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Operations Research as Cold War Science 1945–1980

Lecture at Seminar Sozial– und Wirtschaftsgeschichte Humboldt University Berlin on 13 Januar 2021

The aim of my lecture is to give a critical overview on the history of Operations Research (OR). The current histories are only naïve success stories. My lecture is a supplement to the book of Alexander Nützenadel "Die Stunde der Ökonomen", 2005, that focuses on macroeceonomics and econometrics in the early years of the Federal Republic of Germany. My lecture is instead on mathematical models for business administration. Under OR I understand certain mathematical tools for planning the industrial production or planning the circulation of transport vehicles (urban transport, delivery of shops, cargo fleets of trucks) in order to support management for better decisions.

My research is based on published sources on OR 1945–1980 mainly from the US, which provide rich material.

OR developed in the same environment of US military funding organizations as Game Theory and the digital computer. Many actors occur in all three fields, as the famous mathematician John von Neumann, in 1930 private lecturer at Friedrich–Wilhelms–University Berlin.

Abstract

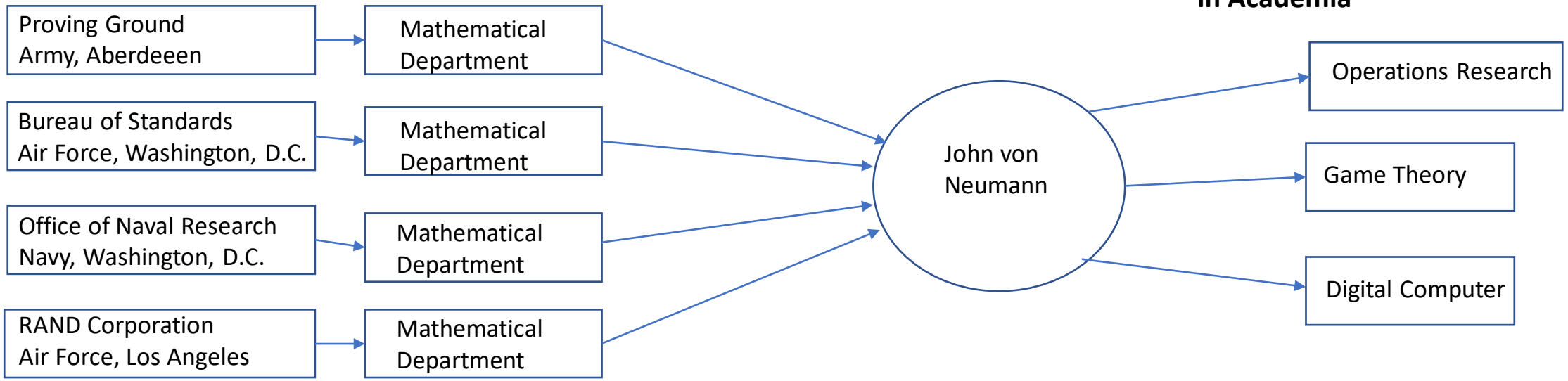
The lecture shows the rise of the academic field of Operations Research, which provides mathematical models for the control of business enterprises, in the political knowledge culture of Cold War Science in the USA. It then leads to the institutionalization of Operations Research in the faculties of economics of the universities of Western Europe and the Federal Republic of Germany in the period 1960 to 1980. It points out the great flood of publications on the topic of Operations Research in the period 1960 to 1980 and explains and discusses the connection between Operations Research and the macroeconomic field of econometrics in chairs, conferences and publications. Based on the scientific-historical study by Alexander Nützenadel, the difference between the field of econometrics, which is based on empirical data, and the field of Operations Research, which is not empirically but mathematically oriented, is worked out. The methodical procedure of Operations Research is called "abstractification". An example of this abstractification is the famous transport model of linear optimization, which simplifies (abstracts) economic reality to such an extent that it can be transformed into manageable formulas. The lecture shows that due to the strong simplification the transport model was not applied in the real economy (logistics) at all and thus only serves as a self-referential project for academic purposes. The lecture shows that Operations Research lacks a level of empirical implementation of the mathematical models known from econometrics and social sciences. How the transport model and transport optimization were received in the political knowledge cultures of the Eastern Bloc (1945 - 1990) and in the GDR is not discussed. The long version of the lecture is available as PDF at

www.vahrenkamp.org/files/Vahrenkamp_History_Operations_Research_WP6_2019.pdf

A publication 2019 is available “Nominal Science without Data: The Cold War Content of Game Theory and Operations Research”, in: Real World Economics Review, vol. 88, 2019, pp. 19–50, as PDF under http://www.paecon.net/PAEReview/issue88/Vahrenkamp88.pdf.

Development in science and technology 1944 – 1955 in the US.
Military agencies supported a network of mathematicians

Movement of mathematicians in Academia



Weapon development in engineering in an industrial setting

Jet propulsion, missiles, jet fighters, AA rockets

Electronic analog Computers at Bell Labs

Atomic Bomb,
large scale production sites for
U 235 (Enrichment in Oakland)
and Pu 240 (Reactor in Hanford)

Vahrenkamp: Operations Research as Cold war Science, 2021

Operations Research as Cold War science

The origin of OR in Cold War science was already subject of critical accounts (Paul Erickson et al., How Reason Almost Lost Its Mind, 2013, Paul Edwards, Closed World 1996, John Krige, Hegemony 2006).

In the 1950s one can observe the institutionalization of OR in chairs at universities and textbooks in the US, and in the 1960s with the support of NATO in England, France, Belgium, Switzerland and Western Germany (Federal Republic of Germany – FRG). In the 1970s there was a flood of new chairs in FRG and a flood of textbooks and research reports. Analysing the bios of the professors on the chairs and their scientific staff reveal OR as a very successful movement of mathematicians at economic departments.

The 1970s were the peak of esteem and influence of Operations Research in academia.
In the 1980s and 1990s it was absorbed by the fields of logistics and computer science in business administration.

How to criticize Operations Research?

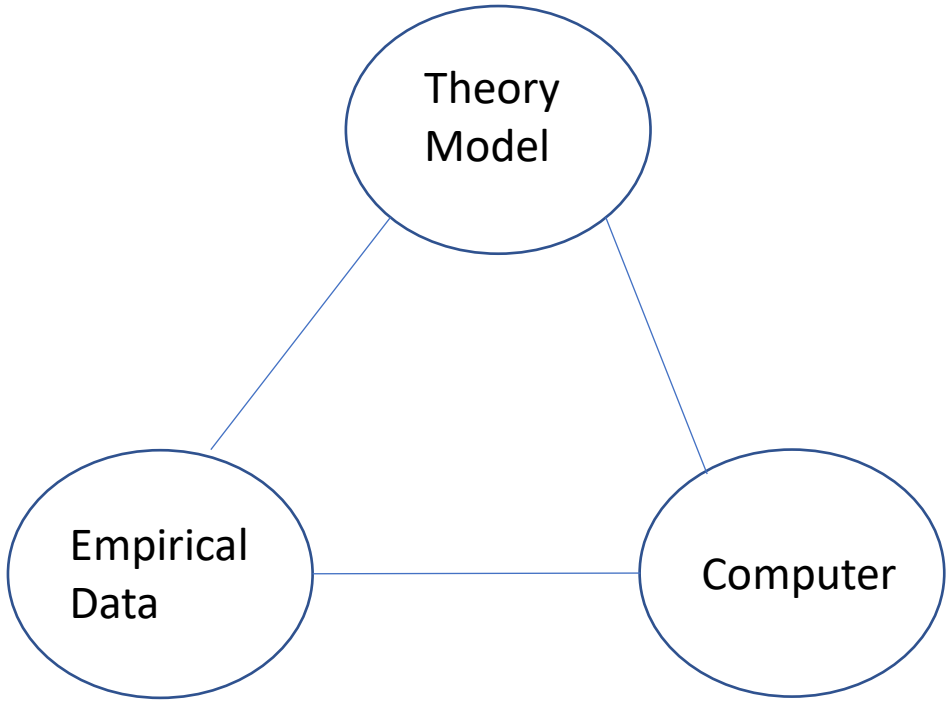
My view is in contrast to the critical accounts of OR mentioned above. These accounts claim that OR was useful for military planning during the Cold War. My view is contrary, despite of NATO support of OR:

(1) My approach is to demonstrate a lack of application. Developed by mathematicians, OR remains in the “mathematical space of numbers” without applications in the empirical field. Mathematicians were not interested in empirical research.

(2) Besides lack of application there was no use of computers.
Mathematicians (theoreticians) did not like the computer (practical).

(3) Economic reality is complex, but the OR models of economic reality were too simple. They could not be applied in empirical cases as I will show at the Transport Model. This failure is contrary to the image the OR–promotors paint. They claim that OR could fit to complex situations of decision making.

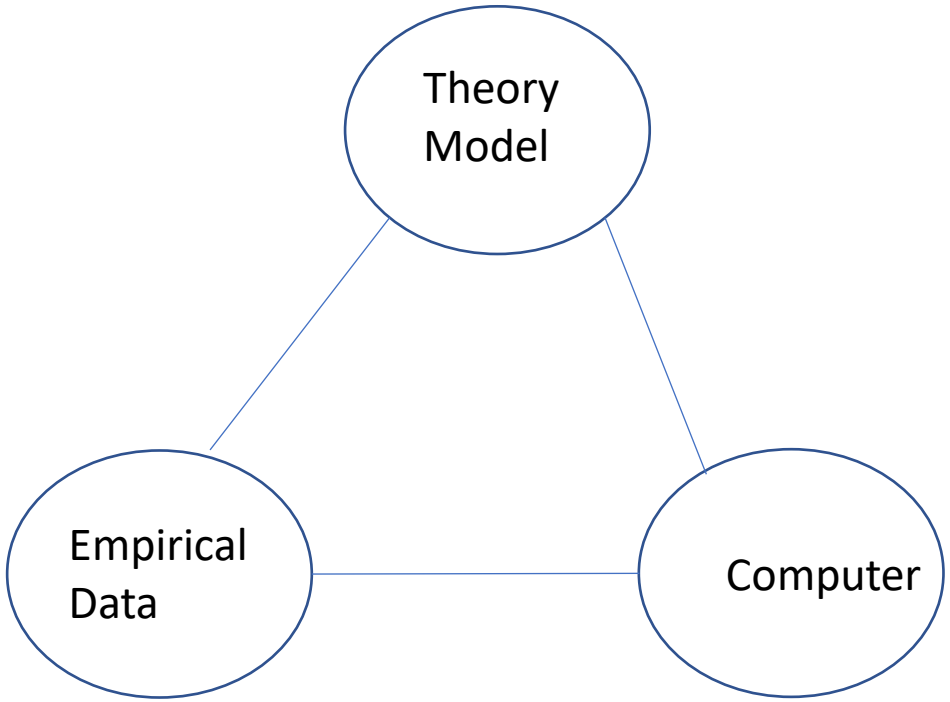
The interplay between theory and empirical data.
The normal procedure of science



The usual procedure in the sciences is as follows. In the theoretical field, a model is developed. In the related empirical field, data are collected to test the model in the empirical field. With the help of the computer, the data are calculated and checked to see if the data and the model match. If not, a revision cycle is initiated.

The normal procedure in science: natural sciences, engineering, sociology, psychology, linguistics…

Operations Research as exemption



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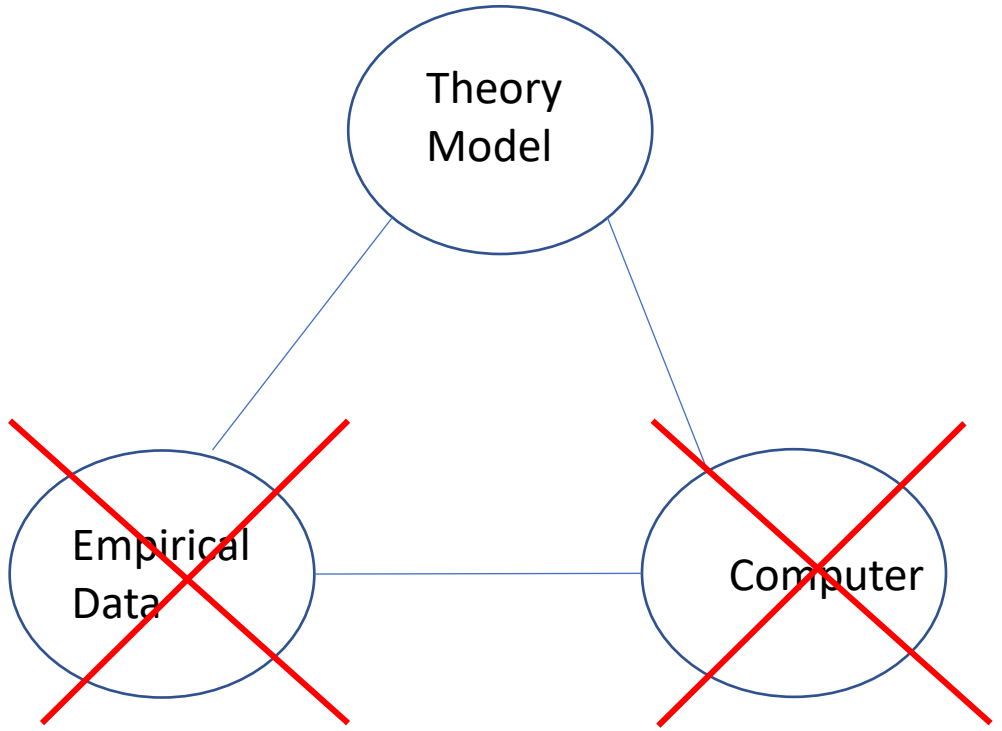


Operations Research without an empirical branch.
Movement of mathematicians.
No interest in empirical fields.
No use of computers.
Position of exemption in science.
Borrowing the scientific esteem from other sciences.

Applications as decoration
The Transport Model as example of the lack of empirical orientation of OR

Applications were only pretended but remained only as decoration for academia and for military agencies to provide a “scientific” appearance. My view is in contrast to the critical accounts of OR mentioned above. These accounts claim that OR was useful for military planning during the Cold War. The lack of application I will demonstrate at the Transport Model of OR.

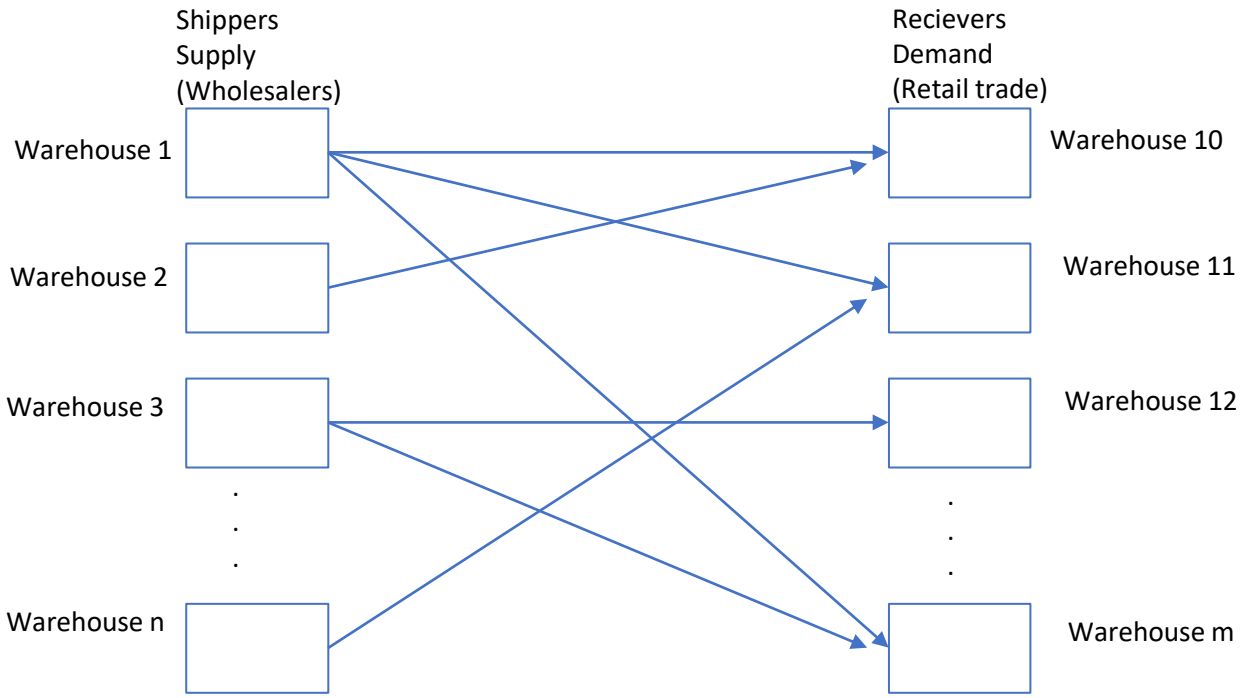
Not every theory must be applied in an empirical field. But the Transport Model is an important content in the OR curiccula of business schools and OR textbooks. One can expect that the Transport Model is formative for management.

But the Transport Model was never applied in economic reality. This claim I can support by a review of literature.

This failure of the Transport Model paradigmatic for many important models in Operations Research. The transport model is treated as such in OR and business administration. In economics it runs under the heading of the optimal use of resources, for which Koopmans received the Nobel Prize in economics. On both levels, however, the model is the same.

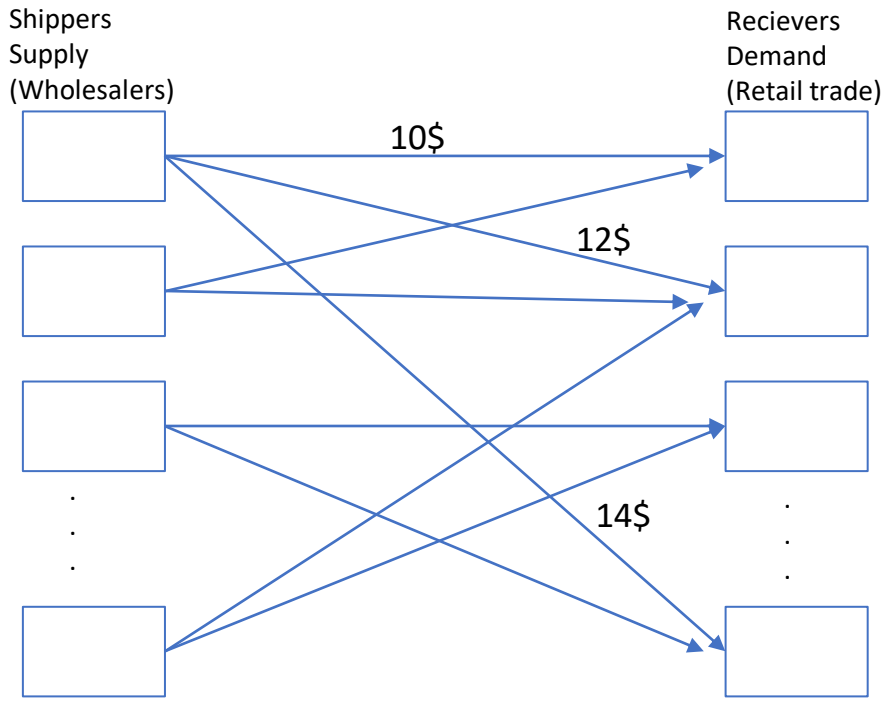
The Transport Model of Operations Research

Transport relations between different locations of warehouses



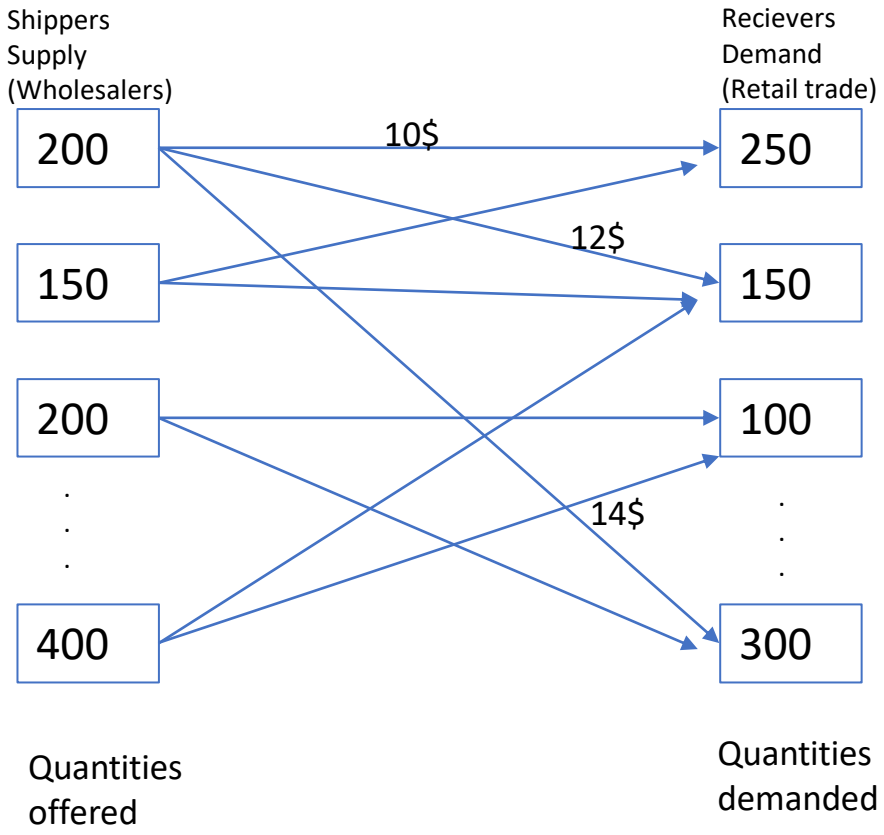
The Transport Model of Operations Research

On the transport relations are costs in $/ton



The Transport Model of Operations Research

Quantities (in tons) for supply and demand are given



Find a shipping plan at minimum cost. Which quantity from which supplier to which recievers to satisfy the demand?

The Transport Model of Operations Research

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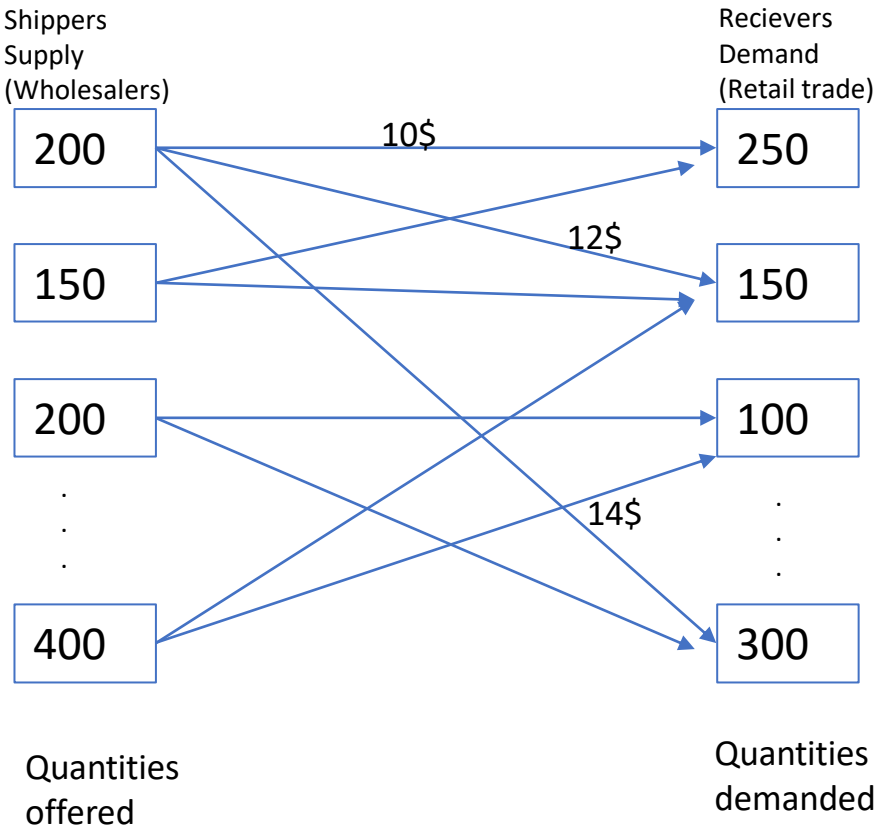


Find a shipping plan at minimum cost. Which quantity from which supplier to which recievers to satisfy the demand?

Operations Research invented a nice algorithm to determine the least cost solution. It provides a rich theoretical context inside Linear Optimization with primal and dual variables.

But the Transport Problem was never applied to an empirical case.

Each case in textbooks was invented on the office desk.

Shortcommings of the Transport Model in economic reality
Abstractification – Why the Transport Model was never applied

In the light of empirical experiences in the economy there are the following shortcomings of the Transport Model:

- In a process of simplification, the diversity of goods is eliminated and only one homogeneous good is considered – for example one specific grade of coal. The model abstracts from different types of goods. So, it is irrelevant for a customer which supplier supplies him. But to determine the source of supply is an important decision for management. This kind of decision is not possible in the Transport Model. One homogeneous good means that on a ship different goods could not be carried – a crazy simplification only to derive an elegant mathematical formula.
- Transport Model abstracts also from temporal changes in transport prices that often occur in the real world.
- It also abstracts from the economies of scale that prevail in the transport industry, where freight rates are higher for one ton than for 1000 tons.

These considerations reveal heavy restrictions the Transport Model imposes on economic actors. The Transport Model simplifies reality too strong. So, it is no wonder that the Transport Model was never applied. The Transport Model is an example of the procedure of abstractification as method of OR.

There are some software packages the great computer firms (IBM, Siemens,…) offered for Linear Optimization techniques. They did not include the Transport Model because it was not applied. There was no need.

The Transport Model as zombie in academia

As a zombie the Transport Model appeared and survived over 70 years in academia very successful. The algorithmic search for the least cost transport plan refers only to simple additions and subtractions of quantities, but not to divisions. This limitation to simple additions and subtractions was ideal for Operations Research, because it allowed a wealth of textbook examples to be generated without the need to resort to a computer. These examples were also ideal for exercises in university courses, which could use transport tasks to suggest applications to students. Students could solve a problem in an exam with paper and pencil without a computer. Dorfman et al. emphasize in 1958 this simple solution method with paper and pencil as a special feature of the transport problem. Churchman et al. even suspected in 1957 that this simple arithmetic structure of the "pre-computer age" was suitable for letting simple office workers work through problems. The authors thus indicate that in 1957 they were mentally still in the pre-computer age. Even William Thomas uncritically presents the Transport Model in his 2015 history of OR as a success story. Until today, the Transport Model survived in university courses as a search on Google and on Youtube reveals.

Tjalling Koopmans invented the Transport Model 1945

The mathematical economist Tjalling Koopmans, who took his PhD in mathematical physics, invented the Transport Model in 1945 and published it in 1949 in the well known journal Econometrica. He derived the model as an abstractification of his experiences as statistician during WW2 in the Combined Shipping Board of the allied powers. To assign his mathematical model with empirical data he decorated his publication with a data set of the world wide shipping industry of the German Statistical Agency (Reichsamt). But he made no use of this data.

Net receipts of dry cargo in overseas trade, 1925

Unit: Millions of metric tons per annum

(1)	(2)	(3)	(4)
Area represented by[1]	All cargoes other than mineral oils		
	Received	Dispatched	Net receipts
New York	23·5	32·7	−9·2
San Francisco	7·2	9·7	−2·5
St. Thomas	10·3	11·5	−1·2
Buenos Aires	7·0	9·6	−2·6
Antofagasta	1·4	4·6	−3·2
Rotterdam*	126·4	130·5	−4·1
Lisbon*	37·5	17·0	20·5
Athens*	28·3	14·4	13·9
Odessa	0·5	4·7	−4·2
Lagos	2·0	2·4	−0·4
Durban*	2·1	4·3	−2·2
Bombay	5·0	8·9	−3·9
Singapore	3·6	6·8	−3·2
Yokohama	9·2	3·0	6·2
Sydney	2·8	6·7	−3·9
Total	266·8	266·8	0·0

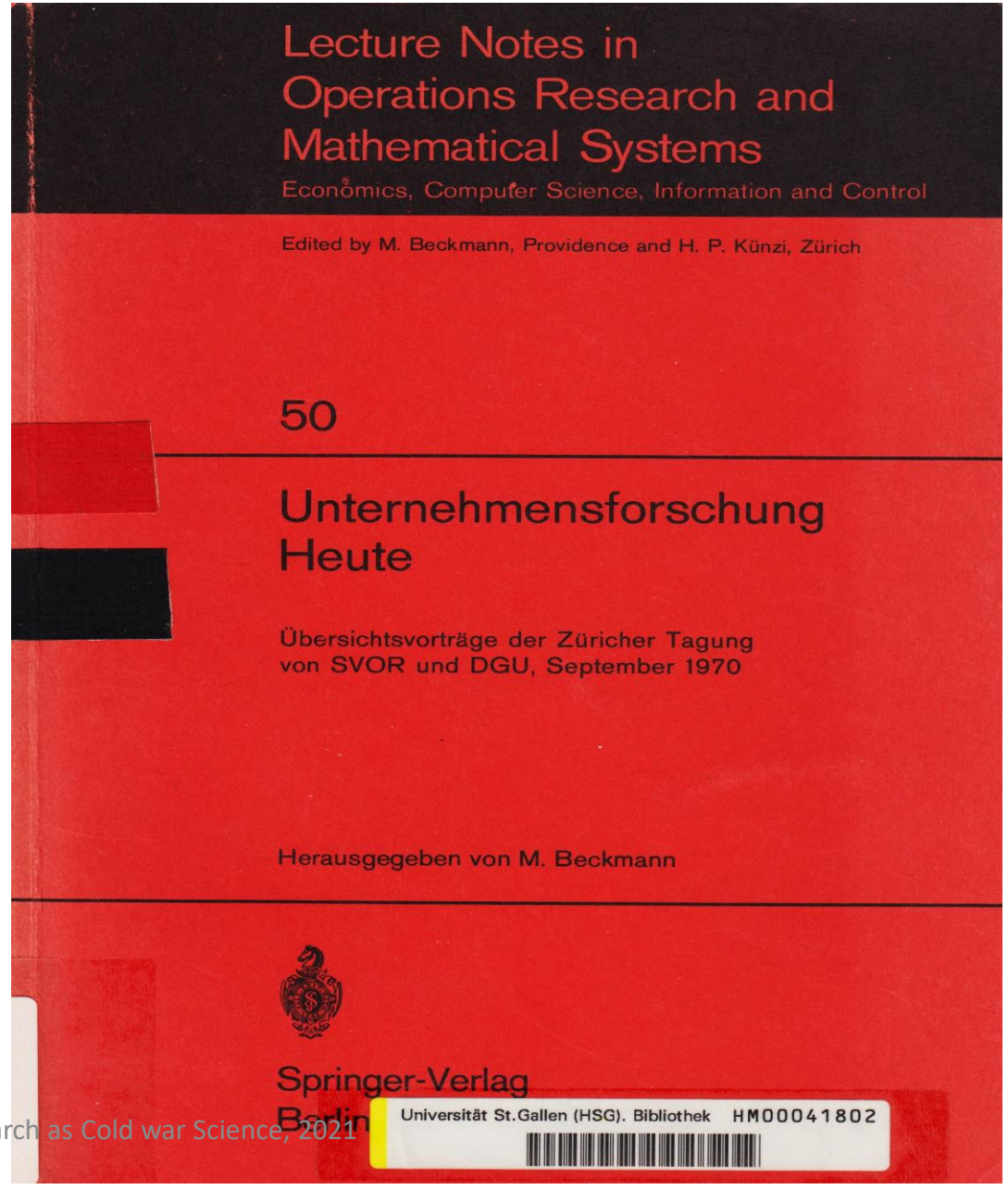
Source: *Der Guterverkehr der Weltschiffahrt*, Statistisches Reichsamt, Berlin, 1928.

Tjalling Koopmans‘ Nobel Prize and Martin Beckmann

Koopmans worked together with the mathematical economist Martin Beckmann in the Cowles Commission at the University of Chicago in the 1950s. Beckmann studied mathematics and physics at University of Goettingen and got in the 1960s a chair in Operations Research at University of Bonn and rose to one of the most influential promotors of OR in Westgermany. He edited the Lecture Notes in OR at the scientific Springer Verlag producing a flood of mathematical papers.

Beckmann edited the scientific papers of Koopmans at Springer Verlag and paved the way for the Nobel Prize in economics in 1975.

Koopmans earned the Nobel Prize for the Transport Model that was never applied.



Lack of empirical reflection in OR community

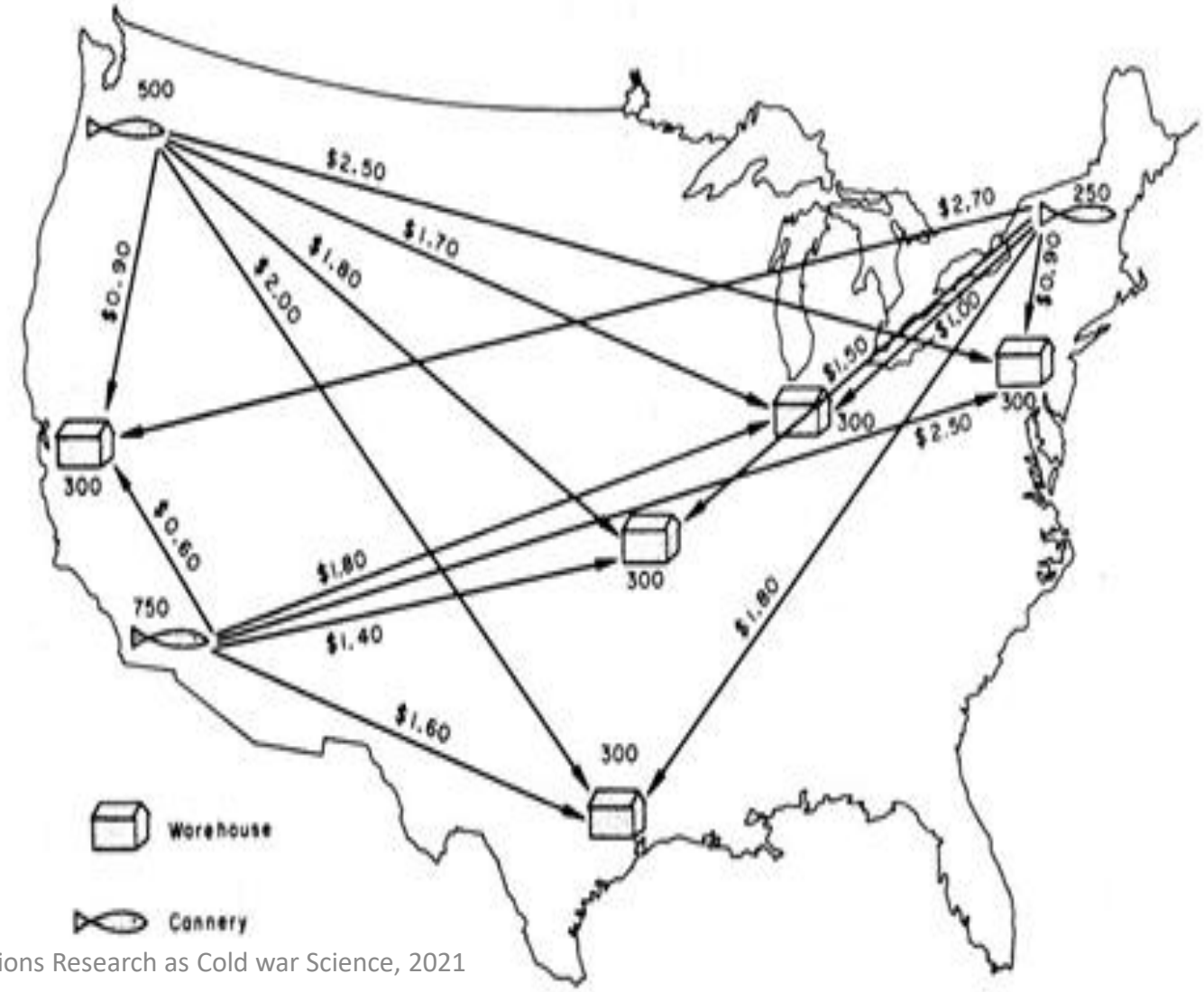
It is remarkable that the OR community did not reflect in the past 70 years the lack of applications of the Transport Model. All textbooks refer to the Transport Model as an important issue. This behaviour of the OR community reveals their insufficient empirical orientation. Empirical data only serve as source of models, but not to solve a social or economic problem. Sections how to gain empirical data lack in all OR textbooks other than in econometrics or sociology.

Dantzig used the Transport Model as invention on his office desk

It is remarkable how George Dantzig uses the Transport model as empirical decoration of his famous textbook “Linear Programming and Extensions” 1963 (German edition 1966). Already on page 3 of his book he displayed a map of the US with locations of warehouses of the fish packing industry. These locations were connected by transport relations and Dantzig rises the question of a least cost transport plan.

It is important to recognize that Dantzig only invented this map on his office desk. He invented reality but did not derive this map from an empirical research contract with the fish packing industry. This claim could be supported insofar as Dantzig quoted no reference to such a contract. This kind of procedure is common in scientific publications in journals: This research was supported by….

Dantzig on page 3



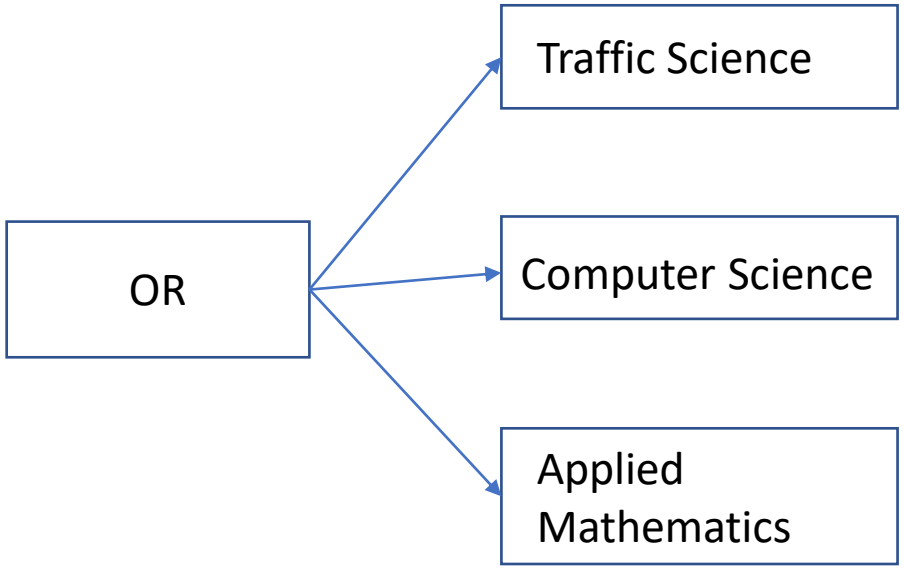
Fish canning and Naval Research in Monterey

It is surprising that Dantzig specifically chose the fish canning industry as an example in a highly industrialised country with a strong high-tech industry like the US instead of, for example, locations of warehouses for spare parts in the aircraft industry. It is possible that Dantzig was referring to John Steinbeck. John Steinbeck received the Nobel Prize for Literature in 1962 for his novel Cannery Row, published in 1945, which describes the fish canning industry on the US West Coast in Monterey - one year before Dantzig's book was published.

In Monterey also the Naval Postgraduate School's Operations Research department is located since 1950. It is one of the greatest OR departments in the world and serve as scientific decoration for the Navy.

The Heritage of Operations Research

The mathematical appearance of Operations Research radiated to other academic fields.



Traffic networks with empirical data

Large travelling Salesman problems with million of cities, without applications

Combinatorical optimization, without application

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