University-industry Partnership in the Vanguard of Knowledge-Driven Economy

László Szentirmai, László Radács

(Department of Electrical and Electronic Engineering, University of Miskolc, Hungary)

Abstract: The words volt, ampere and watt are named after emblematic figures of university and industry and are in common parlance among people. And what is more, the current International System of Units gave many great names to derived measuring units. The 5–10 year-long strategic partnership is top priority for elite universities. This most creative and promising collaboration ensures big and common strategic goals, and shared research vision. New knowledge generated by alliance modernizes university role and industry long-term strategy. Diverse engineering culture serves as brake but could be overcome by both parties when criterion is excellence. Trend is twofold: either richer benefits are given to fewer universities and/or universities in emerging economies are also to flourish. Operational partnerships — the second type — are based on joint research projects utilizing both the core academic strengths of universities and the core research competence of industry. Research projects on professors’ own initiatives and students’ individual research projects all pave the way for achieving strategic partnership. Transactional partnership — the third type — puts significant impact on teaching and learning. Key criteria include multidisciplinary institute on campus with industry contribution, even culture and curriculum and multidisciplinary approach to research. These criteria together with industrial practice for academics and students lead also this link to strategic collaboration. The paper presents the important role of university-industry partnership in knowledge-driven economy emphasizing achievements and weaknesses. Case studies, examples and trend with genuine figures illustrate the topic the world over.

Key words: university-industry partnership, knowledge-driven economy, indicators for partnership evaluation, strategic partnership, operational partnership, transactional partnership, three-mission university

1. Introduction

1.1 Industry and Need for Leading Figures

Partnership between universities and economic life could not exist in the Middle Ages when the precursor of university taught septem artes liberales (seven liberal arts) in schools for student clergymen. Seven liberal arts composed of two groups: quadrivium (four programs) embraced arithmetic, astronomy, geometry, music and three

László Szentirmai, Ph.D., Emeritus Professor of electrical engineering at University of Miskolc; research areas/interests: intelligent electrical machinery and drives, electrical energy application, quality, renewable, control, instrumentation, condition monitoring, and higher education. E-mail: elkszela@uni-miskolc.hu.

László Radács, Dr. tech., Associate Professor of electrical engineering, Deputy Head of Electrical and Electronic Engineering Department, University of Miskolc; research areas/interests: electrical machinery and drives, energy systems, power quality assessment, e-learning in electrical engineering. E-mail: elkrad@uni-miskolc.hu.
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others as dialectic/logic, grammar, rhetoric belonged to trivium (three programs). It looks to be evident that teaching and learning quadrivium and trivium did not need any link with the then rather poor economic life. Industry was born only some centuries later when organized coal, salt, gold and iron core mining expanded and the first industrial revolution in England began.

The Latin word “montanisticum” — coal-salt- and gold-mines along with metallurgy and relating farming, food industry and energy chain — unifies the ancient trades from the Middle Ages within industrial and practical engineering organization until the end of the 18th century and proved to be the flagship of technological progress in Europe for centuries.

The 1750s were a decade in which the pace of innovation took its first tentative step forward. Like the tentative beginnings of any major change, the potential of the growing innovations in England was apparent only to a few. Innovation was clearly linked to commercial development and from about 400 registered patents up to the year 1600; there had been about 700 by 1754 and almost 2000 by 1800. With a focus on new techniques in metals and textiles, but with a range of other inventions, the patent numbers soared upwards by a factor of 10 in about 60 years — the main phase of what is called the first Industrial Revolution. England had become the world leader in improvements in products and techniques and the invention of new devices (Table 1). The two pillars of that first Industrial Revolution were Iron and Power.

The 2010s are a decade in the midst of another revolution. It is one in which Information replaces Iron, and in which Computers and Communications replace Steam. It is one in which the change to an Information or Knowledge Society is altering the global social structures. It is one in which new materials, nanotechnology, space research and molecular biology alter radically the physical and material existence of human beings.

Table 1 The World’s Industry Potential Share in Percentage from around the First Industrial Revolution until Recovery of Economy after World War Two

<table>
<thead>
<tr>
<th>Year</th>
<th>United Kingdom</th>
<th>USA</th>
<th>France</th>
<th>Germany</th>
<th>Other countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1820</td>
<td>50.0</td>
<td>10.0</td>
<td>17.5</td>
<td>8.9</td>
<td>13.6</td>
</tr>
<tr>
<td>1840</td>
<td>45.0</td>
<td>11.0</td>
<td>14.6</td>
<td>12.0</td>
<td>17.4</td>
</tr>
<tr>
<td>1850</td>
<td>39.0</td>
<td>15.0</td>
<td>n.a.</td>
<td>15.9</td>
<td>n.a.</td>
</tr>
<tr>
<td>1860</td>
<td>36.0</td>
<td>17.0</td>
<td>12.0</td>
<td>16.0</td>
<td>19.0</td>
</tr>
<tr>
<td>1870</td>
<td>31.8</td>
<td>23.3</td>
<td>10.3</td>
<td>13.2</td>
<td>21.4</td>
</tr>
<tr>
<td>1880</td>
<td>28.4</td>
<td>28.5</td>
<td>9.1</td>
<td>12.8</td>
<td>21.2</td>
</tr>
<tr>
<td>1890</td>
<td>27.5</td>
<td>31.5</td>
<td>7.6</td>
<td>14.4</td>
<td>19.0</td>
</tr>
<tr>
<td>1900</td>
<td>18.4</td>
<td>31.4</td>
<td>6.5</td>
<td>16.5</td>
<td>27.2</td>
</tr>
<tr>
<td>1910</td>
<td>13.9</td>
<td>35.2</td>
<td>6.6</td>
<td>16.0</td>
<td>28.3</td>
</tr>
<tr>
<td>1913</td>
<td>14.0</td>
<td>35.8</td>
<td>6.4</td>
<td>15.7</td>
<td>28.1</td>
</tr>
<tr>
<td>1929</td>
<td>9.7</td>
<td>44.5</td>
<td>6.8</td>
<td>11.6</td>
<td>27.4**</td>
</tr>
<tr>
<td>1937</td>
<td>11.1</td>
<td>41.1</td>
<td>5.3</td>
<td>12.2</td>
<td>30.3**</td>
</tr>
<tr>
<td>1948</td>
<td>10.8</td>
<td>56.9</td>
<td>4.4</td>
<td>3.7*</td>
<td>24.2**</td>
</tr>
<tr>
<td>1955</td>
<td>9.8</td>
<td>48.1</td>
<td>4.1</td>
<td>8.1*</td>
<td>29.9**</td>
</tr>
<tr>
<td>1958</td>
<td>8.2</td>
<td>45.6</td>
<td>5.2</td>
<td>10.1*</td>
<td>30.9**</td>
</tr>
</tbody>
</table>

Notes: * West Germany, ** Majority attributed to the Soviet Union
Source: Industry statistics, structured by the authors

Mankind from the appearance of anthropoid ancestors of modern man until 1950 consumed primary energy and raw material as much as between 1950 and 2010 (Figure 1).
In the early 2000s European industry was not what it had once been: although many industries were still to be found in Europe, other economic blocs, such as Asia, were establishing themselves as the world’s principal production sites, aided in part by a less costly workforce and the opening up of world markets. The current picture is not too bright: in 2000 the civilized member states of the Organization for Economic Cooperation and Development (OECD) provided 60% of the world’s industrial production, while in 2010 this figure was only 51% and by 2030 the ratio is to drop to 43%.

European leaders therefore decided to stake the EU’s future on science and technology, in which it has always excelled. Knowledge would thus secure the future of Europe through the creation of a knowledge-based society rooted in higher education, innovation and research (Knowledge Triangle). Europe’s added value will thus be based on the new knowledge created within the European Research Area (ERA) established in 2000 where universities are primary players.

The wide difference in a product manufacturing is an exponential increase of added value (Figure 2) which generates the knowledge-driven economy.
1.2 Development of Engineering Education in Symbiosis with Industry

After the fierce wars in the 17th century, engineering corps needed officers for the mechanized aspects of warfare. Central organizations of various countries, regardless of the costs, established such military schools at the beginning of the 18th century in Vienna, Brussels and Paris. However, it was evident that important sectors of economy also required well-trained leaders and specialists. This was just the right time to establish engineering education in order to train engineers in symbiosis with industry.

The history of the University of Miskolc (UM) is closely linked to the evolution of national assets. Mining, metallurgy, the machine industry, electrical power supply, electronics, chemical and cream ware pottery industries and the cement mills in the North-East region of Hungary have a long and distinguished record, and have drawn their skilled manpower from the University and its predecessor.

Its precursor created in 1735 in Selmecbánya, the then Hungary for Exchequer-integrated montanisticum to train officers and specialists. Academy, a higher education rank was granted in 1770 by Queen Maria Theresa in Her Decree on Sistema Academiae Montanisticae envisaging the need for mining officers of higher attainments.

In 1794, when École Polytechnique was established in France, the Laboratory system of the Academy served as an example and the structure of such education was applied also by École des Travaux Publique, as the request for its approval said.
After World War One the city of Selmecbánya was annexed to Czechoslovakia and the University moved to Sopron, West Hungary. University doctor titles in engineering were awarded by law in 1931 the first time and since 1949 the University is working in Miskolc, north-Hungary.

Since 1983 new faculties have been established: Law, Economics, Social Sciences, Humanities and Health Care. In addition, a Music School was attached to the University, thus the total number of academic staff exceeds 800 and the number of full-time students is over 14000 (2013). The skills of this vast source of manpower have been developed for more than 275 years, in part by this University and its forbears.

The UK story was ambiguous in this respect: British higher education was tardy in recognizing the importance of engineering mid-19th century. It was the great civic universities, Manchester, Liverpool, Leeds and Sheffield, cities founded on the prosperity of the First Industrial Revolution, which knew that wealth and well-being were fundamentally linked with engineering.

Thus symbiosis between university and industry was getting started and some interesting mile-stones are drawn from the history of Academia Montanistica and described below:

1. Professors gained a Scientific Advisor position to the mines simultaneously with their professorial appointment and this was the reason why its professors’ salary led the income list in Europe. A unique example is Christian J. Doppler (1803–1853), the world-famous physicist, who selected also Selmecbánya in 1847 to teach there for some years.

2. Alessandro Volta worked in the laboratories for several months. In 1786 Fausto d'Elhuyar, who discovered a new chemical element, vanadium, also visited the Academy and almost all leaders of French mining and metallurgy made extended study tours. And what is more, professors came from Germany, Austria, Italy and the Netherlands.

3. Visiting professors were also welcome, from Sweden and Russia, for example.

4. Professors were active in research and innovation; a new amalgamation process discovered by Ignatius Born is a typical success story.

An interesting example reflects a link between music and engineering: I. Born invited Wolfgang Amadeus Mozart, a colossus among composers, to teach his children on how to play musical instruments well. Oral tradition still holds that he served as a model for Sarastro’s role in Mozart’s opera, “The Magic Flute”.

5. Another group of professors searched for and discovered new crude oil fields in some countries, e.g., H. Böckh (1874–1931) did it in Albania, Guatemala, Iraq, Trinidad and Venezuela.

This paper based on the authors’ research output presents the vivid link between university and industry and the important role of such partnership in knowledge-driven economy. Case studies extracted mainly from University of Miskolc, the authors are working with, moreover experiences of Hungary, Europe and other continents, all illustrate the real world. Trend by 2030 and further tries to make the readings more colorful.

2. Role of University and Industry in Knowledge Generation

2.1 Birth of International Societies and Conferences with Emblematic Leaders of University and Industry

1. International Societies established for various disciplines serve as excellent forums for industrialists, researchers and teachers to exchange views and ideas on professional topics, collecting and emphasizing innovation and advancements.
One of the first events is worthy of note when I. Born of the Academy in the late 1780s organized “Societät der Bergbaukunde” — German was the language of teaching — (Society for Mining and Metallurgical Engineering) which had rather soon members from 15 countries like J. Watt, A. L. Lavoisier, even the well-known poet, J. W. Goethe who was simultaneously working as scientist in mineralogy and optics and many from aristocracy of scientific talent.

(2) Societies and/or institutes on science, engineering and technology organized regular international conferences and some paved the way for today’s Conference series in cooperation with economic life.

One unforgettable example linked to university-industry partnership is extracted from the first International Electrical Congress which was held in Chicago the USA in August 1893. Some sentences are cited below from the journal Electrical World Vol. XXII. No 10 of 1893 to illustrate the Congress on a large-scale environment:

“Never before in the history of the New World and, it may probably be added, never in any part of the Old World, have so many famous investigators in the domain of electricity — electrical engineers and thinkers and writers of national and international reputation — been gathered at one time under the same roof…. College professors are not generally supposed to be particularly noted for their executive qualities.

… It is the glory of all science that it works not only to discipline and enhance the intellectual advancement of men, but it also confers practical benefit, and it is the peculiar glory of electrical science, that studies it, delves in it merely for mental discipline, and you will find it one of the best exercises imaginable…. It is almost a universal science.”

2.2 Great Names in the Full Glare of Publicity

(1) Great names of professors, scientists, researchers and/or inventors are borne by several international derived measuring units used in science, engineering and everyday life to remember them with this specific laudatory.

(2) The words volt, ampere and watt — particularly named after A. Volta, A. M. Ampère and J. Watt — refer to emblematic figures of university and industry. They are in common parlance among people in civilized and some developing countries, although their excellence in engineering are not entirely known by the general public. The Gauss-Weber absolute system, the forerunner of centimeter-gram-second (C.G.S.) system, had a short period only.

There were two general systems of mechanical units, the English and the metric. The metric system is based primarily on prototype standards of length and of mass recognized by the International Metric Convention signed in 1875 and ratified in 1878. The centimeter-gram-second (C.G.S.) system of units was a development of the metric system in which the three units named are taken as fundamental. It was used in scientific work throughout the world. However, electrical and electronics science has been burdened by C.G.S. system and could be eliminated by the adoption of meter, the kilogram and the second (M.K.S.) and the adoption of one of the practical units, such as the ampere, as a fourth fundamental unit and therefore many scientists said M.K.S.A. system (1950).

The current International System of Units, SI derived from the French initials for Système International d'Unités, added three other fundamental units to M.K.S.A., the Kelvin (thermodynamic temperature), candela (luminous intensity) and the mole (mol, amount of substance). The system was adopted by all civilized countries of the world from around the 1980s.

The SI and also earlier systems gave great names to international derived measuring units which are summarized in Table 2.
Table 2 Great Names in Science and Technology Highlighting International Units of Quantities

<table>
<thead>
<tr>
<th>Quantity term</th>
<th>Symbol</th>
<th>Unit and abbreviation</th>
<th>In commemoration of great names</th>
<th>Known for world-wide recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric current</td>
<td>$I$</td>
<td>ampere, A</td>
<td>André-Marie Ampère (1775-1836), French</td>
<td>Electrodyamics</td>
</tr>
<tr>
<td>Thermodynamic temperature</td>
<td>$T$</td>
<td>Kelvin, K</td>
<td>Sir William Thomson Lord Kelvin (1824-1907), English</td>
<td>Electrodyamics, Thermodynamics Thomson bridge</td>
</tr>
<tr>
<td>Temperature in centigrade system*</td>
<td>$T$</td>
<td>Centigrade, °C</td>
<td>Anders Celsius (1701-44), Swedish</td>
<td>Centigrade (Celsius) temperature scale</td>
</tr>
<tr>
<td>Temperature in Fahrenheit system*</td>
<td>$F$</td>
<td>Fahrenheit, °F</td>
<td>Daniel Gabriel Fahrenheit (1686-1936), German</td>
<td>Fahrenheit temperature scale</td>
</tr>
<tr>
<td>Force</td>
<td>$F$</td>
<td>newton, N</td>
<td>Sir Isaac Newton (1642-1727), English</td>
<td>Founder of theory of physics, Newton’s Laws</td>
</tr>
<tr>
<td>Work or energy</td>
<td>$W$</td>
<td>joule, J</td>
<td>James Prescott Joule (1818-89), English</td>
<td>Thermal effect of electricity, conservation of energy</td>
</tr>
<tr>
<td>Power</td>
<td>$P$</td>
<td>watt, W (joule/second)</td>
<td>James Watt (1736-1819), English</td>
<td>Steam engine</td>
</tr>
<tr>
<td>Pressure in fluids and gases</td>
<td>$p$</td>
<td>pascal, Pa</td>
<td>Blaise Pascal (1623-62), French</td>
<td>Pascal’s Law, barometric pointer</td>
</tr>
<tr>
<td>Charge or quantity of electricity</td>
<td>$Q$</td>
<td>coulomb, C</td>
<td>Charles Augustin de Coulomb (1736-1806), French</td>
<td>Coulomb’s Law</td>
</tr>
<tr>
<td>Voltage Difference of potential Electromotive force</td>
<td>$V$</td>
<td>volt, V</td>
<td>Alessandro Giuseppe Volta (1745-1827), Italian</td>
<td>Volta’s pile, voltmeter</td>
</tr>
<tr>
<td>Frequency</td>
<td>$f$</td>
<td>hertz, Hz (cycle/second)</td>
<td>Heinrich Rudolf Hertz (1857-94), German</td>
<td>Electromagnetic radiations in the ether, behaved like waves of light</td>
</tr>
<tr>
<td>Resistance</td>
<td>$R$</td>
<td>ohm, Ω</td>
<td>Georg Simon Ohm (1787-1854), German</td>
<td>Ohm’s Law</td>
</tr>
<tr>
<td>Conductance</td>
<td>$G$</td>
<td>Siemens, S</td>
<td>Werner Siemens (1816-92), German Industry magnate, inventor</td>
<td>Direct current generator, electric locomotive</td>
</tr>
<tr>
<td>Magnetomotive force (in C.G.S. system)</td>
<td>$mmf$</td>
<td>gilbert, Gb</td>
<td>William Gilbert (1544–1603), English</td>
<td>First experiments with magnetic phenomena, introduction of “electrical” word</td>
</tr>
<tr>
<td>Magnetic field strength (in C.G.S. system)</td>
<td>$H$</td>
<td>Oersted, Oe</td>
<td>Hans Christian Oersted (1777–1851), Danish</td>
<td>Relationship between electricity and magnetism</td>
</tr>
<tr>
<td>Magnetic flux (in C.G.S. system)</td>
<td>$Φ$</td>
<td>Maxwell, Mx</td>
<td>James Clerk Maxwell (1831–1879), Scottish</td>
<td>Maxwell equations</td>
</tr>
<tr>
<td>Magnetic flux density or Magnetic induction</td>
<td>$B$</td>
<td>Tesla, T</td>
<td>Nikola Tesla (1856–1943), Serbian-American, worked in the US and two years in Hungary</td>
<td>Tesla-transformer in electrotherapy, alternating current power system</td>
</tr>
<tr>
<td>Magnetic induction (in C.G.S. system)</td>
<td>$B$</td>
<td>Gauss, G</td>
<td>Karl Friedrich Gauss (1777–1855), German</td>
<td>Gauss-Weber electrical quantity system, Mathematics</td>
</tr>
<tr>
<td>Magnetic flux</td>
<td>$Φ$</td>
<td>Weber, Wb</td>
<td>Wilhelm Eduard Weber (1804–1891), German</td>
<td>First electrical quantity measurement system with Gauss</td>
</tr>
<tr>
<td>Radioactivity of a source</td>
<td>Becquerel, Bq</td>
<td>Antoine Henri Becquerel (1852–1908), French</td>
<td>Nobel Laureate for radioactivity</td>
<td></td>
</tr>
<tr>
<td>Absorbed radiation</td>
<td>Gray, Gy</td>
<td>Louis Harold Gray (1905–1965), British</td>
<td>Effects of radiation on biological systems</td>
<td></td>
</tr>
<tr>
<td>Biological effect of radiation</td>
<td>Sievert, Sv</td>
<td>Rolf Maximilian Sievert (1896–1966), Swedish</td>
<td>Sievert chamber, Sievert integral</td>
<td></td>
</tr>
<tr>
<td>Older unit of radioactivity</td>
<td>curie, Ci</td>
<td>Marie Curie Sklodowska (1867–1934), Polish-French</td>
<td>Nobel Prize for polonium, radium</td>
<td></td>
</tr>
<tr>
<td>Sound pressure and energy</td>
<td>decibel, dB</td>
<td>Alexander Graham Bell (1847–1922), English-American</td>
<td>Telephone system transmitting the human voice</td>
<td></td>
</tr>
</tbody>
</table>

* Although the Celsius or centigrade system (°C) is now officially in use, many people continue to refer informally to degrees Fahrenheit which is still used in the United States for non-scientific purposes. Source: the authors, 2013.
The world of science dedicated the great names of the inventor to the respective theorem, law, phenomenon, etc. Few examples reflect this ordinary custom but we can list hundreds:

Napierian or natural logarithm is named after John Napier or Neper (1550–1617), English professor and the unit of signal transmission was neper (n) or decineper (dn) which is in correlation with decibel: 1 dB = 0.115 n).

Daniel Bernoulli (1700–1782), Swiss professor’s name was given to his equation in fluid mechanics.

Christian Doppler’s name is still alive in medical science (Doppler-effect) and in engineering (Doppler velocity and position — Dovap).

Gustav Robert Kirchhoff (1824–1887), German professor invented two laws for easy computation of electric circuits.

Heinrich Friedrich Emil Lenz (1804–1865) was native German but worked mainly in Russia. Lenz’s law refers to the electromagnetic induction, and implies both a cause and an effect opposing the cause.

Some education and research programs in Europe great names of significant professors and scholars, e.g., Erasmus for staff and student mobility schemes, Marie Curie Initiatives and awards for researchers’ mobility, Descartes Prize for young scientists, and Galileo for a specific European Space Research Program remind us of their talent.

The founder’s great name is written generally in the logo of industry and university, e.g., Henry Ford, Adam Opel, Robert Bosch, Nicholas Brown, John Napier and James McGill. And what is more, great names of economic life and university found in many cities world-wide to distinguish streets, avenues, parks or squares.

3. Modern Partnership Needs Knowledge-Driven Industry

3.1 Industry Viewed from Partnership Aspect

There are two different trends observed since the last quarter of the 20th century in the world as the globalization of economy and the fast improvement of small and medium sized enterprises (SMEs). The largest 100 multinational firms/companies/industries serve as a dominant empire providing 33% of the world-economy rate, 40% of world trade and 75% of industrial products of the world. In addition, 75% of research and technological development (RTD) belongs to the highly developed OECD countries. SMEs being closer to general public serve people’s everyday need and thus employ 70% to 80% of labor force in much industrial fabric of European countries (2010).

The central idea behind the creation of a single European market was and remains the creation of an economic space capable of meeting the challenges and threats presented by the leading economic powers; that is, the United States, Japan and from the last decade of the 20th century the Asian “tigers”. In strictly business terminology, the European Union is to apply, on a massive scale, the logic of economies of scale\(^1\) by providing easy access for commercial enterprises to a potential market of 550 million people, a population much larger than either the United States or Japan.

European industry viewed from the partnership aspect has some particular characters:

(1) While 550 million people are a huge potential market, the Maastricht Treaty on the European Union was not a simple date in history that will suddenly and miraculously provide a single consumer market. The European Union is still the amalgam of 27 (and 28 since July 1, 2013) individual countries and cultures, thus providing

\(^1\) Economies of scale imply that the unit costs of production decrease as the cumulative volume of production increases.
psychological barriers much more difficult to solve than the existence of legal obstacles.

(2) Easy access for all companies to innovative technology as well as the increasing sophistication of the consumer is gradually eroding the traditional competitive advantages such as economies of scale, thus intensifying competition and forcing businesses to seek new ways to compete.

(3) Increasing pressure from the consumer is forcing businesses to take a more socially conscious approach to the implementation of their respective strategies.

(4) Expanding beyond the borders of Europe, the internationalization of the world’s markets and the tendency towards globalization are undeniable factors in the conduct of business, be it of a multinational or of a domestically-orientated company. Large Union industries for their sophisticated and expensive products can find new market in rich Far East countries only, e.g., Siemens super-fast maglev (magnetic levitation) train in Shanghai. Manufacture European Union products in Far East countries concluded in higher unemployment rate in Europe and contributed to the economic crisis of the world since 2008.

(5) With the accession of 12 new members to the European Union in less than a decade (2004 and 2007), the scale and scope of the new Europe has suddenly changed. These new members are a special challenge: an untapped pool of talent, a new market, universities of long tradition, but by and large an infrastructure impoverished by decades of under-investment and in some cases old-fashioned management.

(6) The “fifth freedom” — the freedom of knowledge across borders within the EU — is becoming integrated into the existing rights of people, capital, services and goods to move freely. By 2030 an open, fair, genuine single market for innovation will pull new ideas, talent and investment from around the world.

(7) The challenges facing the European economy integrate climate change, energy supply, water resources, ageing of western world’s population (demographic challenge), healthcare and sustainable prosperity for all.

(8) In future, Europe’s added value would be based on the new knowledge created within the European Research Area.

(9) Europe is told to be the richest continent (2010 — Boston Financial Consulting Group and others). The second one is the United States although the difference between Europe and North America is small, then Asia is coming up. In addition, Japan and the Pacific Rim are developing very fast: the investments for national economies are double to the world average rate. The system of world economy will be changing: the world trade in the South is developing continuously; today China is the No.1 trade partner of Brazil, South Africa and India. The political significance of these countries will be emerging and observed rather soon (Figure 3).

3.1 Internet Companies

From mid-twentieth century with the appearance of the globalization era new enterprises emerged mainly in information and communication technology, with close link to universities. One of them is technology start-up which is a knowledge-intensive enterprise, begins working, running with small investment of capital and intellectual innovation and achieves fast growth.

Another new enterprise is spin-off which separates a university, similar to start-up, thus based on intellectual work. Benefit or product is produced incidentally from a larger process, or while it is being developed.

Digital communication is a revolution not only in high technology, but personal communication among people. The Internet accounted for 4.7% of the US gross domestic product in 2010, compared with 3.8% for the EU-27 (Boston Consulting Group Report 2012). While in Europe the Nordic region, the Netherlands and the UK generally performed well, southern countries lagged considerably behind the average.
And the benefits of the Internet continue to accrue disproportionately to US companies like Facebook, Apple, Amazon, eBay and Google which often have more dominant positions in Europe than they do in the US. Facebook measures its success by the 900 million monthly users it has around the world, who “Like” things or write a comment 3.2 billion in advertising sales and gaming for the site (2011).

As Europe wrestles with the Euro (€) crisis and struggles to recover from a deep economic slump (still in 2013), it desperately needs technology start-ups to spur employment and generate growth, because big companies are more likely to be shedding jobs. Policy makers from one European country to another, gaze enviously across the Atlantic, where the dynamism of the US high-technology sector provides hope for the future, despite the economic woes. The public offering of Facebook (2012), a company conceived in a Harvard University dormitory provides a timely reminder.

The solution is available: capitalizing on the innovation space will be the key to Europe’s future economic growth, and this is fuelled by small companies (Report of European Investment Fund). Europe has made high-technology innovation a cornerstone of its policy-making; it is in the focus of the Europe 2020 agenda as well.

The recent success of emerging European Internet companies shows that Europe can deliver innovation on a global scale, e.g., Finland — “Angry Birds”.

Over the past years, start-up activity has heated up in Berlin, which has joined London as a European capital of digital innovation.

3.2 European Internet Ventures

The reasons why Europe has not managed to create a Facebook or a Google are complex according to entrepreneurs, investors and analysts. The categories of reasons summarized in five points:

1. European start-ups have been too focused on copying Silicon Valley ideas.
2. Europe lacks the necessary entrepreneurial get-go.

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2 Name Google comes from a somewhat forced interpretation of the word googol which means 100th power of 10.
(3) The fragmentation of European markets, with dozens of languages and legal systems, stymies even the most energetic.

(4) An overriding problem is a shortage of financing, especially private capital, for the risky business of starting and growing high-technology companies.

(5) There is a lot of competition, thus a lot of energy, innovation, talent and enthusiasm needed. Compared with the United States, there is not as much money to draw from in Europe because of a lesser reliance on private pension funds. Many European investors are also growing wary of venture capital after they were burned in the dot-com bust, heightening a European aversion to risk-taking.

While the US government provides support for start-ups and small businesses, Silicon Valley venture capital funds are more likely to be oversubscribed than looking for money.

European policy-makers are also stepping up efforts to develop clusters of high-technology innovation from the ground up. The idea is to replicate the Silicon Valley ecosystem, where entrepreneurs, researchers, financiers and large pools of employable talent are all in close proximity.

US venture investors are to step up their activity in Europe, attracted by lower company valuations than the sometimes sky-high levels in Silicon Valley. US investors tend to be more interested in European ventures that are already up and running.

Since 1980 until the end of 2012 there have been about 2400 technology, Internet and telecom initial public offerings (IPO) in the world. On the first day of trading the average share price rose around 30% above its offer price. However, most companies had negative returns after three years and many companies had a checkered performance beyond that.

4. Two Parties of Healthy Partnership — Strengths and Weaknesses

4.1 Players of Knowledge-Market

(1) There are two significant parties of the “knowledge-market” • university supplies new knowledge, i.e., talent and ideas, and • industry are in demand as a consumer. The market also benefits from the input of practitioners from both industries and universities.

(2) Industries, or more generally the companies, for their part, formulate through their representative bodies, positive policy for developing partnership with universities. They have an organized interface with higher education at all levels — BSc, MSc, even PhD — in order to promote and facilitate dialogue/consultation. They also have an explicit education and training strategy linked to staff development within the company. They should be prepared to play their part in training for the overall good of industry and in the interest of stabilizing the labor market as well as in their own immediate interest. Companies do and must also accept (as is the case for a number of European Research and Technological Development projects and consortia) that involvement in consortia can lead to transfer of know-how as between companies, but that this does not threaten their position (excerpts from European Commission Memorandum on Higher Education).

(3) University, the other party has done much to support the public service research and technological development function in industry by the establishment of liaison and arrangements for technology transfer and scientific advice. The education and training requirements have not, however, been equally well catered for. One of the reasons for this is that companies frequently require a total training provision going from top to bottom of the company and this cannot be supplied by a single institution. Also employees cannot always be released in a
regular manner from work responsibilities and therefore a more flexible training arrangement is required.

Most universities engaged in partnerships are motivated “learning by doing” or “learning by research”, and sometimes lack academics with experience in industry or the proclivity to network outside their area of expertise.

(4) In the European context cooperation between university and industry has been fostered in the first instance through education (curriculum development and examinations’ board), research and technological development programs (three types of partnership).

(5) Partnership in Europe generally runs smooth, however, the walls between industry and university are still too high; mobility of staff between them is low. Europe’s past failures at innovation are true, thus a robust whole-business model for researchers and industrialists and an integrated innovation system in order to strengthen the “put-through” capacities are needed. When large international companies look for a site a research facility, they look not only for major markets, but also for a strong research and competence base. Yet to date, the fact was ignored that proximity of competences matters (European Research Area Report–2010).

(6) Another weakness is the average rate of industry participation, e.g., within the 7th European Science and Technological Development Framework Program (FP7–2007-2013) was around 30%. The participation of industry is a question of the challenges faced by different sectors. When objectives of research are very important for European industrial competitiveness, they should be industry-driven. Often European projects do not respect that priority. They are coordinated by universities or other research organizations which are collecting support from industrial corporations. The opposite situation was more frequent in the first European Framework Programs in the 1980s. Throughout Europe industrial participants say that they are not in the driving seat anymore. The prime question is the role industry can play in the implementation of the European Framework Programs.

4.2 University Modernization

Today’s universities largely embrace a model of higher education developed over 100 years ago. A new vision should include producing the highly skilled workforce for a globally competitive economy. The university in the 21st century should be viewed not just as a generator of ideas but as a source of knowledge and competence that can benefit society.

University modernization in parallel with industry renewal is moving everywhere in Europe since the mid-twentieth century, though not without economic and financial crises, as still in many European universities (2012). Thus a broad consensus exists on

(1) the need for universities to be given genuine autonomy, with greater responsibility,
(2) to enable them to fully initiate policies of excellence and encourage their communities and
(3) to adopt a culture of results and social contracting.

Responses to the demands include the need • to pursue a pioneering role in fundamental (basic) research, • to open up to new sections of the population and • democratize education, • to train researchers, • to capitalize on their research results, • to fulfil missions of expertise, and • to be more firmly rooted in the local socio-economic and cultural fabric (European Commission’s conclusion).

For this reason the League of European Research Universities (LERU) would like to see a university system characterized by “excellence in research” and “excellence in diversity”. We should add “excellence in teaching” and “excellence in the new mission (3)”. This would empower universities to make the most of their specific assets and to formulate their missions accordingly.

(1) A first type of universities concentrates on fields of applied research and on forging close links with
industry, business companies and regional bodies. 

(2) A second type, specialized in first cycle (BSc) education, concentrates on teaching a wide range of courses/subjects.

(3) A third type of universities with a large ratio of doctoral students contributes to fundamental and blue sky (curiosity-driven) researches. In some European countries, e.g., in Greece 80% of fundamental research is performed at universities.

(4) A fourth type of universities giving priority to frontier (high-risk) research probably will be emerging because Europe provides huge financial aid for this purpose by 2030.

Whatever the university specialty is excellence needs to be a common characteristic of universities. On that, all stakeholders are agreed. There is a need to “identify the areas in which different universities have attained, or can reasonably be expected to attain, the excellence judged to be essential at European or international level — and to concentrate on them the funds to support academic research.” (European Commission notes).

Among other things, this must involve increased inter-disciplinary. “It is crucially important to maintain and strengthen the excellence of teaching and research, without compromising on quality, while still ensuring broad, fair and democratic access.” (Euroscience — European Association for the Promotion of Science and Technology).

4.3 New Climate of Partnership

The convergence of interests of both parties helps create a new climate of partnership which originates from companies. These companies are • faced with developing structured training programs for their employees and for the users of their products and they are increasingly • involved in research and development at a level equal to or surpassing that in higher education are taking on many of the characteristics of higher education institutions.

This environment is reflected also in altered management styles which encourage team-work and foster creativity and entrepreneurship at all levels. This partnership will support the emergence of knowledge and learning society where an individual's daily activities, in and out of the workplace, constitute part of a learning process and knowledge application.

Partnership implies an equal and open relationship where a fair value is set on the services given by both sides. It must also recognize the differences between the primary functions of the parties:

(1) teaching, public service research linked to business innovation (two basic missions where new knowledge generation and transmission are dominant) for university and successful partnership concluded in

(2) creation of new products, processes and services (output—added value here knowledge generation governs everyday practice) for industry.

The definition of the nature, extent and obligation of such partnerships calls for a consistency of approach both from universities, from industry and in specific topics from worker representatives, e.g., concerning work safety, wages, on-the-job training and lunch break (Figure 4).

Major efforts have been made, frequently encouraged by the necessity to cope with practical situations and with a real concern for foresight. For job seekers who have already had a professional activity, experience has shown that re-conversion problems are better solved when they are anticipated.
The example of a number of companies who have implemented re-conversion operations (possibly leading to diplomas), sometimes months or years before a reduction in the workforce materializes, demonstrates the benefits of formulas which undoubtedly require public assistance, but also a confirmation of their will and commitment.

Universities generally adopt cooperation with industry (Figure 4) as a fundamental part of their two basic missions — teaching and public service research with business innovation — and are generally ready to adapt their structures of courses and qualifications and the methods of course delivery to support this cooperation.

A bright picture on industry serving as producer and consumer of university product is illustrated by a new teaching and research unit “Robert Bosch” Department of Mechatronics at University of Miskolc initiated and funded by the German Bosch GmbH multinational. Its operation began on 1 July 2005 with the involvement of four Bosch subsidiaries working in Hungary. In the field of mechatronics programs for all three cycles — undergraduate, graduate and PhD — are running with the utilization of new hydraulics, pneumatics and sensor application and in addition laboratories are built up in which scientific research is also carried out. Bosch industry enjoys priority in the selection of the best graduates.

Creating more strategic industry-university partnerships will substantially improve Europe’s climate for innovation. The agenda for the modernization of Europe’s higher education systems has made it a priority to strengthen the links between higher education, research and business to drive innovation. The future academic staff and student’s mobility programs of the Union on education (Erasmus for All) and research and innovation
(Horizon, 2020) will ensure that such interactions are fostered and fully exploited.

4.4 Training Needs of Industry

To meet the training needs of industry universities will have to work together with other institutions and training agencies — networking — and develop the systems necessary for flexible delivery.

(1) One typical example is customized education. At the origin of vocational education the programs were tailored for a custom fit as presented by Academia Montanistica (1770). The origin of today’s customized programs is that corporations, which want to see visible returns on their investment, are seeking programs that address specific needs and goals, therefore companies are making a larger investment in their senior executive ranks. Thus, there is increasing demand for programs that are closely aligned with company strategy while addressing specific business challenges.

This objective has meant an increase in the complexity of program designs that often extend over several months, geographies and involve various teaching/learning methodologies like action-, problem-based learning as well as information and communication technology even digital media application.

Non-degree programs for midlevel and senior managers have been growing for decades. Customized courses are growing faster than open enrolment programs, which have a general curriculum and students from a variety of companies particularly at US and some European universities in partnership with industry (2012).

(2) Success of industry staff development programs is observed by using advanced social media technologies. Successful and celebrated attempts adopt social media technologies into industry, more specifically large-scale engineering organizations which have invested significant amount of time and resources into the development of customized applications.

(i) One group of firms uses social media for innovation and new product development and is concerned about how to capture the knowledge of a retiring generation, with around 30–50% of its workforce eligible to retire in the next 5–10 years.

Most of the contributors to their social media blogs, open to all employees, are members of their workforce aged over 40 years which underlines more experienced employees possess more knowledge to contribute.

(ii) The goal of another group was to facilitate a greater level of collaborative knowledge transfer within the firm, thus it established social media websites which increased collaboration within and beyond organizational boundaries.

It is a user-driven initiative triggered with the desire of one employee to improve collaboration and communication with colleagues. Vast majority of employees participate in social networking application, while there are around 5–10% content contributors.

(3) A particular field of staff development embraces small- and medium-sized enterprises. Many universities of economically and demographically heavy-weight European countries — the UK, Germany, France and Italy — lead the list of course conduction in advanced technology for SME employees generally on weekends. New knowledge gained inspire them to participate in European research programs like Eurostars adjusted to the needs of innovative SMEs.

(4) When companies and universities work in tandem to ensure the free movement of knowledge and researchers (the Fifth Freedom in Europe), they become a powerful engine for innovation and economic growth. This is the symbiosis of which the output is the successful partnership and joint benefits.
4.5 Joint Steering Committee

(1) The vital criterion for any type of collaboration is that university heads (vice chancellors or rectors) should make industry-university partnership a strategic priority and communicate the message regularly to the entire academic community. Strategic and other significant partnerships need input at the highest level from both the company and the university.

Once a potential industry partner is in view, universities should engage with top management. Academics need a relationship with someone who is senior enough at the company to allow strategic issues to emerge and to be addressed in research.

(2) To understand the key challenges on science, engineering and technology companies are seeking to answer, universities should create advisory boards of executives from selected industry sectors where they are well positioned to develop partnerships within the newly set-up Joint Steering Committee. Creation of a Joint Steering Committee including senior academics and industry executives with invited worker representatives helps the partnership efficiently. Senior executives and university principal academics should map out together the key questions and research challenges that mean high priority for both. Sufficient high-level exchange of information and brainstorming helps enable common areas of interest to emerge.

(3) In emerging economies multinationals are ready to build a subsidiary in agreement with the host national government. Primary prerequisite is generally the proximity of engineering college/polytechnic or university for a partnership establishment. Such development is picturesque in Hungary where Daimler Benz, a global car manufacturer is working in the city of Kecskemét region collaborating with the Polytechnic there. Opel and Audi automobile industries in Győr region — West Hungary — have link with Széchenyi University and Takata Automotive Safety Systems of Japan in Miskolc-Region is in coming partnership with University of Miskolc.

In such cases, University Senates serve as a top Joint Steering Committee involving Head of respective University and Chief Executive Officer (CEO) of subsidiary establishment from scratch and all concentrate their efforts to conclude in strong partnership.

Universities examine the scope for involving industrialists and worker representatives to a greater extent in their work, through participation in Senates, Joint Steering and other Committees and advisory structures. As far as subsidiary of multinationals in emerging economies is concerned, University Senate having top executives among its members serves as actual decision-making committee. They develop appropriate structures for interaction with industry at a business level which can handle the external market for training and other university services.

(4) This newly formed Joint Steering Committee which meets regularly encourages strong two-way communications between academics and senior company officials (Figure 4). The chair follows up regularly with senior members to keep the dialogue flowing and encourage impromptu feedback on the project from both sides at any time. Two-way exchanges will be developed to build a substratum of academics who understand industry on how knowledge is transferred to advanced technology and generate new products or systems. Universities encourage professors to work in industry and invite industry executives and researchers to teach.

(5) The goals and benefits of partnering help Joint Steering Committee familiarize the entire academics with:

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3 The term "emerging economies" mean countries that are developed in some sectors while facing the problems of developing countries in others.
• incentives to be designed for university academics and • resources to be provided to manage a cultural shift that does not undercut fundamental (basic) research but puts a clear priority on engaging with industry for mutual benefit and for the benefit of society in order to help drive economic growth are indispensable factors.

Partnership develops a broad overarching framework agreement and works out details on a case-by-case basis also by the instructions of Joint Steering Committee. A framework agreement saves time and avoids the acrimony that often results from too narrow a focus on who owns what.

(6) It should be manifest in areas such as continuing education, research and development, advisory and consultancy services and should also be • reflected in student and staff exchanges (study tours) and • in the structures for the flow of information from university to industry and vice versa. The conditions of engagement of university staff encourage and reward collaborative efforts with industry.

All in one, industry-university partnerships vary widely, but the executives and academics managing them agreed on the core elements needed to make a partnership work well.

International Organizations contribute to successful partnership: Science Business Innovation Board AISBL (the acronym AISBL is derived from the French initials for Association Internationale sans but lucrative — International Non-Profit Organization) in the Old World provides an important impetus at regional and Member State levels to continuing education, various training and manpower needs analysis and student placements.

A foregone conclusion includes three different types of possible partnerships which are classified since the early 2000s in strategic, operational and transactional categories.

(i) **Strategic partnerships** need a broad, flexible agreement. The new knowledge produced by the collaboration is likely to influence the university’s future research and teaching while leads to the third mission and a company’s long-term strategy.

(ii) **Operational partners** have one or more research projects with a division or particular research and technological development (RTD) laboratory and run generally for one to three years. They can be valuable for building ties that eventually move to transactional alliance, even lead to a strategic partnership.

(iii) **Transactional partnerships** are lesser interactions, such as when one or more executives to agreeing to teach courses even for years, which may lead to doing more and bigger projects together in the future and many other joint activities are running. Ties can lead to operational collaboration and these, too, can ultimately give rise to a long-term strategic partnership (Figure 5).

And what is more, university-industry partnerships have been grouped under four key categories regarding particular points of interest (Figure 5) also to policymakers, stakeholders, i.e., members of “error-detecting mechanism”:

(i) *A contributory advanced technology scheme*,
(ii) Partnerships that increased *funding streams for universities*,
(iii) Partnerships that put a *significant impact on teaching and learning*, and
(iv) Partnerships that prompted *a rethinking of the role of the research university*.

The first step to a healthy partnership is assessing the core academic strengths of the university and the core research competence of industry to identify promising opportunities for collaboration.
5. Strategic Partnership

5.1 Background

(1) For an elite group of world-class research universities strategic, long-term collaboration is top priority. The benefits looked to be obvious to these institutions: • substantial streams of external funding, • enhanced opportunities for professors, Ph.D. students and graduates to work on groundbreaking research, • vital input to
keep teaching and learning on the cutting edge of a discipline, and • the impact of delivering solutions for pressing global challenges.

The most productive collaborations are therefore strategic and work for long-term, five to ten years, deliver greater and often unanticipated benefits to all parties through a vicious circle of interactions.

(2) University partnership initiatives in the United States reflect the fact that American higher education institutions have spearheaded the evolution of large-scale industry-university collaborations. For strategic partnership Silicon Valley is a dramatic example. For over five decades, a dense web of rich and long-running collaborations in the region have given rise to new technologies at a breakneck pace, and transformed industries while modernizing the role of the university.

(3) The root of the university-industry partnership in Europe is that the Union does not have many strong centers of excellence, like Massachusetts Institute of Technology (MIT), Berkeley, Stanford, Columbia in the USA, which are leading academic research institutions. Industry cannot find these kinds of partners in the Union, but the EU established a separate European MIT, the new European Institute of Innovation and Technology (EIT) in Budapest, Hungary and reconciles the partners with the different approach and attitudes to public-private partnerships in Member States.

The EU simply must be able • to use the best universities in Europe, • to start strengthening them and • creating an incentive structure where they would have a genuine interest in collaborating with industry. This is the culture that Europe needs but is getting implemented.

(4) However, Europe also has many prominent and productive, strategic partnerships. There is an example: IBM’s — International Business Machine, a large computer company — new US$90 million nanotechnology center in Zurich which is the cornerstone of a new 10-year strategic partnership in nano-science between IBM and the Swiss Federal Institute of Technology (ETH Zurich) aimed at advancing energy and information technologies. Ties between the two parties run deep; the investment caps many years of partnership and thorough collaboration.

Takata Corporation of Japan, a leading global supplier of automotive safety systems, operating 56 plants in 20 countries (2013) with more than 36,100 employees, establishes a Hungarian subsidiary to build a new production facility in the city of Miskolc (2013). The high tech manufacturing plant will produce airbags and airbag components for car manufacturers in Europe and initiates a strategic partnership with University of Miskolc.

(5) Around the fourth quarter of the 20th century more research universities have been formed and a new, third role restructures universities; this third mission declares university to serve as source of competence and problem-solving for society. Thus, a knowledge-driven industry enters the stage a university of three missions.

5.2 Human — Grey Matter — Resources

The main attractions of strategic partnership can be integrated into three categories: human and materialized resources of university and open-knowledge institution.

(1) The substratum of human talent ensures the success of existing projects; it is also the key to developing future collaborations, thus human talents are always behind successful partnerships. Strategic partnerships are • built around a shared research vision and • may continue for a decade or beyond, • establishing deep professional ties, trust and shared benefits that work to bridge the sharp diverse engineering culture between academia and industry.

Above all, long-term alliances build the vital human capital (grey matter) needed to make the
University-industry collaborations work. It is the human ties, understanding and trust on both sides of the partnership that count most. Over time, a well-managed partnership produces a growing number of professors and postgraduate students who can (1) think and act across the diverse engineering culture, (2) connect with the key research interests of a company and (3) work harmoniously to define big and common strategic goals.

(2) The diverse engineering culture between universities and industries, a typical negative aspect runs deep. It continues to act as a brake on effective collaboration with the business world (Technopolis Study, 2011).

The cultural divide can be overcome, many experts believe, but it requires (1) strong and provident university leadership, (2) academics who understand business, and (3) incentives and structures for academics to bridge that gap. Many European universities could significantly increase their attractiveness to industry by making industry partnerships a clear priority and by developing a pool of academics who have worked in industry.

Collaborations only work well when they are managed by people who cross boundaries easily and who have a deep understanding of the two cultures they need to bridge this gap.

“It is individuals who understand both worlds — academia and business — that are the driving force behind successful partnerships” (study of the Swedish roller bearing global manufacturer, SKF Group).

(3) Personal ties can lead to the most creative and promising collaborations. Universities should create opportunities for academics and company researchers and executives with shared interest to come together and develop a dialogue/consultation. Informal exchanges over curriculum, lectures, teaching materials or seminars that bring both sides together can spark conversations and lead to new relationships.

A group of professors insist that, despite calls for universities to come closer to industry and generally business companies, their job are not to take over their role. For them this is a wrong path, which undermines universities’ fundamental mission to extend the areas of knowledge and to exchange innovative knowledge on an open basis with the world of entrepreneurship. Successful partnerships rectify the difference between two cultures of university and industry.

For most universities — even those with cutting-edge research — partnering with industry does not come naturally. Some European academics are not engaged in collaboration with industry and less than the required cooperate with industry or business to a high degree (Study on European University-Business Cooperation, 2010).

Both parties should determine the success or failure of industry-university partnerships. To attract industry involvement, universities must have specialists capable of building and managing partnerships. If some industry executives graduated at a partner university, success would be guaranteed (the authors’ experiences).

5.3 Open Knowledge Institution — European Reform

University programs need to be strongly orientated toward helping solve the scientific and technological challenges that companies should respond to. That means breaking down barriers inside the university and engaging academics who have industry experience (Open knowledge institution).

As far as human and materialized resources of university are concerned universities must also become more open to giving people leading positions who bring more than just a research pedigree. They need multidisciplinary individuals who are mentors and bridge-builders.

A new European reform starts with the “open knowledge institution”. This is a model of the university, research institute or vocational center of the future: open to industry, politics and society at large. Knowledge, resources and people flow in and out of the campus and industry. These institutions must be autonomous from government, with the power to set budget, seek funding, set priorities and attract talent. University career
structures must change, so that excellence, not time served, is the criterion for advancement in research. Universities should not shrink from rewarding those that concentrate on teaching since they will inspire future generations in their subject.

For the university, industry provides a longer stream of secure funding that can bolster academic strength. They help modernize teaching and learning by fostering an exchange of ideas and developing people with the skills and competences needed as new innovations along with leading-edge infrastructure transform markets and industries.

Multinationals spend around 15% of their revenue on scientific research and technological development efforts (2012), pharmaceutical and automobile industries lead the list.

To improve leading-edge infrastructure a complete reference laboratory was equipped and continuously modernized by National Instruments, the world-wide known global industry, at the Department of Electrical and Electronic Engineering of University of Miskolc where relevant research projects, then full-day regular, on-the-job and other courses are designed and run since 2007. Advanced infrastructure is also available at other engineering departments. It also serves as a source for academic staff development program.

The world's leading technology multinationals have hundreds of strategic partnerships with universities. But increasingly, the trend is to narrow the focus on a handful of strategic partnerships that • aim higher, • receive significantly greater funding and • last longer. These partnerships increasingly will drive richer benefits to fewer universities.

However the reverse trend also observed: new multinationals are born year by year and, e.g., universities of BRIC countries (Brazil, Russia, India and China) are emerging partly due to such partnership (Figure 3). Hungary has also new investors, e.g., Daimler Benz opens up new partnership with Polytechnic at Kecskemét, mid-Hungary, University of Miskolc has fruitful link with National Instruments, Technical University of Budapest with global telecom companies and Széchenyi University Győr, west-Hungary with Opel and Audi automobile manufacturers.

5.4 Endeavour from Fundamental to Applied Research

Endeavour from fundamental (basic) to applied research cannot perform overnight. However, the growth of strategic alliances reflects the evolution of corporate research and technological development (RTD) away from fundamental research toward applied research that is much nearer to the company’s immediate needs.

As a result, • a gap has emerged in industries' ability to peer into the future, and • industry is increasingly turning to universities to know what is going on and what to do with the frontier (high-risk) research. High-risk research will enjoy 50% of European research funding by 2030 reflecting this sector's importance.

International conferences help both parties exchange their views and conclude in joint vision and agreement.

6. Indicators for Partnership Evaluation

(1) Measure the partnership in metrics is a delicate question although joint projects should have well-defined objectives. There are quite different and ambiguous points of view:

(i) One expert group says that industries and universities should avoid trying to measure the value of an industry-university partnership in metrics such as the number of papers published and/or patent applications filed. The quality and nature of scientific breakthroughs vary, and volume does not automatically equate with value.

(ii) The second opinion agreeing to some extent with the European stand point is just the opposite referring to
World University Rankings which prefer cited publications and patents filed. And when research ranks are qualified the number of publications and patents plays vital role. An international slogan, what Europeans also frequently cite, says: “publish or perish”.

It is not easy to take the problem at the horn because European publications may be more numerous, but they are not the most cited, and that is the criterion that traditionally measures the true impact of scientific research. Of the 10% most cited publications, a clear majority are US publications. The reason for this is the lack of thematic specialization on the part of European research. While the EU puts in a respectable performance in all fields, it is dominant in none of the most dynamic sectors. The United States dominates in the biomedical field and Japan is the undisputed leader in material sciences; the EU does a little of everything.

Whilst the EU is ahead of the United States in terms of number of scientific articles published, the lion’s share of citations and articles appearing in influential scientific publications remains the prerogative of the US.

A lead ranking of the European Research Area: (i) first for the number of scientific publications and (ii) second (behind the United States) for the number of patents registered and money invested in RTD.

It is these NBIC which stands for the initials of Nanotechnologies, Biotechnologies, Information and communication technologies, and Cognitive science (nano-bio-info-cogno) that are crucial for the future of the knowledge-driven economy. In these fields, applications are close to, indeed often inextricable from, the production of new knowledge.

(iii) Intellectual Property (IP) is important but it should not be observed exclusively as the centerpiece of industry-university partnership (a third expert group statement). Instead of a narrow focus on IP as income source, universities should be engaged in providing solutions for the partner industry — the income stream will be greater and benefits wider.

(iv) A fourth study reflects company executives who tend to walk away from universities that have too inflexible an approach to intellectual property, no matter how good the science.

(v) The role of IP looks to be overemphasized, says a fifth group: the true value in research and technological development is often the tacit knowledge it produces.

(vi) The sixth different view coming from executives for research and technological development — pharmaceuticals lead this list — declares patent filing an obstacle to technological development because a lot of grey matter resources should be used to scrutinize respective patents, filing new and provide added value for the innovative product.

(3) Common agreement is that both parties, university and industry should focus on quality instead of quantity of output and select projects from the outset with a focus on excellent science through peer review of projects and funding. This builds in • quality control up front, • attracts industry investment and • ensures better results.

(4) In conclusion:

(i) the most fruitful strategic partnerships take time to bear fruit.

(ii) Setting up artificial metrics to measure them can undercut the alliance and fail to capture the unanticipated benefits that accrue when a strategic relationship is built on trust, structured well and managed by people who understand both worlds.

(iii) Long-term strategic partnerships focus the university’s creativity and talent on enabling future innovations that can be taken to market by industry and deliver benefits to society within five to 10 years.

(5) To strive for a partnership of equals with shared decision-making creates successful partnerships which
are based on a win-win situation for all the parties.

7. Operational Partnership — Research Projects for Building Ties

7.1 Research Projects on Professor’s Own Initiatives

Research projects on professor’s own initiatives (Figure 5) can be implemented in different ways. One case study from Hungary refers to a larger scale operating within the framework of the National Scientific Research Fund; the acronym OTKA is derived from the Hungarian initials for Országos Tudományos Kutatási Alap. It is managed, financed and evaluated by the Hungarian Academy of Sciences. This fund deals with both fundamental and applied research and mainly University Departments or consortia with research institutes and industries apply for grants. Talented, mainly Ph.D. students are also involved in such projects that have 2 to 4-year-duration.

This fund encourages academic staff for application because the grants provide sources for participation in international conferences, modernization of infrastructure along with laboratory equipment and involve students ambitious in the respective research field. UM runs 8 to 16 projects per annum generally for 3-year duration. Knowledge generation, transfer and brain circulation are targeted by all projects funded.

7.2 Students’ Individual Research Projects

Creativity and innovation capability can be developed particularly by motivation of students through individual research projects.

A case study from Hungary presents the Students’ Scientific Forum — or in another English translation Students’ Research Society — which has its acronym TDK derived from the Hungarian initials for Tudományos Diákkör. Its objective is • to stop the reduction of students’ enrolment in higher education and • to pave way for researcher career. Thus, both students and just new graduates whose calling is science, engineering and technology are invited to participate.

The project is launched as an extracurricular activity during the whole academic year just before the final examination is due. The best ones are forwarded to the National TDK Forum hosted by a Hungarian University on rotation every other year.

The medal in Latin “Pro Scientia” means “For Science” is the highest rank awarded to around 0.1% of total applications for top performances.

The year 1951 saw the birth of TDK with the participation of a few hundred students only. In the 2010s there are around 11000 applications submitted to the nation-wide TDK conference.

The students’ motivation, importance and success in participation of this competition are summarized in five statements below:

(i) There is a strong group, 8–12% of higher education students, who have talent in science, engineering and technology.

(ii) TDK serves European policy as to prepare society “scientific talent-friendly”.

(iii) Eight in ten prominent leaders on top positions in the country have been TDK participant even winner of medals.

(iv) Nine in ten Ph.D. students have participated earlier in TDK programs.

(v) TDK is revolving around the solid pillars of talent, knowledge and ambition.

Remember here that generally students’ creativity and innovation capability cannot be evaluated properly
apart from such nation-wide events since effective tests have not yet been available. However, the achievements of students contributing to national competition, innovation in industry, joint research output, patent applications, publications, etc. rank respective students and graduates.

7.3 Public Service Research and Business Innovation

Public service research and business innovation functions integrate all areas presented in Figure 5. Case study comes from experiences of University of Miskolc.

(1) University-attached research Institute on Applied Earth Sciences, plus a Regional Knowledge Centre on Logistics and Material Science and Uni-Flexys Enterprise Ltd dealing with business innovation and projects with industry are working. 60 to 90 academics participate in scientific research carried out by these units and 15 to 25 researchers deliver lectures or conduct laboratory and industrial practice for students each year.

(2) One unit of the research institute on applied earth sciences deals with controlled systems of gas storage and oil refinery stations. Thus it attracts MSc and PhD students in electrical, electronics and control engineering to participate in its research projects, provides and monitors industry practice by foreign students as well.

(3) A medium-scale research project initiated by material science departments has been involved for more than a decade in various materials testing in space cabins by telemetering within the umbrella of the European Space Agency.

(4) There is a new research group in cooperation with some Hungarian universities working for the help of disabled to develop a three-dimension speaking head which promotes learning process through the monitor to speak well-articulated way even transparent thus the tongue’s motion can be observed. For disabled who badly or do not understand at all the speech by their ears another project can develop speaking ability.

(5) Close collaboration is being established with two large research laboratories working in the region: “Z. Bay” National Research Institute for Logistics and Production Engineering — named after the Hungarian professor who sent radar signals to the Moon from Budapest in 1946 — and Nanotechnology Research Institute. Both researchers and academic staff cross the border to participate also in joint research project and conduction of courses.

(6) National research programs involve 30 to 50 joint research and technological development (RTD) projects initiated and implemented by department’s staff in all respecting engineering areas.

(7) The fifth freedom of researchers and knowledge is a vital benefit: 6 to 9 joint research projects a year are working together with few EU and third country universities and/or few enterprises for staff/student exchange and research program. They are in Switzerland, Ukraine, Russia, Canada, the USA, Turkey and co-operation is effective mainly in the fields of mechanical and electrical engineering, logistics, information technology, material science and technology, earth science and technology.

(8) A new non-profit small enterprise UNI-ENERGY established to exploit research potential in 2011 provides research and development service in electrical network diagnostics for industry and public institutions with university staff. The aim is to search for the quality of energy input, determine cost-cut, improve consumers’ efficiency, reduce even eliminate disturbances. Consulting engineering is also available in information technology.

Chances for new jobs in the latest decades are fairly good for new graduates: one young engineer can choose 3 to 4 jobs offered by partner and national industries.

Industry contribution to increase or at least maintain the number of new university entrants by offering attractive technical environment to industrial practice, contributing to the implementation of thesis is an
indispensable component. At the opening and closing ceremonies of each academic year the industry partners’ achievements are appreciated and various University medals awarded to 3 to 5 industry representatives.

UM helps industry creating more jobs for graduates by publicizing university-industry partnership through 30 to 60 projects a year, then by conferences, events and written and electronic media. Roughly 30% of revenue comes from research projects (2010).

8. Transactional Partnership — A Significant Impact on Teaching and Learning

8.1 Impact of Transactional Partnership

Universities seeking to form partnerships with industry to modernize teaching and learning generally should not insist on protecting intellectual property that comes out of that research. The key benefit to the university is the impact on teaching and learning from industry-based projects.

Innovation increasingly depends on the ability of university and industry experts to work together across a number of disciplines, such as technology, design and engineering even management. Encourage multidisciplinary academic programs and promote the engagement of industry in such programs are key criteria. Setting up a multidisciplinary institute on campus in partnership with industry can help break down traditional academic ivory towers and drive a new multidisciplinary culture and curricula.

Emerging technology is a specific component of industry-university collaboration to run 3 to 10 intensive in-service advanced training courses a year on computer-aided engineering in various disciplines by academic staff to industry personnel by industry request (staff development program). Industry technical staff need emerging technology integrating theoretical background of design, operation, diagnostics, condition monitoring, measurement performances, etc. of the respective products, components, devices, equipment, machines, processes, all in one to give responses to adequate challenges by the use of software concerned.

An outstanding reference is microCAD international conference which organized each spring-time at Miskolc with participation of around 300 academics, PhD students and industrialists. At its cradle, microCAD was a computing science meeting and rapidly was converted to the present term and category emphasising computer application in various disciplines.

University officials seeking to develop partnerships with industry risk losing projects if they are not willing to embrace a multidisciplinary approach to research.

To improve teaching partnership several contracts are effective at University of Miskolc: 100 to 170 industry executives and specialists of over 200 contracted industry are involved in joint design and evaluation of engineering curriculum, monitoring of engineering courses, organization and evaluation of industrial practice of students and graduates if and when needed.

Its teaching function embraces all three — BSc, MSc and PhD — cycles and continuing education attainment as illustrated in Figures 4 and 5. Knowledge generation and transfer are represented well by 8 to 16 engineering PhD theses presentations and defences each year where industry leaders and specialists, one at each board, are invited to act as referees, members of the boards, consultants and at last but not at least potential employers.

Joint training with industry — a partnership with impact on teaching and learning — is also effective in Hungary, although there are two different explanations of dual training: (i) the first, when two universities in two countries organize joint courses and the diploma/degree is issued by both universities and (ii) the second, when higher engineering education course runs partly in classrooms and partly in partner industry. Such a new positive
example emphasizes the link between the proximity of competences and strong research. Daimler Benz, German multinational promoted a strategic partnership with the nearby Polytechnic to start with dual engineering training in the field of motor vehicle manufacture (2012). Around 25 students each academic year have been attending lectures, doing laboratory works and learning in the school for 24 weeks. During the other 24 weeks they are carrying out engineering work at the factory. After graduation all diploma-holders can enter the world of work at Daimler Benz.

8.2 Preparation and Recognition of Students and Graduates by Both Parties

(1) Student mobility is crucial for their career: short visits to the EU and third countries’ industries each year are organized for groups of selected students based on joint agreements with respective Engineering Institutes/Industries with the involvement of 20 to 30 engineering students. Erasmus mobility scheme is also a good chance for dozens engineering students each year. 10 to 14 industry personnel are involved in European education projects coordinated by the university from partner industry based on their specific knowledge.

(2) The Final Examination Board for BSc and MSc engineering cycles appointed by the Rector at UM involve 20–28 industry leaders, receives feedback on students’ knowledge, skill and competences. Tutors in cooperation with industry specialists serving as referees evaluate the theses for graduation and submit their joint opinion to the board. All units of final examination — the academic marks of previous basic (fundamental) science and applied engineering courses with the thesis quality and the oral presentation of definite professional area — are scrutinized and different weighted factors are attributed to each unit and in such a way the final result of the diploma/degree is available. This symbolizes the knowledge, skills, capability and competences of the graduate ranking between A academic mark indicating the highest standard of work (this is 5 in Hungary) then B (or 4) for the second highest standard of work, C (or 3) for the third highest standard and D (or 2) for a low standard written in the diploma/certificate.

(3) Recognition of talented graduates, who build up the future, is a particular task of Engineering Institutes. The Final Examination Board selects the best three or four diploma theses from each group of specialization. These theses along with the evaluation of the Board are submitted to the Institutes of Electrical, Mechanical and other Engineering of Hungary.

There is a country-wide evaluation committee working at each Engineering Institute composed of top industry specialists and principal academics, and they make joint decision on the first, second and third ranks along with the fourth, fifth and sixth. At the Annual Conferences of the Engineering Institutes, usually taking place at end of summer on rotation in different cities of the country, the winners deliver the summary of their theses for 500–600 researchers, academics and executives of respective industries. The gold, silver and bronze medals and also the 4th, 5th and 6th ranks are awarded there. This event proves to be an excellent event for the young generation to get acquainted with the respective professional personnel and participate by their works in knowledge transfer and brain circulation. The summaries of the theses are published in the periodicals concerned like Elektrotechnika (Electrical Engineering), Gép (Machine Industry) or in other engineering journals.

(4) Engineering Institutes integrate both industry personnel and university academics.

(i) Three Hungarian Engineering Institutes — Mechanical, Electrical and Mining/Metallurgical — are served by 24 to 28 UM academic staff who maintained close cooperation with all important industries in the country, as chairpersons and/or members of editorial boards of journals, executive, scientific, education and professional committees, and invited speakers of annual conferences. This collaboration strengthens the link directly with these Institutes and indirectly by Hungarian industries, their leaders and specialists as well and leads frequently to other
specific partner programs.

(ii) Membership in international engineering societies provides a particular chance for international reputation of academics, departments and the university as well.

(5) Industrial practice is indispensable in higher engineering education. Collection of engineering and technology experiences in industry criterion targets mainly young lecturers by involving them in joint university-industry projects, short-term industrial practice in summer-time, and such contribution leads to courses run by industry personnel in industry with the involvement of 12 to 15 young lecturers a year and leading industrial practice of 200 to 400 students, both in this country and monitor 20 to 30 students abroad.

(6) Continuing education attainment is carried out within the framework of a separate Regional Center for Adult Education at the university involving several industry executives.

Industry, both as a consumer and/or producer of higher education products, has an important role to play in the cooperation between higher engineering education institutions, networks and Member States.


9.1 The Third Mission

The new role of the coming three-mission-university leads to a new target of particular partnership which is defined as a source of competence and problem-solving for society.

![Figure 6 Trend of University-Industry Partnership – Post-2015](image)

Source: the authors, 2013
Bold, visionary partnerships between industry and universities can accelerate innovation and help deliver solutions to pressing social challenges. But to harness that symbiosis, the universities of three missions need to be defined or redefined for the 21st century.

Mission (3) now extends beyond teaching (mission 1) and public service research and business innovation (mission 2) to tackling key social challenges and helping drive economic growth (Figure 6).

Win-win situation provides feedback on the partnership, follows-up and communicate on the work of graduates, important for university as a whole to gain experiences on their professional quality.

University of Miskolc organizes each year at the end of August get-together (reunion) meetings for engineers graduated 10, 20, 25, 30, 40, 50 and 60 years earlier and such events provide good forum to get acquainted with how the graduates high-up in the management, research, etc. hierarchy. In addition, their opinion on curriculum, degree quality, infrastructure and academics contribute to get near to excellence.

9.2 Case Study Focusing on Excellence

One case study tries to clarify what and how a university works in the direction of excellence.

University of Miskolc develops its education (teaching-learning), training, research and service processes based on the operation of four Centers of Excellence and concluded in the following advancements:

(i) scientific research achievements will be interwoven with the teaching and indirectly the education structure, therefore

(ii) the quality of PhD Schools will be improving.

(iii) New competences created by customized education based on research activities will be transferred to the stakeholders and

(iv) the income stems from research and technological development along with four new projects’ output will be getting higher.

The Operative Programme for Society Renewal (in Hungarian: Társadalmi Megújulás Operatív Program – TÁMOP, which is derived from the Hungarian initials) working within the framework of the New Hungarian Development Plan between 2009 and 2013 (in Hungarian: Új Magyarország Fejlesztési Terv) awarded Hungarian Forints (HUF) 2000 million, roughly US$9.8 million to the University, to improve the quality of higher engineering education or in other words to striving for excellence.

The objective of this TÁMOP project is • to contribute to the step-up attractiveness of UM through the higher degree of quality assurance and • to help by the project’s implementation the economic and social modernization of the North-East Hungarian region — efficient step to the third mission implementation.

To serve this objective UM is striving for the creation of intellectual capacity, “a critical mass”, needed for research, technological development and innovation carrying out on international scale in strategic areas by the new Centers of Excellence. Advanced research infrastructure has been provided by another joint project.

For young researchers — as well as PhD candidates and MSc students — with the provision of scientific leaders of high caliber and advanced research infrastructure the project puts direct impact on the scientific quality of PhD Schools, the provision of talented students and the new generation of researchers. The Strategic Board of Experts has been assisting in the positioning and recognition of research teams in the large-scale professional and scientific world in the designated four strategic fields.

(1) The Centre of Excellence on Sustainable Natural Resources Management focuses mainly, among others, water resource management, energy economy, efficient use of natural resources, soil and arable land as well as
geo-informatics*.

(2) The Centre of Excellence on Applied Material Science and Nano-technology has the objective to apply, even further develop up-to-date scientific methods and processes and gain new experiences on the research areas of material science and material-informatics.

(3) The Centre of Excellence on Mechatronics and Logistics particularly deals with re-organization of material- and product-flow and assembly processes in the most optimal way. By the development of latter-day technologies the opportunity opens up the door to create new systems and processes meeting the relevant requirements.

(4) The Centre of Excellence on Innovative Mechanical Engineering Design and Technology needs researchers qualified for the development and analysis of design algorithm, product routes and innovative material technology.

A brief account of the results is breathtaking • 137 significant publications in international journals and periodicals, all of them have impact factors, • more than 1000 national and international publications in journals, periodicals and conference proceedings and furthermore, • relevant patents and know-how characterize the implementation of the excellence criterion (2013).

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References


*“Informatics” is sometimes known in European Community jargon which integrates computing, telecommunications and audiovisual technologies.
Slovakia.