

Challenges to OR in Switzerland for the years to come¹

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To avoid pure speculation on future tasks in OR we may look at just a few OR projects dealt with and published recently. Thereby, we may get some clues to future needs in the field as well as to the skills necessary to fulfil them. Among many others, we find for instance:

- **Energy studies**, concerned either with generation capacity expansions in imperfectly competitive electricity markets [18] leading to equilibrium models (the analysis involving variational inequalities),
or with the price-formation process in infinite-horizon oligopoly models (hydro-electric generators in dynamic price-based competition) [10] tending to a *Markov Perfect Equilibrium (MPE)* shown to be approximated by a learning algorithm,
or else with hydro-power plant dispatch planning, depending on the random dynamic development of water inflows and electricity market's spot prices [8], modelled as a multistage stochastic program observing risk constraints (for stochastic programming models and solvers see [15, 16] and [23]);
- **efficiency investigations**, e.g. *Data Envelopment Analysis (DEA)* papers like [6] dealing with efficiency games between two supply chain members (supplier, manufacturer),
or *Imprecise DEA (IDEA)* as in [22], assuming some outputs and inputs of a DMU to be unknown decision variables, yielding nonlinear programs being converted into linear programs by a special algorithm, applied at a Korean mobile telecommunication company;
- **assignment and scheduling** problems, like locating a single facility into the plane with varying distance measures, induced by different norms on the interior of a bounded region (city) and its exterior (countryside), yielding a nonconvex objective for this problem, solved in [4] by some approximation procedure,
or the *Dial-a-Ride Problem (DARP)* designing vehicle routes and schedules for n users with particular pickup and delivery requests between various origins and destinations, aiming for a set of m minimum cost vehicle routes accomodating as many users as possible, modelled in [7] by (large scale) integer programs,
or else class scheduling for the training of airline pilots with new assignments [20], with the objective to minimize the total weighted length of all classes (a combinatorial optimization problem) requiring tractable procedures for approximate solution;
- research on **finance and risk** in a very broad variety, considering e.g. portfolio optimization [3, 17], asset and liability management [13, 14], option pricing [21],

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one- and multistage risk measures [1, 2] etc., involving among others measure and probability theory, (non)linear optimization, dynamic and stochastic optimization (including risk constraints), (stochastic) control, and so on;

- many papers on **services and supply chains (SC)**, e.g. SC with one manufacturer and two competing retailers with random demands [19], wherein contracts designed by the manufacturer and accepted either by both retailers or by just one imply different equilibria,
or option contracts (& pricing) in a SC [5] under slope conditions for the demand curve,
or on an optimal inventory policy with two suppliers [9] such that the buyer incurs a high variable cost but negligible fixed cost with the first supplier and with the second supplier a lower variable cost but a substantial fixed cost, where it is shown that, given a log-concave demand density, a reduced form of a generalized (s, S) policy is optimal for both finite and (discounted) infinite-horizon problems,
or managing patient service in a hospital's diagnostic medical facility [11], serving outpatients scheduled in advance, inpatients with demands generated randomly during the day, and emergency patients to be served as soon as possible, leading to a finite horizon dynamic programming model,
or else the design of zone tariff systems in public transportation [12], including the fare problem to find “good” tariffs in an existing zone system, as well as the zone problem to design the zones which depending on the choice of the objectives may be NP hard and hence needs appropriate heuristics to be solved.

This does not mean that all the above problems are perfectly solved. On the one hand it is not evident that always the necessary expertise (economical, technical, organizational, financial, or others) was available and involved to validate an appropriate mapping of the real problem into the particular mathematical model. On the other hand most of the mathematical problems in the above models are, and will be for years to come, under investigation with respect to their properties as well as to the existence and design of safe and efficient solution methods.

After all it is evident, that OR in practice can only be successful if it is dealt with as a really interdisciplinary subject between expertise in the application area and mathematical methods (applied mathematics including computer science). This requires for the mathematical skills of the applications expert (AE) to be sufficient to describe the real problem in a form enabling the methods specialist (MS) to design a model, and in turn for the MS's acquaintance with the terminology of the application area to allow grasping the essential elements and relations of the real problem from the AE's description.

In Swiss universities these requirements are presumably satisfied for the relation of engineering towards methods at the ETHL and ETHZ. For the relation of business administration/economics and methods the standing was impaired with the new curricula, since mathematics was not intensified and OR does not appear any more in the masters program. Hence there remain only few specialized areas where a qualified relation would be possible, e.g. with experts in finance.

Sometimes the question comes up (maybe more in this country than abroad) whether and where OR in academia is justified. To this question just briefly: There are several

other areas in academia, in which “real” problems are investigated by mapping them into mathematical models, analyze (or solve) them, and derive from these results conclusions for the “real” problems. Instances are theoretical physics, mathematical chemistry, mathematical biology, electrical engineering, automatic control, financial “engineering”, and so on. In analogy OR is scientifically as demanding as the addressed applied problems in these areas and the involved models and methods there. Therefore, if these areas are justified in academia, why not OR?

The academic home base of OR may be in economics, engineering, mathematics, or computer science departments, depending on the local situation.

Finally, to maintain (and perhaps improve) the scientific level of OR achieved in this country so far, the joint PhD program on OR—proposed some time ago by H.-J. Lüthi—is still a good idea for this country; otherwise it seems realistic to expect, that very soon the expert knowledge of OR needed in Switzerland will have to be imported from outside!

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