Episode 9 Origins & Applications of Ops Research - 5.12.2022, 11.26

Length of recording: 33 minutes

Transcription notes

I:	Interviewer(s)
R: **S:**	Respondent(s) Speaker(s)
wo-	an unfinished word
(word)	an uncertain passage in speech or an unrecognized speaker
(-)	an unrecognizable word
(--)	unrecognizable words
[pause 10 s]	a pause in speech of at least 10 seconds
, . ? :	a grammatically correct punctuation mark or a pause in speech of less than 10 seconds

[intro music]

S1: The operations leadership podcast with Gautam Basu provides insights for today's business leaders on creating value through operations improvement, process excellence, digital innovation and organizational leadership.

S2: Our guest for this episode is Juuso Liesiö. Juuso is an associate professor at the management science group in the information services management department at the Aalto business school. He has an extensive background in operations research where he has developed novel modeling approaches, algorithms and computer software related to portfolio, decision analysis, multi-objective optimization and sophisticated resource allocation models to name a few. In this interview

Juuso provides us with an overview of the origin, application and future of the field of operations research. We hope you enjoy.

Gautam: Hi Juuso, how are you doing today?

Juuso: Hi thanks, I'm good.

Gautam: Great. Well, welcome to the operation leadership podcast. Maybe we can just start off with a very simple basic question, maybe you could tell us a little bit about your background and what got you interested in operations research?

Juuso: Yea, thanks. I'm an associate professor at the business school and my field is actually the management side. So that's the kind of a (sibling) discipline of operations research, business school usually has management science while engineering schools have operations research. But actually I did my dissertation at the Helsinki university of technology and that was in operations research. What got me interested, I think you could trace this back to high school already. I think math and science were always my strong thing, I was interested in those and the fact that you learn some basic principles and you don't have to remember everything by heart. You are presented the problems and then you use the tools you have and the algorithms and the equations to solve them. So I think it's always been a strong suit and then I think my career is really about-, really showing that math is useful in real life applications and helping make better decisions and that type of thing. So after my dissertation, I did some stuff-, I was a research fellow in Vienna Austria in the international institute of applied systems analysis, I was university lecturer at the math department and then in 2015 got the tenure position at the business school in management science.

Gautam: Maybe a followup question, because you mentioned that the different aspects of OR operations research and how do you see for example the engineering vs the business or the management science side, what were the main differences that you noticed from the application perspective (-) the problems or the domain, does it affect anything?

Juuso: I think the applications are quite the same, at least the methods and models are the same. I think in engineering, they are hugely overlapping that (sides) of applications we see at the business school and at the engineering school. Maybe in engineering, you have more like also included on top of business applications you have let's say military applications, maybe historically you have had more

environmental management problems, that type of thing. And of course pure engineering OR, so optimization models to help design an actual product when you have to consider multiple aspects. So maybe more emphasis on those in the engineering side and then in the business school more emphasis on management type of OR applications. But I would also kind of say that this is changing, I think for instance our business school is now focusing on better business, better society types of things so we are constantly bringing in all (--) [04:43] sustainability aspects in even the types of assignments and problems we teach our students at the basic bachelor business analytics courses.

Gautam: Right right. I guess for those that are not familiar with operation research or could you give a brief or synopsis on the background of the field, because you mentioned the defense military and business and of course engineering, so could you give us a brief history on that?

Juuso: So I think the standard story of where operations research began, at least the term was just before world war 2 in Britain and America. So during that war operations research, mathematical and statistical models to help make better decisions were used to optimize military operations. So how to setup your air defenses in Britain for instance or how to organize the convoys from the States to Europe to bring supplies should you have a lot of small convoys or few bigger ones which could then be more better protected I guess, the German (-) and then after the war I think we had- especially in the States and the Britain you had a lot of people, officers from the military with this kind of background so they brought these kinds of mathematical and statistical models to be used in the civilian life, so in business and of course also public administration. That being said, I mean there have been quantitative tools used in management already in the industrial revolution when it began, in the beginning of the last century. So I would say that there are more rules than simply the military applications of world war 2. So after the war, operations research management science became things to be taught in the universities and I think the last part of the history is like the last 20 years. So the amount of data, also the amount of computational power has increased and become much cheaper so all of the different methods developed back in the day all of a sudden are now useful because we have the data and we have the computational power to actually use them.

Gautam: And was it-, I mean because you mentioned this has been around since the industrial revolution but it really kind of blossomed after world war 2 after the military applications and then actually going into the business and other fields. So when was this OR formally introduced in the academic or university curriculum?

Juuso: I don't know exactly, 60s -70s (--) [07:53]. A lot of the things we now consider at the core of a (war) like linear programming which is basically linear optimization, I mean that's been developed in the 50s.

Gautam: Yea, it's interesting because I guess the OR it encompasses this development of the wider range of problem solving techniques and methods really to improve decision making and efficiency. If you think about some of these methods, whether its simulation of optimization or (-) process models, (-) data envelope analysis, so on and so forth, my question is that, how do you and other operation researchers approach problem solving and how do you determine which model is the most appropriate solution for given problem set?

Juuso: So maybe the starting point would be to say that one of the (sins) of all of us in the methods part is that we have our kind of favorite methods and we try to apply them and there's also the bias of when I'm in an academic world I have some freedom in choosing the sides of applications that I really work with. So then I'm more interested in applications where I see that we can use state of the art methods. But kind of from a more consulting perspective, I think its an iterative process, maybe at a very early stage you kind of know that, is this something where we will end up without very quantitative state of the art model or is the problem still kind of unstructured even for the client in a sense that what is most useful here is really to apply softer methods that just help to structure the problem in a sense that what is the objective here, what is the actual decision we are trying to support, what are the different uncertainties related to identifying the best possible decision alternative. Okay, so then if we are really in a process that a lot of these has been already figured out and we are really building on the data model, then I think its an iterative process, so you start with something, you show maybe even with dummy data what these models could provide for the client and then you fine-tune it if you see that okay this is not really the thing that is most valuable. And often the client kind of sees something then realizes that actually what we would need, what could be important for us, for our decision making would be to analyze these parts of the problem and then we bring in more methods. And maybe a part of this is also kind of figuring out what data do we have available, I mean the best approach always would be that we start from, what do we want to achieve, generating different types of ideas for decision alternatives help us achieve those objectives and then gathering really the data we need to evaluate, how good the different alternatives are with respect to those objectives. But of course in reality a lot of the time the projects are from the fact we have all this data, what can we do with that?

Gautam: It’s interesting and you are mentioning that obviously with increased computing power the proliferation of data that this has become quite a hot area for especially younger folks, so could you talk a little bit about that in terms of for example here at Aalto there is this new business analytics, you know specialization, so how do you see like for example for younger people that want to get into this field whether it’s management science or OR you know, data analytics, what have you, how do you see that for younger people that are interested in getting into the field?

Juuso: It’s an interesting field with a lot of opportunities I think. The demand for people with the title like operations analysts, operations research data scientist data analyst, those kinds of positions are open all the time. Maybe the thing I would-, because you have a lot of opportunities, maybe the thing to kind of emphasize here is that now that you are young, spend your time in learning some of the theory and the details behind all of these methods because later it's always easier to learn the softer part of the profession like facilitating workshops or communicating in an organization and these types of things. So, at this time, in the early stages there are equations, a lot of those things, a lot of struggling with different software to get them to work, so I think at a young age that's the place to learn that part of the profession.

Gautam: Yeah, and that kind of leads to follow up question because this is the operations leadership podcast, so here we’re talking about both the technical quantitative methods, mathematical models that you're speaking about that are very much part of the OR management science domain, but how do you blend for example some of the software skills from leadership (-) communication or (personal) communication, you know, persuading for example the outputs or the results of the model and maybe persuading somebody on the board of directors or the management team, how do you see that linkage between let's say the leadership and more the technical hard skills, so blending the hard and the soft skills, how do you view that?

Juuso: I think that's definitely one of the strengths of a business school. So if you think of the curriculum of students, they will have courses on lot of the softer issues as well but then in really business analytics courses how we kind of simulate this from the very beginning, from the bachelor level courses is that all of our assignments are based on application story, so like a case study that, there’s always a background, we’re always supporting kind of (our) real decision making problem, of course we need to scale them down from the actual application since we want to complete dozens of those during one six week course. But its always about really not just figuring out or formulating the model with pen and paper but really doing the implementation and in a lot of the assignments

also visualizing the results and not only with (--) [15:16] but for instance when we talk about supply chains like an optimizing supply chain really using the map to highlight which factories are we using to produce this stuff, where is it transported and to which warehouses and from which warehouses do we serve different customer areas. Just as one example. And one thing I would also say is if we think about it, the real life application is putting a lot of emphasis on creating (turns), putting a lot of emphasis on actually the assignments and rather than the exam because the exam is a poor simulation of what building, solving models is in real life. And then of course working in teams I think. A lot of the time you need to combine expertise of different people. And maybe the final thing I would say is that the masters thesis is one of the important, so a lot of our students are in a situation where they really have to first convince an organization, their managers or executives that this is important, find something interesting and then do their analysis and present them in a way that's understandable and that the benefits of the analysis are obvious to the higher ups.

Gautam: Yea and that kind of leads logically into the next question which is around, what are some of the typical operations research methods and tools which could be applicable for supply chain management, logistics, operations management? Because I see that as a big domain or sub discipline that can be applicable to solve real world problems, so have you worked on-, you mentioned for example supply chain optimization, sort of network optimization, so are there other kinds of methods or tools that can be used specifically for supply chain management, logistics or OM?

Juuso: Even optimization involves a lot of different types of things. So the thing we mentioned already is network optimization models which can then also include integer optimization parts. When you are really planning not only the distribution to satisfy demand but also maybe products, so where do you produce these types of things? Then of course (--) [17:56] optimization, now maybe more than ever, it's important to consider the uncertainties in the decision making situations so if its about deciding on the distribution plan or even the overall structure of the supply network then thinking that not all the parameters are-, we don't know all the parameters, there might be uncertainties, we have to take a stance on how much risk are we willing to take and maybe reduce the average efficiency so that we are better prepared for uncertainties and extreme events and we won’t be too-, our whole operation will not fail if something like that happens. Then procurement, maybe revenue management, those are places where simulation, decision analysis, stochastic optimization are commonly used. I'm thinking of an example where a company was thinking the procurement of natural gas, so they used that as a source of energy in their operations, but then the way in which you buy gas, there's a pipeline coming but in advanced kind of make contracts that I

will buy this amount of gas at this hour, at this month and then if you commit to that early on, you get it cheaper so that will then combine all kinds of time series forecasting on how much gas do you need and what's the uncertainty in that and then stochastic optimization part to really structure a portfolio of this contract so that you're on average. Pay us as little as possible for the gas you will need. Then about operations management, I think vendor selection would be a place where decision analysis, especially decision analysis models that consider multiple criteria are often used so maybe not just worried about the price but also the quality of the vendor and past record and a lot of other things that might be needed. And then if we think about where the world is going, I think a lot of the time we are now seeing that all of these optimization models might have multiple objectives so then you're dealing with multi-objective optimizations. Maybe you're not only interested in minimizing the transportation cost but as another objective you're trying to minimize the CO2 emissions. Of course simulation as I mentioned, kind of just figuring out if things are uncertain, how does this process work in the long run, you could think about queuing in a restaurant, those type of things, so simulation would be a good way to test out different designs of the overall operation that how do they work when we have uncertainties and the number of customers or service times or these kinds of things.

Gautam: And I guess one interesting question that I might have for you is that, you know, based on let's say the current geopolitical, economic, social uncertainties, increase in terms of the volatility and fluctuations in many different things. Going back to the question I asked earlier, would that actually factor into the types of models that you'd be using because you mentioned simulation, you mentioned multi-criteria optimization. So if something becomes more volatile or uncertain, those decisions have to be made under increased levels of uncertainty, would that actually influence the types of models or methods you used from an OR perspective?

Juuso: To some degree, yes of course. Always when you're moving just from kind of optimizing the expected value of something, we're also considering the entire distribution of what might happen. Then the (-) measures and those types of things that might not be visible in all standard models have to be brought in from the decision analysis basically. That's one thing actually changing the model but maybe the more important thing is that where do the inputs to the model come from? We are mostly used and the most efficient mathematical tool is that you just get the data, historical data from some databases runs the things over and over again, you have a repeated decision making setting and it requires little development after you have made it work. But data is always looking at the past. So then if you want inputs that consider something that hasn't happened in the history,

then you need to bring in expert judgment. So the numbers have to be-, they're partly motivated by historical facts forecasting models based on historical data but they also were adjusted based on the expert judgment of people, actual humans. And that's of course if you think about the effort needed to run the model, if you're not just pulling in data from a database but you're actually organizing workshops with the different experts from different parts of the organization to get really an understanding of the uncertainties and what different values these parameters, this cost parameter, this demand parameter can have, that requires a lot of work but that is definitely something that we need to do, we have to use the human imagination to think about what can happen and code it in a quantitative way into our models so they can make use of this uncertainty estimates.

Gautam: So I guess that would be kind of an example of blending the technical hardscale with kind of the expert software stuff. So how would you actually code that? If you take an expert for example quantifying for example supply risk for natural gas, do you bring those people in, interview them and then how would you kind of code that and use that as input into the model? How does that work?

Juuso: I think this is one of the strengths of operations research from the historical perspective that a lot of the time we didn't have that much data and maybe computer science where you don't have this interface, two humans and expert judgment so a lot of methods are specially designed, a lot of researchers are focused on developing methods with which you can interact with the experts. So it's really about questioning, so at the same place this can be that what do you think is the probability that the demand will be below 1000 units? What's the probability that it's between 1000 and 1500? and of course if you continue this kind of questioning then you get really subjective, probability distribution for the demand and in terms of how stochastic models work, it doesn't really matter whether the probabilities are based on historical frequencies of events or whether they come from experts subjective probability statements like, like the one I just mentioned. So once we have the data it's easy to use but as you can imagine, organizing these kinds of interviews and probably you want views from multiple experts to make the estimate more reliable and that requires more effort.

Gautam: Fascinating. Maybe one final question for you Juuso and that's around the-, how do you see the operations research field developing in the next 5, 10, 15, 20 years? So, really in the future, I think you touched upon it a little bit in terms of the proliferation of data, increased computing power, processing power, and so on and so forth. So how do you see the field growing or developing in the next 5 to 10 to 20 years?

Juuso: Yea, maybe the thing we talked about already, so I think we have had a increased focus on data that comes from a database and now that the world once again seems more less predictable than maybe in the past, we'll see more reliance on actually also utilizing expert scenario work to bring in those kinds of uncertainties that are not reflected by the historical data. So that's definitely one thing. Second thing I would say and maybe this goes a bit beyond operations management but if we think about fields such as finance or logistics supply chain planning operations management, those are places where that have been traditionally quite quantitative so it's not surprising that a lot of operations research applications can be found in those areas. But what we will probably see in the future and I think we're seeing already now that functions like human resources are more and more hiring people with the titles, with the analytic skills, operations research management science so we will see the same kinds of tools being applied for the things to support decision making in softer areas such as human resources. So we covered that, and maybe the third thing I would maybe talk about is automated decision making. So, traditionally operations research has been about models that support a decision maker or a group of decision makers to identify the best possible decision alternatives so the models give decision recommendations, that's the historical origin, give decision recommendation but the final decision is always made by a human decision maker and he or she also takes also the responsibility. So maybe the responsibility still falls with one person or more but we will see things that take the human decision maker out of the loop. So you have an optimization model, it finds the optimal alternative, maybe it's linked directly to the production system that then actually already implements this. So one of the applications I'm thinking of is electricity production. A lot of optimization models are used there, they take in predictions on the spot, price for the coming 24 hours and then they give recommendations that at this hour you should produce this much hydro power, hydroelectricity for instance. So do we need a human there always or should it just be an optimization model to control the actual gates at the hydropower plant to produce that energy at that time when it's optimal to do so and that will bring a lot of interesting development and research work for our professionals.

Gautam: Right, so kind of like light out decision making?

Juuso: Exactly yea.

Gautam: Okay, sounds good. So Juuso, how would people either learn more about the work that you're doing, how could they get in touch with you if they're interested in maybe taking a class or

what have you? So what are the kinds of vehicles to learn about the work that you're doing and maybe take part in your upcoming class or seminars?

Juuso: Yea, I think Aalto university has people.aalto.fi, so I have a profile, definitely there and I think it automatically updates all the publications I have made. Some of the publications probably you can use as sleeping pills but if you check the abstracts, I think they will pretty neatly and tightly kind of give the key insights that how is this beneficial and what is the type of application that we are doing here and those kinds of things. And I'm teaching business analytics right now so it runs on the second period, from October to November every year and that's a big class and we don't have any limits on the number of participants. So definitely join us there. So that's I think an introductory level course and introduces optimization models with a very strong application focus rather than theory, so now I think we have 260 students there, an increase of almost 100% from last year, so definitely, a growing area.

Gautam: Wonderful. Well, Juuso I would like to thank you for being a guest on the operations leadership podcast, very interesting insights, very fascinating insights on the operations research world, very important for operations leadership. So thanks for joining us.

Juuso: Thank you.

[outro music]

S2: That's it for this week's operations leadership podcast. We hope you enjoyed it and until next time.

[outro music continues]

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