Competitiveness and productivity of tourism countries: Two sides of the same medal

Prof. Peter F. Keller, PhD.
Visiting professor at the University of Bergamo
3.1. Productivity as challenge for advanced economies
3.2. Theoretical foundation
3.3. Ways to increase productivity
3.4. Digital revolution and quality
3.5. Quality and productivity
3.6. Cluster advantages and framework conditions
3.7. The problem of measuring tourism related productivity
1.1. The problem

Why do we need productivity-led growth in advanced economies?
Keywords

Price competition on the world market
Competition on the local factor market
Cost disease and productivity gap
The double challenge for developed countries: competition on the global tourism and local factor markets

The developed countries suffer from price competition and from increasing competition on their local factor markets

There is an increasing price competition on the largely liberalised world tourism market, particularly from the catching up countries which offer almost the same to cheaper prices.

The more the European economies will return to strong growth, the more their tourism related industries with stagnant services will have difficulties to compete on the local factor markets for capital and labour with more productive and faster growing industries.

It is therefore important, to discuss how the competitive position of the European countries can be enhanced without falling into the trap of price competition which is based on low salaries and low quality of services.
The **cost disease** makes labour intensive tourism businesses in developed countries more expensive and less productive.

Small labour intensive tourism firms cannot rationalise and suffer from cost disease. Their lack of productivity compared to other sectors and the economy as a whole must be compensated by higher prices which limits their ability to compete on the international tourism and the local factor markets. More productive sectors can pay more to their employees on the labour market (Keller, 2008).

**Industries with lower productivity shrink normally compared to more productive industries and their part at the GDP is diminishing.** This can be the case in saturated tourism areas which are not able to rejuvenate the comfort, the quality of the convenience of their supply or to improve the distribution of their products.
The need to fill the productivity gap

The productivity problem has become stronger under conditions of worldwide competition. **Tourism economies of developed countries are under the competitive pressure of the emerging and developing countries which have abundant and still not yet developed tourism resources.** These countries can produce cheaper and are therefore more competitive on the international markets.

Tourism related industries which are labor intensive have to fight on the factor markets with more productive economic sectors. **The high part of stagnant services make them suffer from “cost disease”.** They have to compensate the lack of productivity by an increase of the prices for their services.

The higher costs of the tourism related industries in the developed countries obliges tourism economies **to better use its resources and to improve its distribution structures.**
Emerging countries

Catching-up process

Input-led growth

Increase of inputs in capital and human resources for developing non-exploited resources

Developed countries

Productivity-led growth

Increase in the efficiency of these inputs and their outputs by R&D, innovation, uniqueness of the product, organisational skills and leaner structures for developing existing resources

Productivity-led growth matters
The mostly small structured hotel and catering businesses as core industries of tourism have in developed countries a productivity problem (the case of Switzerland)

Contribution of the hotel and restaurant industries in Switzerland to labour productivity growth 1991-2010

Growth rate of the economy as a whole 1.3 % per year

Growth rate of the hotel and restaurant industries -0.1 % per year
Conclusions

The **core business of the local tourism economy in advanced economies**, the accommodation and the catering industries, is less productive than the average of all the other industries. It suffers from cost disease. The negative difference of productivity must be bridged by higher prices.

Emerging and developing countries mostly by **input-led growth** which means an increasing input of production factors such as labour or capital.

Advanced economies grow by **productivity-led growth** which means they have to increase the efficiency of inputs and outputs through R&D, innovation, uniqueness of the product, organisational skills and leaner structures.
Questions to be asked

- What is the challenge of tourism in advanced economies?
- What do we call “cost disease”?
- How can the hotel and restaurant industries overcome their cost disease?
- What is input-led and productivity-led growth?
3.2. Theoretical foundation

What means competitiveness for advanced economies?
Keywords

New and old understanding of competitiveness

Competitiveness and productivity

Productivity gap
The productivity challenge for national economies

The objective of the economic policy and also of the tourism policy is to contribute to attractive and well paid working places.

This is only possible by an always higher productivity. The part of tourism part at the GDP shrinks if the sector fails to increase its productivity compared to other sectors of the economy and fill its productivity gap.
The price level is the criteria to define competitiveness for countries. Following this criteria and translating it to the firm, competitiveness is simply defined as surviving at conditions of perfect competition by producing at world market prices. Each company which can offer to costs that correspond to the market price, is considered as competitive even if its profit is nil.

Volatile competitive advantage
This understanding of competitiveness led to the outsourcing of the production to cheaper countries and huge trade surpluses and strategic economic policy in emerging countries but also to heavy social and ecological costs. The reduction of these costs will rise the price level in these countries.
The new understanding of competitiveness of countries and firms

The new definition of competitiveness include **goals such as the creation of value added and employment**, the advances in technology, the efficiency of the political system or the reduction of waste and pollution. At the firm level, the implementation of these goals needs the building of high capability to sell and to earn by **putting new and unique products on the market** for changing the market conditions and by **effective and efficient production and distribution of these products**.

**Durable competitive advantage**

This understanding of competitiveness combines a **differentiation strategy which helps to reduce competition and an effective and efficient production and distribution**.
Competitiveness and productivity are the two faces of the same medal.

Competitiveness
The tool to increase competitiveness is productivity.

Productivity
Productivity-led growth is the source of prosperity.
Conclusions

The price level determined the competitiveness of a country in the old understanding of competitiveness. Companies producing and selling products and services to world market prices are considered to be competitive. This understanding of competitiveness led to the outsourcing of industries from advanced to emerging economies which produce to lower costs.

The new definition of competitiveness includes a larger scope of goals such as the creation of employment through high value added creation, the advances in technology, the effectiveness and the efficiency of the political system and the reduction of waste. It forces the company to put new products on the market for strengthening their competitive position.
Questions to be asked

- What is the consequence of the purely price level oriented definition of competitiveness for companies operating in advanced economies?

- How can companies in advanced economies get competitive advantages on the world market?

- Why do we say that competitiveness and productivity are two sides of the same medal?
3.3. The need for a new understanding of productivity in tourism

How can labour intensive tourism firms become more competitive?
Keywords

Ability to sell and to earn

Physical and monetary aspects of productivity

Innovation & value added creation vs. cost reductions and dumping prices
Firms are only competitive in open markets when they can sell their products to good prices.

**Production**

The effectiveness and the efficiency with which inputs of human capital and natural resources are used for developing services

*(physical aspect)*

**Distribution**

The prices these services can command in open markets by their uniqueness and their quality

*(monetary aspect)*
Innovation and value creation vs. cost reduction and price dumping

**Inputs**

The physical aspect of productivity cannot only be associated with cost reductions by rationalizing and diminishing human resources or by standardizing and industrializing services. A higher effectiveness and efficiency of the input means also raising working skills, increasing research and investing in innovation and technology.

**Outputs**

The monetary aspect of competitiveness depends on the ability of firms to create value for the customer, to distribute the products in a targeted and to offer additional value with attractive and affordable prices.
The new definition of tourism productivity takes into account not only the physical but also the monetary dimension.

Companies can increase their receipts by value based pricing. The value can be the creation of unique experiences for visitors and the excellency of the services provided to them.
Questions to be asked

- What is the new in the definition of productivity of tourism which takes into account the monetary dimension of the demand driven tourism economy?

- Following the new definition of productivity in the field of tourism related services, can hotels and restaurants be as competitive as high tech factories in the industry?
3.3. Ways to increase productivity

How can companies become more competitive?
Keywords

Customer value and value based pricing
Internalisation and externalisation of services
Economies of scale and scope
The main strategy for SME’s is to get a mark-up on the market price through creating customer value

Overcoming the cost disease of small companies providing stagnant services and fill the productivity gap

- **Creation of customer value**
  - Assure quality of service, comfort and convenience

- **Value based pricing**
  - Get a mark-up on the market prices

Price reductions are only possible if the occupancy rate can be increased
The popularisation of tourism transformed tourism partly into a self-service economy

The **externalisation of the services to the customers** makes tourism products more productive and solves partly the shortage of labour force.

The transport, the accommodation and the catering industry reduced the services and developed **forms of self-service** such as non controlled trains, non serviced apartments or buffets instead of table service.

Self service products **need less labour intensive resources which lowers the costs and reduces the final price for consumers.**
There are limits of economies of scale and profitability through sheer size.

There is no doubt that the productivity and the profitability increases with the size of the company.

Recent studies showed nevertheless that these economies of scale are shrinking in time (Beritelli, Laesser, 2007).

Bigger tourism companies can overinvest. If their industry is in a consolidation process, price competition may reduce their productivity and profitability.
Conclusions

Small tourism related companies in the field of tourism can improve productivity by creating consumer surpluses and by practising value based pricing.

Tourism companies can **outsource services to customers** and introduce self service for visitors with lower purchasing power.

Bigger tourism related companies can use the advantages of **economies of scale and scope**.
Questions to be asked

- What do we understand by “consumer surpluses”?
- Is externalising, outsourcing to the visitors and self serving the same?
- What are economies of scale and scope?
3.4. The influence of the ICT revolution on productivity

Does technological progress make tourism more productive?
Keywords

Information good

Switched and sunk costs

Network economics and domino effect

Rise of big portals

Digitalisation
Tourism is an information business with high fix and low reproduction costs

The tourism product has the characteristics of an information good when it is purchased.

The consumer needs information before making his travel or destination choice.

The need for information causes high fix costs and low reproduction costs.

The fix costs have the characteristics of « sunk costs ».

The high quantity and intensity of the information stream make it necessary to establish an « economy of attention ». 
Information goods need an infrastructure (cables) for transporting such as internet.

The infrastructure of information creates network externalities (law of Metcalf).

New IT structures have a long take-off stage followed by explosive growth.

There are network externalities e.g. economies of scale and scope on the demand and supply side.
Network externalities can reduce costs and offer more to their customers.

Marginal costs shrink with each new user.
Marginal returns increase with each new user.

Combined impacts:
- Marginal costs continue to decrease
- Marginal returns continue to increase
Network externalities lead to «domino effects» following the principle «the winner takes it all».
Repeater have «Switching costs» as those who change from one software to another.
Strategic advantages of the use of ICT technologies

<table>
<thead>
<tr>
<th>Stagnation</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failures in cooperation</td>
<td>Reduction of the transaction costs</td>
</tr>
<tr>
<td>Weaknesses in marketing</td>
<td>Interactive planning and booking of trips by sovereign consumers</td>
</tr>
<tr>
<td>Market access problems</td>
<td>Global electronic market access 24h</td>
</tr>
<tr>
<td>Perception of tourism as a personalised service industry</td>
<td>Perception of tourism as a sector with « high tech » applications</td>
</tr>
</tbody>
</table>

Former situation       Actual situation
There is a strong concentration of big players owning the digital world

<table>
<thead>
<tr>
<th>Company</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>USD 216 Mia.</td>
</tr>
<tr>
<td>- iPhone, iPad, MacBook, iMac, Apple Watch, Apple TV, iCloud, Siri</td>
<td></td>
</tr>
<tr>
<td>Alphabet Inc.</td>
<td>USD 90 Mia.</td>
</tr>
<tr>
<td>- Google, Youtube, Maps, StreetView, Trips, Android, Nest, Pixel, Home, Glass, DayDream, TensorFlow</td>
<td></td>
</tr>
<tr>
<td>Amazon</td>
<td>USD 136 Mia.</td>
</tr>
<tr>
<td>- Logistik, Rechenzentrum, Amazon Web Services, Echo / Alexa</td>
<td></td>
</tr>
<tr>
<td>Facebook</td>
<td>USD 28 Mia.</td>
</tr>
<tr>
<td>- Facebook, Instagram, WhatsApp, Oculus Rift</td>
<td></td>
</tr>
<tr>
<td>Microsoft</td>
<td>USD 85 Mia.</td>
</tr>
<tr>
<td>- Windows, Office, Azure, HoloLens</td>
<td></td>
</tr>
</tbody>
</table>
There are five big groups which dominate the digitalised tourism world

<table>
<thead>
<tr>
<th>Group</th>
<th>Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priceline</td>
<td>US$ 10.7 Mia.</td>
</tr>
<tr>
<td>Booking.com, Agoda, Kayak, OpenTable, Rentalcars</td>
<td></td>
</tr>
<tr>
<td>Tripadvisor</td>
<td>US$ 1.5 Mia.</td>
</tr>
<tr>
<td>AirfareWatchdog, BookingBuddy, Citymaps, CruiseCritic, ...</td>
<td></td>
</tr>
<tr>
<td>Expedia</td>
<td>US$ 8.8 Mia.</td>
</tr>
<tr>
<td>Hotels.com, trivago, venere.com Travelocity, Orbitz, HomeAway</td>
<td></td>
</tr>
<tr>
<td>AirBnb</td>
<td>US$ 2.8 Mia.</td>
</tr>
<tr>
<td>Alphabet Inc.</td>
<td>US$ 90 Mia.</td>
</tr>
</tbody>
</table>
AirBnB & Co. strengthen their leader position trough forward integration of services. They are not only booking platforms.

They bundle activities for offering experiences in order to sell them. They take over the role of tour operators.

Furthermore, the one who sells the best experiences dominates Google ranking and can ask higher commission. Content leadership is the big online battle in the field of tourism. The winner takes it all.

Source: Jürg Schmid, Director, Switzerland Tourism, Swiss Tourism Council 2017
AirBnB in its role of digital tour operator
Digitalisation allows even SME’s to play the role of tour operators

Possible digital business model of hotel owner/manager:

A guest books a room, lodge in his hotel, stays for a moment and leaves.

The hotel owner can organise and bundle other services than lodging such a dining around, a skipass or the train ticket to reach his hotel. By doing this, he can increase his returns through commission for his organisation and bundling activities by the service providers.
The digital revolution changes tourism on the demand and supply side.

The consumers are more sovereign as before since there is a new transparency of the information on the supply and the prices of tourism related services. Tourism has now really become a “buyer’s” market.

Tourism companies can make their marketing more targeted to the customers. They can produce their information and promotion material cheaper. They can be present on the online market with low costs and without any time restrictions.

Websites of DMOs’ allow FIT consumers to dream, to plan and to book their trips without the help of intermediaries.

Digitalisation led to the emergence of big portals which dominate the digital market. Digital business models are coming on the market allowing also small operators to increase their returns by enlarging the value added chain.
Questions to be asked

- Why is tourism an information good?
- What is an information infrastructure?
- What are switching costs?
- Does ICT make consumers more sovereign and why?
- What should the websites of DMO’s include?
- What are the big portals looking for?
- Who can SME’s profit from digitalisation?
3.5. The link between quality and productivity

How can quality create consumer surpluses and value added?
Keywords

Expected minus – provided service

Total quality management

Asymmetric information process

Price-quality- ratio

Clienting
The perception of the quality by a single visitor depends on his expectations of quality before travelling and consuming.

To define tourism quality from the demand side is also a challenge. The perception of tourism related services and experiences is subjective. The collective expectancies about travelling and stay outside the daily environment are high. Tourism is in developed countries the most important form of individual happiness.

From a demand side view, quality can be defined as the expected service minus the provided service. If the sum of this subtraction is zero, the visitor is satisfied and happy.
The industrial concept of quality management can only be applied by analogy in tourism (the supply side view)

Tourism is not an industry where “Total Quality Management TQM” is possible. The service chain in tourism is too complex. It cannot be managed and controlled like in the industrial production.

Furthermore, quality is not totally manageable since services are always marked by the relationship between the host and the visitor but also the relations between visitors. An unfriendly receptionist or a group of noisy guests sitting can reduce quality. The human component of tourism related services is a factor of risk and insecurity in the field of quality management in tourism.

Finally, tourism quality depends a lot on externalities. A functioning infrastructure or a well protected landscape impact on the perception of the quality by the visitors. The state is therefore a co-producer of tourism related quality. If it is not efficient, it is an impediment for tourism quality.
The perception of the quality by the visitor matters (the demand side view)

The satisfaction of visitors depends not only on the quality of tourism related products which can be objectively measured. The individual perception of the quality provided for a given good or service matters. **This perception can be understood as an experience.** Tourism quality is always experience quality.

The souvenir of the honeymoon is mostly excellent even if the provided services were only of an average quality. Visitors normally say that their holidays were beautiful even if this was not the case. The former director of “St. Moritz Tourism” put the emotional character of the perception of the visitor into the following formula: **“Quality in tourism is if the guest of a resort is totally happy with his stay, wants to come back and recommend the resort to his friends and relatives.”**
TQM is not possible in the field of tourism

Swatch (for Swiss Watches) stands for **TQM which aim is to offer high quality but affordable or even cheap good.**

The complexity of **the often non coordinated tourism related service chain makes it difficult to control quality from A to Z** in the field of tourism.

The fact that tourism services front need **contacts between visitors and service personal can lead to misunderstandings and even to conflicts.**
Mass is a quality killer

Overcrowded or totally fully booked capacities can reduce quality for individual visitors. This is often the case during demand peaks. There are seasonal or daily concentration of the demand in time and space.

Planning the infrastructures and the supply capacities can reduce the negative impacts of a too great number of visitors. This is the case in centrally planned resorts where capacities of transport, accommodation and leisure activities are harmonised to avoid negative agglomeration impacts.
The information process is often asymmetric in the field of tourism.

Visitors do not know before travelling if the quality of their travelling and their stay will be satisfactory. The market information in tourism is never as total as on a fruit market where “search-in quality” prevails. Tourism is an “experience quality” business.

Providers of services often use this situation to operate at the lower limit of quality. This is particularly the case if the visitors are not willing to pay enough for quality or if the visitors will probably not coming back to a given place. The strategy of lowering quality to obtain higher profits doesn’t work when it comes to keep repeaters.

Brands are a sort of guarantee against the structural insecurity. Small companies which are not branded cooperate together for offering visitors comfort and quality classification systems which make the supply more transparent.
Quality increases productivity

Quality creates consumer surpluses and adds value to the tourism related product. It increases productivity on the input and output side. Better quality means higher returns.

Good prices on the open international markets can only be obtained if the quality of the product is high. This principle counts for every tourism related product. Quality doesn’t mean luxury.

Only visitors which are satisfied with the quality with its service, comfort and convenience dimensions will come back and become repeaters.
The price-quality performance ratio is crucial for companies

The higher the comfort, the convenience and the services the higher the price. There is a link between quality performance and price. Quality is not luxury but it causes costs and makes the service therefore more expensive.

Prices are for potential visitors important information which include in general quality. The consumer compares the quality of a given offer with the price for it. He chooses in most cases not the cheapest but the one with the best price-performance ratio.

The quality strategies of most SME’s are based on this consumer behaviour. By increasing quality suppliers want to charge a higher price. They are looking for visitors with a higher purchasing power.
Investments in quality do not bring profit when the additional costs cannot be put on the price

The *market situation doesn’t always allow to put the investment cost for increasing quality on the consumer prices*. It is difficult to sell high quality when competition is strong e.g. in the case of overcapacities. The quality increases in the field of airline companies couldn’t be used for higher prices. This industry had to support in the last decade mostly losses.

In periods where the economies do not grow in the countries of origin, the TO market follows the basic law of offer and demand. *This obliges the companies to limit quality to the essentials and to offer cheaper products*. Superfluous quality elements are removed.
Welcome is an intangible element which can increase guest satisfaction

A warm welcome and a guest friendly atmosphere are immaterial factors of tourism quality. These factors must be taken into account by the managers in a targeted way. The key for a warm welcome or a successful “clienting” is the personal contact between visitors and hosts. Each personal contact with a guest is a “moment of truth”. If it doesn’t succeed, visitors are disappointed and will not return back. Welcome is manageable. It is part of the strategic management.

Welcome has a collective aspect. Tourism services are often consumed in a public atmosphere of a plane, a hotel or a restaurant. Not only unfriendly staff but also co-visitors can destroy a good welcome atmosphere. Knowing this “Club Med” innovated by creating a new category of staff in charge for the wellbeing of the visitors, the “gentils organisateur”.

Conclusions

Quality can be defined from the demand side as expected service minus provided service. Quality doesn’t mean luxury.

**Total quality is not possible in the field of tourism** since personalised service cannot be provided without failures and the service chain is too complex.

Quality increases productivity since it allows suppliers of services to ask a good price.

The welcome creates the stage for producing good quality.
Questions to be asked

- How can you define quality from the demand side?
- Is quality equal to luxury?
- Is total quality possible in the field of tourism?
- What is the link between quality and productivity?
- What does “search-in” and “experience” quality mean?
- What do we understand by “welcome”?
3.6. Business environment and framework conditions

How does the state influence productivity?
Keywords

Framework conditions

Business environment

State as co-producer and promoter
Productivity depends not only on the firm but also on the business environment and the framework conditions.

The enterprise as a productive unit

First of all, productivity depends on the firm. **Only firms can create wealth.**

The environment in which business occur

But productivity depends also on the business environment. Productive enterprises need attractive public goods, functioning infrastructures, highly skilled labour, low taxes etc.

The framework condition of a given place

The macro-economic and political framework condition put forward by a given state.
States can contribute to business environments and stimulate productivity-led tourism growth

State as a co-producer:
- Makes available attractive public goods
- Invests in tourism related infrastructure
- Enhances tourism clusters

State as a promoter:
- Creates a competitive business environment
- Maximises positive externalities of tourism
- Supports innovation creation mechanism
Conclusions

Good framework conditions and business environments put forward by the state and its representatives at all the levels can boost productivity in the field of tourism.

They can facilitate the task of the companies which alone can create value by producing in a always more productive way.
Questions to be asked

- What are macro-economic framework conditions?
- What do we understand by “business environment”?
- Which is the impact of a tourism friendly “business environment”?
- Does a performing state contribute to make tourism in its territory more productive?
3.7. The problem of measuring tourism related productivity

Which is the correct indicator for tourism related productivity?
Keywords

Total factor productivity

Labour productivity

Input & output indicators
The concept of “Total Factor Productivity TFP” couldn’t be proved in the past for explaining growth.

Total factor productivity explains productivity gains by the combined efficiency of all the inputs which are used. It includes particularly the factor capital productivity. The concept served to explain the fast catching up process of the East Asian countries which is supposed to be a function of taking over the most modern technologies.

Or, economists claim that capital is not really a factor of production, the same as labour. Machines are also an output that human thinking and work produced. TFP cannot be measured since it is an open question if the sum of capital and labour inputs can be summed or multiplied.
The concept of “labour productivity” includes all inputs and it is measurable

The concept of labour productivity is the more appropriate concept since it includes also the residential part of Solow’s growth function. It can explain the long term growth of developed economies.

These economies grow essentially by innovation and changes in the organisation of the production and the distribution. They do not grow such as BRIC countries which rely on cheap labour force coming from the agricultural to the industrial sector and the investments in the infrastructure.

Labour productivity is a concept which can be used at the level of industries, sectors and the economy as a whole. It allows benchmarking productivity between different industries, sectors and countries.
Labour productivity has to be measured in values or monetary terms

Labour productivity is a ratio of output to labour, also expressed in physical terms. The units are overnights or workers. At any aggregate level, labour productivity cannot be expressed as the ratio of two physical magnitudes (number of visitors or tons of apples cannot be summed up or workers of different types who perform different activities).

There is only one solution, namely to express aggregate and heterogeneous outputs in value or monetary terms (for example value added). In this case, the values of different outputs can be summed up. It is a compromise since all kind of workers are summed up.
Labour productivity is the best measure for making tourism performance comparable with other the sectors and the economy

Labour productivity reflects both, ability to earn and ability to sell which are essential criteria for competitiveness

Labour productivity in tourism

\[
\text{Labour productivity in tourism} = \frac{\text{Gross value added}}{\text{Full time job equivalent}}
\]

Instrument of measuring Tourism Satellite Account TSA
Building a set of sector indicators measuring the tourism sector productivity

**Inputs**
- Adding customer value
- Externalising services, increasing size and using ITC
- Mark up for destination goods

**Outputs**
- Increasing quality
- Economies of scale & Scope
- Value based pricing
It is not the current performance but the innovation creation mechanism which determine productivity and future growth.
The definition of labour productivity includes the ability to sell and to earn which include both aspects of competitiveness.

The definition fits with the new understanding of tourism productivity which takes into account monetary and physical aspects since it takes a monetary variable (creation of gross value added) and physical variable (full time job equivalent).

The labour productivity allows to compare tourism with all the other industries and sectors.
Questions to be asked

- Why does labour productivity correspond to the definition of competitiveness?
- Is it possible to divide monetary with physical terms when it comes to measure labour productivity?
- Why does labour productivity make comparable all the different industries?
Reader:


OECD (2011), *Studies on Tourism, Italy, Review of Issues and Policies*, Paris 2011, Expert Prof. Peter F. Keller, University of Lausanne, Switzerland