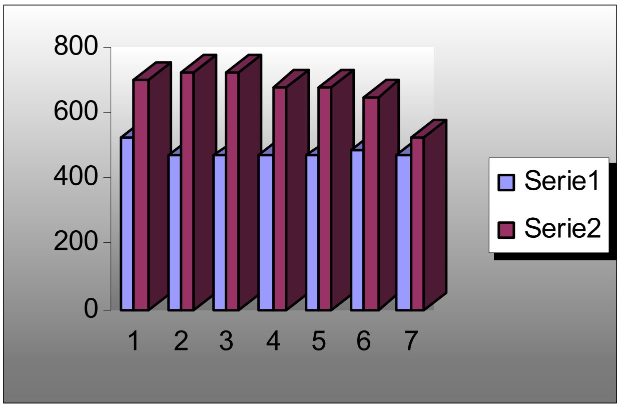
We assume that the freight is guaranteed up to the intermodal node closest to the final destination (destination door). The liner shipping companies control almost all the supply chain.

- The terminals are not all controlled
- The leg under consideration starts from the hub port, therefore transport costs at sea are not considered, neither are transhipment costs;
- the rail service is managed by the rail company and the tariffs (given) are taken as costs by the liner shipping companies (NB. they can be modified according to the volume transported and the number of yearly - weekly journeys. Once fixed they are given in the calculation)

Which of these two aspects prevails in choice of the modality? Are there any opportunity costs that can play a role as variables affecting choice? What weight does the value of the container have?

The risk is that because of the lower time efficiency, the more economical modality ends up inducing immobilisation costs (passive interests on bank loans) and other types of disadvantages (risk of deterioration, reduction of consumer loyalty, etc.).

FIGURE 2: UNIT COST DIFFERENCE



The histograms of Figures 2 ise based on the data taken from Tables 3

Source: Author's elaboration on MCT, Italcontainer, CDC-Livorno data

Consider for example a personal computer importer. Is this importer willing to allow for the greater number of days connected to maritime transport or does he prefer to pay more in order to have the freight at an earlier delivery date, given the added value of the PCs and the customers' impatience?
The difference in unit costs (which acts against the intermodal choice) must therefore be set in comparison to the difference in transit time (which acts in favour of this choice); other factors to be weighed up are also the opportunity costs (such as interest rates, deterioration, customer pressure, etc.) as a function of the added value of the containers.

2.3. The 'cost- time transit choice model'

Let UFC(τ), be the unit costs per leg of the 'via feeder' (number 1 of Table 3) and UTC(τ) be the transit time per leg of the 'via intermodal' (number 2 of Tab. 3). Unit costs are a function of the volume of TEU transported. For the purposes of this model, however, they are given.
We indicate the difference between these costs as ΔUC, where:

(1) $$\Delta UC = [UFC - UTC]$$

Let FTT be the transit time in 'via feeder' (number 1 of Tab. 2) and TTT be the transit time in 'via intermodal' (number 2 of Table 2). For the purposes of this model they are given.

We indicate the difference between the different levels of transit time per leg as ΔTT, where:

(2) $$\Delta TT = [FTT - TTT]$$

Let r be the annual interest rate imposed by the banks when granting an advance on freight, and let h be the number of hours per year, and it is given. Therefore, we can write that:

(3) $$\Delta UC = (r/h).\Delta TT.\ VC$$

where VC is the value of a 20 TEU container.
The choice of a more expensive modality is explained by the preference for a faster delivery, at a given annual interest rate and given the value of container.
Eq (3) compares the two types of cost: the greater cost of terrestrial transport when the faster modality is choice, and the cost of immobilization, deriving from the interest rate, if the faster modality is not chosen (i.e. the increase in cost is balanced by a saving on interest).
That is to say:

if
(4) $$\Delta UC > (r/h).\ \Delta TT\ VC$$
then the cost of efficiency is greater than the immobilization cost: therefore preference is awarded to saving on transport cost and so the “via feeder” modality is chosen
if
(5) $$\Delta UC < (r/h).\Delta TT.VC$$

then the cost of efficiency is greater than the immobilization cost: therefore preference is awarded to saving on transport cost and so the “via feeder” modality is chosen
if
(6) $$\Delta UC = (r/h).\Delta TT.VC$$

then there is indifference.

From Eq (3) we obtain:

(7) $$\Delta UC/\ \Delta TT = (r/h)\ VC$$

Eq (7) expresses the rate of variation in unit costs as compared to the variation of one hour of transit time. The ΔUC/ ΔTT is negative, in other words if I choose efficiency I have to pay more, and viceversa.
Eq (7) also indicates that the ΔUC/ ΔTT is a linear function of VC, the value of the container. The slope of the straight line is given by (r/h). The straight line can be interpreted as a line of indifference below which the terrestrial modality is chosen and above which the maritime modality is chosen.

The points on the straight line indicate the value of container at which the two modalities (‘via feeder’ and ‘via intermodal’)should be indifferent. Thati is:
The points on the straight line indicates the value of container at which level the two modalities (‘via feeder and ‘via intermodal’ should be indifferent.

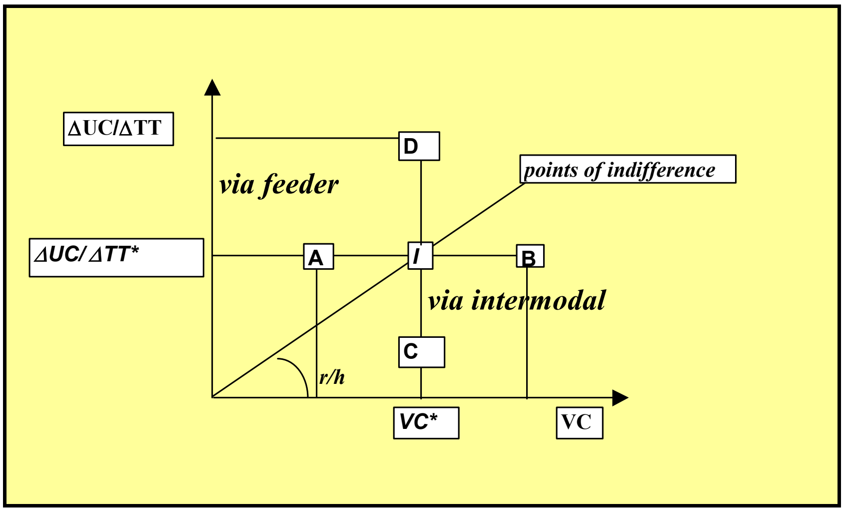
(8) $$VC =(\Delta UC/ \Delta TT) / (r/h)$$

Figure 3, shown below in the text, graphically represents what is expressed by Eqs. (7) and (8)

VC is a theoretical value against which, for each route, the effective value, VC ^{E}, of a container is compared

therefore if VC = VC, the modality is indifferent; if VC >VC the ‘via intermodal’ modality is preferred: if VC < VC ‘via feeder’. is preferred.

FIGURE 3: CHOICE BETWEEN “VIA FEEDER” AND “VIA INTERMODAL” AS A FUNCTION OF VC, VALUE OF THE CONTAINER, GIVEN THE INTEREST RATE, UNIT COSTS AND TRANSIT TIME



Source: Author’s elaboration

2.4. Application of the model with reference to the legs, costs and times assumed in paragraph 2.1. and for a given rate of interest

On the basis of data in Tables 2 and 3, one can obtain the data necessary for calulcation of VC on each leg (Table 4).
The data of column 8 (difference in unit cost of transport over difference in transit time) must be compared with the cost of immobilization per hour multiplied by the value of the container, in order to decide which mode of transport to choose.

Hypothesizing a prime rate of about 9% a year for clients, r = 0.06[5], with reference to equation (7) one can obtain the VC values at which there is indifference of choice[6].

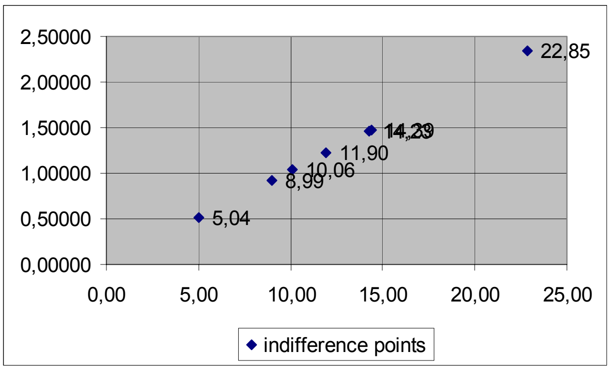
TABLE 4.: ΔUC/ ΔTT – VALUE OF CONTAINER IN POINTS OF INDIFFERENCE (in €)

LEGS	ΔUC/ΔTT	VC
GT - PD	0,92408	89944
GT - MI (via SP)	1,46183	142284
GT - MI (via GE)	1,47805	143863
GT - MO	1,03398	100641
GT - BO	1,22286	119025
GT - NA	2,34783	228522
GT - CT	0,51786	50405

Source: elaboration of data on 'Foschi Cost-Time Transit Choice Model' (2004)

Line 5 of Table 4, for example, informs us that in order for the two transport modalities to be indifferent it is necessary that the value of the container, VC, should be at least equal to 119.025€, given the assumptions made concerning the interest rate, transit time and unit costs.
The following figure is obtained from Table 4:

FIGURE 4:INDIFFERENCE BETWEEN TRANSPORT MODALITIES (VALUE OF CONTAINER IN €/10.000 AND R=9%)



Source: elaboration of data on 'Foschi Cost-Time Transit Choice Model' (2004)

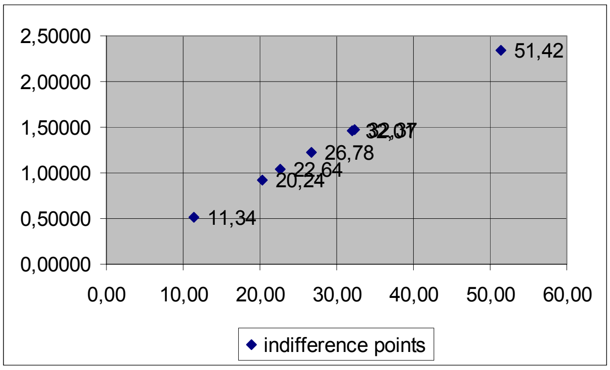
The graphic interpretation indicates that in the upper part of the graph one finds the containers with a VC greater than those represented by the straight line, and

[5] As already explained in the text, the rate, r, corresponds to the immobilization cost of 1 € in a year. for VC = 1 the hourly immobilization cost is very low (roughly circa 0,00001027), but even for one container, with VC worth, for example, 1.000.000€, the hourly immobilization cost would amoung to more than 9€ for each hour of delay, namely over 200 € a day per container.

[6] The ratio is considered in absolute value.

therefore the rail modality is chosen, whereas for those below, the feeder modality is chosen.
Each point of indifference on the graph corresponds to a leg.
For example, the point labelled 5-04 refers to the leg Gioa Tauro-Catania. It is the point of indifference between the two transport modalities: if VC = 50400 then the choice is indifferent. If we have VC > 50400 then the terrestrical modality is chosen; otherwise the choice is via feeder. The point labelled 10.06 corresponds to the leg Gioia Tauro-Modena. And so forth for the others.
These calculations were performed supposing that r=9%. If we hypothesised a rate of 4%, which is one of the most favourable rates granted by banks to their most reliable clients, then the indifference points would be as follows.

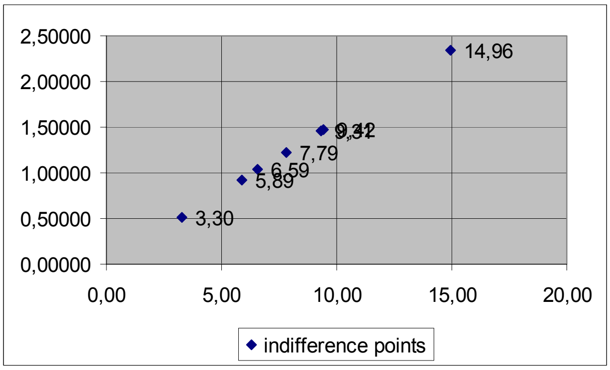
FIGURA 5: INDIFFERENCE OF TRANPORT MODALITIES (VALUE OF THE CONTAINER IN €/10.000 AN R= 4%)



Source: elaboration of data on 'Foschi Cost-Time Transit Choice Model' (2004)

In this second case the value of the container on the individual leg must be much higher in order for preference to be given to "via intermodal". The opposite case would occur if we considered the highest rateimposable, 13.75%. As can be seen, in the latter case the value of the container that justifies is considerably lower.

FIGURE 6: INDIFFERENCE BETWEEN TRANSPORT MODALITIES (VALUE OF CONTAINER IN €/10.000 AND R=13.75%%)



Source: elaboration of data on 'Foschi Cost-Time Transit Choice Model' (2004)

3. *Application to transport of various types of freight, differing in volume and value*

The following types of freight wer considered: notebook PCs, desktop PCs, snowboard boots, Nike trainers, Barbie dolls. For each commody we estimated the volume of the individual package, the final unit cost for the customer, the value of the container as a funciton of the number of units transported in a container, and their unit cost.

TABLE 5: VALUE OF THE CONTAINER BY FREIGHT TYPOLOGY

Desktop	
Volume unitario	111150
Costo unitario	1000
Valore container	293859
Computer portatile	
Volume unitario	77064
Costo unitario	1250
Valore container	529794
Scarponi snowboard	
Volume unitario	108000
Costo unitario	150
Valore container	45364
Scarpe sportive	
Volume unitario	6750
Costo unitario	60
Valore container	290332
Barbies	
Volume unitario	6000
Costo unitario	15
Valore container	81656

Source: Author's elaboration

The container is presumed to be a standard 20 TEU, corresponding to roughly 32.662.406 cm^3. The hourly immobilisation cost depends on the passve interest rate. Supposing that r = 9%, the immobilisation cost is equal to 1.02739 E-05.

If we compared the value of the container of each commodity with the data of Table 5, we can easily see that for personal computers, both desktop and notebooks, sports trainers and Barbies, it is preferable to have "via intermodal" transport rather than "via feeder", whereas for snowboard boots it is better for them to be tansported "via ship" on each leg except for the Gioia Tauro - Catania leg. But, for example, on the other routes it would be preferable to adopt "via feeder" for the Barbie dolls as well.

It is evident that the value of the container (number of packages inside the container by their unit value) is strategic for choice of modality[7].
However, choice depends on existing constraints and the assumptions that have been made. If these are modified, then the results might change, as can be seen in the following example.

[7] In the applications, we have not considered commodities which could, alone, occupy a single container, eg. an automobile. However, if one considers that the value of a car with average engine capacity is around 20,000 Euro, then it is easy to propose that new cars should be transported "via feeder", according to the definition of this expression given in the text: maritime transport, followed by a terrestrial leg. This analysis corresponds, for example to the strategy of the GRINAVI Group (Grimaldi), which has made massive investments in ro-ro mainly for transporting new cars. Grimaldi strongly supports the revival of cabotage in Italy and of Short Sea Shipping in Europe and in general in the Mediterranean.

Let us hypothesise a reduction in feeder transit time following adoption of fast ferries. This could lead to a reduction in transit time, eg. by 30%, but unit transport cost could increase by 25% to amortise the greater cost of purchase and running of these ferries (Alternative 1).
We now hypothesise a reduction in unit cost of rail transport , eg. by 15%,due to greater competitiveness of the market and improvement in rail infrastructures. Transit time is reduced by 10% (Alternative 2).

TABLE 6.: ALTERNATIVES

LEGS	BASE SOLUTIONS	Alternative 1	Alternative 2
GT - PD	8,99	4,62	3
GT - MI (via SP)	14,23	15,64	2
GT - MI (via GE)	14,39	15,88	2
GT - MO	10,06	8,74	3
GT - BO	11,90	10,92	3
GT - NA	22,85	24,49	12
GT - CT	5,04	-12,51	12

Source: Author's elaboration

The value of indifference points per route changes considerably. Eg., (Tab. 5), on the Gioia Tauro-Modena leg it shifts from 100600 € a 87400€ in the first alternative and even more in the second one.

4. *Generalization of the model*

The model of choice of Eq. (3) can be made more complex by introducing other opportunity costs.

With reference to § 2.1. and δ as risk of deterioration of the goods; α, as the clientele strength; β as supplier strength; and γ, as other residual variables,

then (3) can be rewritten as:

$$\Delta UC = [(r + \delta + \alpha + \beta + \gamma)/h].\ \Delta TT.\ VC \tag{9}$$

which for OC= $(r + \delta + \alpha + \beta + \gamma)$, becomes

$$\Delta UC = (OC/h).\ \Delta TT.\ VC \tag{10}$$

from which

$$VC = (\Delta UC/\ \Delta TT) / (OC/h) \tag{11}$$

The model is a better fit to reality is unit transport and transit time costs are not assumed as given, but as dependent on volume of TEU transported, on infrastructure effectiveness and many other socio-economic variables[8].

The model of choice becomes:

$$(12)\qquad \begin{cases} \Delta UC\ (\tau, \iota, \omega) \\ \Delta TT\ (\iota, \omega) \\ VC\ (\tau, \iota, \omega, OC, h) \end{cases}$$

Where τ = TEU; i = infrastructure efficiency; x = other socio-economic variables.

thereby, in addition to greater analytic capacity, the model is particularly attractive for constructing alternative scenarios featuring industrial policy, transport and general economic policy measures.

5. *Conclusions*

Elaboration of a model for choice among different transport modalities arises from the need to provide simple answers to complex problems, while preventing stylisation of reality from causing loss of the information required for in-depth understanding.

In the complex real situation, the proposed decision-making rule if the "cost-transit time choice model" may appear simplistic. But even this preliminary version gives insight into decision-making processes for simple problems and facilitates possible answers in more complex situations.

Starting from the observation that the hub and spokes network system is consolidating in the Mediterranean, inquiry focuses on the possible evolution of this system in Italy, given the transport constraints in Italy. Will maritime or terrestrial spokes dominate?

We show it may be useful to enhance terrestrial spokes, especially by rail, but the bottlenecks and limits of the Italian railways are highlighted. Would it thus be more expedient to strengthen only cabotage and short see shipping, or should development of the railway system also be encouraged, as part of sustainable economic-environmental development?

Analysis of the current system with attention to unit transport costs and transit times shows that the "via feeder" more is economically more advantageous, but the "via intermodal – rail modality is faster, despite the bottlenecks.

How should the policy maker effect a choice? Measures are required to compare alternative scenarios on objective bases, partly with case-by-case

[8] These variables could likewise be endogenized.

considerations, taking into account corporate, sectorial and general economic implications.

Firstly, it should be assessed whether financial savings on individual containers, obtained by lower unit costs but entailing longer waiting times, is really a saving for the final customer. Companies suffer immobilisation costs due to bank financing etc. How can these costs be included in the decision-making process? The 'cost – transit choice model'. seeks to address such issues. Choices can be made for an individual leg, or a network of legs, a transport system. The decision-making process can be made more complex by endogenising various economic variables, to be considered in evaluating alternative strategies.

In attempting to predict the development model and future predominant transport systems for the Mediterranean and Italy in particular, it is clear that innovation and investment in infrastructure and technology will be required. Interventions affecting single modalities that fail to take into account the complex transport system extending throughout the continent could distort a balanced strategy of sustainable development.

The literature has shown that hub and spokes networks will dominate on continental routes, and will coexist with multiports systems over short routes. Alleviating excessive heavy traffic on the roads will also be necessary. Sea transport – in all forms: cabotage, short sea shipping, feederage – is attractive because it causes little pollution, as does rail transport, which also needs boosting, although neither mode should dominate over the other. Public and private operators should aim to diversify transport systems and render both modes more efficient and in tune with sustainable development, without favouring one or the other for ulterior reasons or their own.

Quali-quantitative tools can be utilised to design possible answers. The cost-transit time choice model is a useful example, keeping in mind that whatever measures are enacted must, in the end, satisfy the economic rationale of the final user, to avert the risk of pointlessly diverting resources from one productive sector to another than might at first sight appear economically more attractive.

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