

TO INNOVATE OR PERISH. YOUR CHOICE

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“Vice-Chancellor, Dean of the faculty of forest sciences, colleagues, ladies and gentlemen”. I must first express my deep thanks and appreciation for the high honor of receiving this honorary doctorate. It is a highest recognition we in academia can receive.

I would like to discuss a topic with which I have been involved the last few years, and which I think is of high importance today in the world.

There are few key words in this topic:

- Innovation
- Technology
- Creativity
- Research

There is a well-known cycle of value added through new ideas: Research in basic science, applied science, innovation and entrepreneurship. All these components are needed to attain a high level of productivity:

Basic research is the backbone of knowledge, as well as a basic need to satisfy our curiosity. A country without thinkers in basic research lacks a fundamental piece of culture.

Applied research generates ideas that can have practical importance.

Innovation is the center piece. How to translate knowledge into products, services that could have impact in society.

And finally, we need entrepreneurship to make it happen. To produce and distribute these new products or services.

Innovation can be seen as the pivot element in this chain. Innovation plays a role at all levels. It defines in an important way countries. Obviously in companies, many of whom live or die through innovation. In most cases it is through new products:

What will happen to Apple, now that the great innovator Steve Jobs is no longer there?

What happened to Microsoft when Bill Gates left to do good works?

Who remembers Commodore, an important computer firm some decades ago? It run out of ideas.

See Nokia next door.

Pharmaceutical firms are all about the products they create.

Google is a continuous laboratory, employing hundreds of high level researchers.

In other cases the innovation is through production processes.

Like the Japanese decades ago with their Just in Time, Total Quality concepts, which changed the paradigm in manufacturing.

Like Walmart and their exceptional logistics.

And innovation also plays a role in personal lives. Let me add here a few additional words to describe innovation:

- Flexibility
- Capacity to adapt to new circumstances
- Ability to seize opportunities
- capacity to reinvent yourself
- It relies also on emotion, on a state of mind.

I believe most successful people, in work, in private life, need these capacities

So there is a need to be able to innovate at all levels, your country, your firm, your University, and also in your personal life. But let's concentrate on innovation which impacts from basic research to production.

In developed countries this chain is fulfilled through the integration, not usually planned, of universities and industry. In less developed countries usually the innovation part in industries is lacking.

Why is innovation important? I think there is no country we can considered developed with a low level of innovation. Just think about it. If a country is not innovative, it is unlikely it will be highly developed. Can you think of many relevant exceptions?

We can measure the level of innovation by the inputs:

- % of the GNP invested in Research and Development (slide)

- Number of PhD students graduated a year

And by the outputs, usually correlated to inputs:

- Papers in reputed journals, citations (slide)
- Further along the chain, patents
- And as a vital end product , the level of high tech industries

In this area, Sweden is doing well with its industries in cars, trucks, planes, telecommunications, electricity generation, manufacturing, mechanical equipment, mining, forestry, Sweden can certainly claim a leadership in innovation.

Now let's analyze less developed countries. The numbers of inputs and outputs are significantly lower. The % of the economy based of high tech industries is not high. Those countries that have lived on exporting commodities or on tourism have not really succeeded, and I think will not until they incorporate innovation as a main principle.

My country, Chile, has finally realized this dilemma in the last 10 years. We don't want to perish, so we are trying to be innovative (21)Efforts are being made to improve basic education this by itself is a huge challenge.

In R&D, while developed countries spend 2-3 % of GNP, Chile spends only 0.5%, Brazil 1%. More resources are now being devoted to form and support researchers. Fellowships for doctoral students have increased significantly, though are still quite below good standards Research is being supported, as well as university-industry developments.

But actually, the only true innovation with important impact at international level was carried out without any support. The story is interesting.

This guy was in the building business, and he built a large resort condominium on a beach. Since the beach was of quite poor quality, he offered as a sales attraction a huge artificial lagoon, both for both bathing and sailing. The lagoon was a failure at first, it got dirty. The problem was that the technology available could not keep it clean, as he had been assured. Facing financial disaster, he, who by chance had studied chemistry, developed on his own a method that worked. It was a great system. He could keep the large lagoons clean, at low cost. He made a name for it when the 7 star hotels in Dubai and other emirate countries created lagoons using his method. His firm, working in over 70 countries is now worth over one billion dollars. But this individual success is not a recipe for the country.

We are still developing innovation with only moderate added value
I want to tell a little about my experience in relation to innovation

I direct an Institute, Complex Engineering Systems, funded by the state, at 2.5 million US a year, for 10 years. We have about 35 academics, which in addition work full time at different engineering departments and universities, and a staff of 16 people. We chose a path of innovation, in an arc covering from basic research to important problems we have in different areas in our country: Forestry, Mining, Education, Logistics, Transportation, Urban developments, Energy, Public Institutions. We are well evaluated because our research covers the whole span I have mentioned, from basic research reflected successfully through publications, to applications with impact and originality.

Our projects, some of which I will describe, have had an important impact in different areas. Those that can be measured monetarily had an impact of more than 300 million dollars in 2010, and are also novel; we have a large number of papers showing these applications. We rank number one in papers

on OR applications in the main US OR journals among universities outside the US. In this sense, innovation is the driver of our Institute. I will describe briefly some of the projects we have worked on. The methodological basis for these projects has included Operations Research and Operations Management, which are the core discipline of quantitative management, statistics, information technology, data mining and industrial organization. We have taken on important problems we had in different areas in our country. Here are some of the projects

Forestry

Operations Research has been highly successful in improving decision making in forest management worldwide. In our case we worked with Chilean forest firms to improve their forest operations. There is a sequence for these operations.

If you wish to harvest an area, trees are felled and cut into pieces or logs of different lengths and diameters. There are forest areas ready for harvesting; there is data which determines how much volume can be obtained of each type of log from a tree, given any cutting pattern. On the other hand, the firm has contracts to sell logs of different lengths and diameters, in given volumes and dates. The decisions then are: which areas should be harvested each week and how to cut up the trees to satisfy the orders, and try to get the maximum net revenues.

These problems were formerly solved manually, with significant loss of efficiency. One well known Operations Research tool, Linear programming, was implemented with some enhancements, leading to significant improvement in matching demand with existing trees. Loss of timber due to poor matching was reduced from 15% to 1%, when the model was used.

The trees are felled into the ground and cut into logs. They need to be carried to main roads so they can be then transported to destinations like mills. The logs are transported using tractors or skidders for flat areas. For steep areas cable logging is used, where logs are lifted using cables, attached to a tower to bring them up. The decisions here are where to locate the towers, how to use the skidders, what roads to build to link towers and skidders with main roads. By using Geographic Information Systems and Operations Research models, forest analysts have been able to do the planning much faster than manually with topographical maps, reducing from one week to 30 minutes, and obtain significantly less costly solutions, which in addition are better environmentally, as fewer roads need to be built.

Finally the logs, now laying on main roads need to be transported to their final destinations, which could be a pulp plant, sawmills, stocking areas or the port, for export. To schedule 50 or 200 trucks to do this task, between origins in the forest and destinations, is difficult. There are millions of combinations. The manual scheduling led to poor solutions: long queues both at origins and destinations or inability to fulfill the transport goals for the day. We first centralized the scheduling, and then developed a simulation model, with heuristic rules which defined the instructions for the drivers each. Why send a truck to some point in the forest if there will be already 3 trucks in the queue and thus our truck will have to wait over an hour. Be certain that all the logs are transported as planned. The proposed system was very successful: daily queues per truck went from 4.5 hours to half an hour, truck fleets were reduced by about 30% to do the same work, and costs went down about 20%. This system was implemented by most forest firms in Chile, as well as firms in South Africa (MONDI won the South Africa logistics prize in 1996 using this system), in Brazil and other South American forest firms. These systems were awarded the Edelman

Prize, given by INFORMS, the US Society for Operations Research and Management Sciences , in a competition for best applied OR work in 1998.

Other developments in forestry where Operations Research has played an important role have been in long range harvest planning. In the last few decades environmental constraints have become important, to preserve wildlife, water and soil quality. One form to impose these environmental imperatives has been through not allowing harvesting large continuous areas, which compel to harvest like a chess board. If you harvest a black cell, you cannot harvest the neighboring white cells. This makes harvest planning quite complicated, and sophisticated algorithms have been developed to handle these problems.

Another area has been to plan harvesting considering the risk of fires, which introduces a large measure of uncertainty, we don't really know when a fire is going to break out or how it will expand), and we need to protect valuable timber lands or urban areas.

Mining

Mining has been another important area for Chile. Copper production accounts for about half of Chile's exports Mining can be carried out extracting copper from open pit and underground mines.

For decades long range planning on how best to extract mineral has been carried out using software packages which lead to approximate solutions. The improvement both in software and computers is tremendous. Every 15 years the power to solve these problems improves by a factor of one million; this allows solving now problems which were impossible before. In our mining case,

we can use now more accurate operations research algorithms to improve decisions.

We work with CODELCO, one of the largest copper firms in the world. We developed new decision tools for their long range planning, which resulted in additional net earnings of 100 million dollars per year.

CSAV

CSAV is a top 10 world shipping company located in Chile, whose main business is carrying cargo for customers in containers. Serving over 100 countries divided into 7 regions. The firm handles about 500.000 containers. Knowing how many empty containers of different types should be stored in each of 700 ports in case customers ask for them to ship their goods is complex, in part as there are several elements of uncertainty, In particular demand. How do I know if a customer will come next week asking for 50 containers to ship goods between Shanghai and Hamburg? The main problem for the firm was that in order to make sure the managers could satisfy demand; they carried too many empty containers. And high inventories are expensive. We worked with CSAV's professionals to develop tools to improve this situation, in a project that took 4 years.

Several problems needed to be tackled here. First estimate demand, with its uncertainty. And also other uncertain factors like ships travel time. And handle large amounts of data (every day 400.000 data parameters change). We had to look at the whole system in a centralized way and develop models and algorithms to optimize the global operation.(52) But also, we needed to incorporate local knowledge in each region, for example, there is going to be a strike next week in Brazil. It was a challenging proposition. We developed a web page where local managers

interacted with the centralized solution to integrate the global outlook with local knowledge. The system went live in 2010, and reported additional net earnings of 80 million US for that year

Finally a fun development. Since 2005 we have scheduled the football season in the professional Chilean league. Who plays who every week. There are millions of combinations, so typical leagues just use random selection. This often leads to bad scheduling. In Chile, in 2004 the game of the two strongest teams was scheduled in the first week, when there is still little interest in the tournament, and as a consequence had a small attendance. A couple of years ago, Real Madrid and Barcelona were playing the semifinals of the European Champions tournament. They played two consecutive Wednesdays. The Sunday in between, the random scheduling had them playing against each other. Given the huge rivalry between them, it was a game to the death, while their rivals, Chelsea and Bayern Munich rested their best players. Both Real Madrid and Barcelona lost the second games. This could have been avoided by scheduling the Spanish league games using models and having the Real Madrid-Barcelona game played another weekend, knowing that it was quite likely that at least one of the teams would be in the semifinals.

Operations Research algorithms allow scheduling the tournament in a rational way. When do you want specific games? When dates to avoid big games Several leagues are also using these approach, like Brazil, Belgium.

And this slide I could not resist showing. It has nothing to do with innovation; I recently joined the board of my football club, Universidad de Chile, one of the 3 top clubs in Chile. Here we are celebrating winning the Chile Cup 2 months ago.

I have tried to give you a sense of the work we do. How innovation in our field can be very significant in being competitive. It is not easy to do innovative projects. There are multiple challenges.

- To detect opportunities
- To establish a cooperation with industry in order to develop frontier solutions
- To be able to grasp the core of the problem and find models that reflect this core.
- To develop algorithms and data basis to provide workable solutions
- To implement successfully these systems so they can be used on a daily basis

There are here challenges, but at the same time huge opportunities.

I am particularly thinking about student about to enter the job market, the real world, what does the future look like. Thomas Friedman, the New York Times columnist writes. The future will be global, digital, technological and competitive and there are clear challenging areas:

- Energy
- Biotechnology
- Environment
- The emerging forms of Education

Yes, maybe.

Who really knows what the future holds.

There is this story: A prominent intellectual was asked to give a lecture at the Davos 2000 meeting and discuss what he saw coming

for the 21st century. What he responded to the invitation: "Thinking about this lecture, I looked at literature, and found a similar conference, in the year 1900 with a speaker predicting what the 20th century might bring. He missed the fall of the European empires, the conditions which led to the first World war, the rise of communism, the explosion in technology and manufacturing: cars, planes, household items like refrigerators, penicillin and the amazing leaps in medicine. In 1950 few would have predicted the explosion in communications and computers. So the speaker concluded it would be foolish of me to try to predict the 21st century. And I better not give any such talk.

I like this story. "Si non e vero, e ben trovata", If it is not true, it is a good made up story.

We don't really know what the future holds. At best, we can think of different possible scenarios, in politics, social movements and technology. So I come back to some of the words I used in relation to innovation

We should be flexible, open to new ideas, capable of reinventing ourselves, seize opportunities and be well prepared to face what knows which scenarios will come up

I have discussed mainly issues in the professional area. But I think that is not the central part of life. It is the human aspects and relations that are the determinant, important factors. It is what you are about.

When I look back to the things I regret, or caused me joy, by far most of them are related to the people around me I have been fortunate in this, my parents, my wife, my children and now my

grandchildren. My close relatives and many friends, many of them in academia around the world. Because at the end of the road, what really count are the feelings you share with those close to you.