WORKING
PAPER

The Pursuit of Excellence

A European Institute of Technology

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Preface

At the end of 2005, the European Commission launched a consultation procedure to actively explore how to best take the general idea of a European Institute of Technology (EIT) forward. Many interested parties have since contributed their opinions and thoughts to the public debate, and with this paper RAND Europe joins in.

The aim of this RAND Europe paper is to further deepen the debate and to provide initial insights into the structure and approach to be chosen in setting up an EIT. This paper does not aim to answer the question of whether the EIT is desirable in the first place. It takes the EIT as a given and focuses on how best to accomplish the wider objective of the EIT: to raise the competitiveness of the European Union through scientific and technological excellence.

We compare European universities with top institutes of technology to determine the differentiating and key success factors that result in excellence in research and education. Based on this, the guiding principles and core features of the EIT are formulated, potential forms are developed, and risks and alternatives are discussed.

The findings of this paper are intended to stimulate the debate. They are based on preliminary research that will have to be expanded in the near future. Our paper consequently identifies a number of areas and issues that require further research and elaboration.

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We welcome readers to exchange views. For more information about RAND Europe or this paper, please contact Dr. Titus Galama:

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[1] Galama, T.J., Mundstein, S., Pawel, G., *Eurotech – a feasibility study for a European Institute of Technology,* INSEAD 2003 (Prof. P. Turner)

Summary

The European Commission has formulated a bold vision: the creation of a European Institute of Technology (EIT) that should become the most prestigious institute of technology in the world, with access to world-class research facilities, hosting top scientists from across the world, and training the researchers of tomorrow.

If Europe is to achieve scientific excellence and reap the associated economic and social benefits, a daring initiative will have to be taken. Assuming, the EIT has the potential to be that initiative and to give a boost to the renewal of the European scientific base, it becomes vital that its design and creation be carried out carefully and based on sound, evidence-based analysis.

In this paper we present a first analysis of essential requirements and key features based on a comparison with leading European and global science and technology institutes, particularly the Massachusetts (MIT) and California (Caltech) Institutes of Technology, on interviews with experts (faculty and business leaders), a focus group with (former) students of technology, and on a survey of preferences and requirements among students and scholars.

One of the main challenges faced by the EIT is that it will need to establish *excellence, prestige, brand name, and scientific credibility*. Our research has identified that the world's top universities achieve this by meeting four essential requirements: (i) access to world-class research facilities, and concentration of (ii) faculty talent, (iii) student talent, and (iv) financial resources. The world's top universities ensure these aforementioned four essential requirements by: (i) seeking a broad funding base (including tuition fees), (ii) performance-based payment, (iii) a highly selective admission process, (iv) competition in research funding, (v) independence and (vi) focus.

These main requirements for prestige and acknowledged excellence strongly suggest a future EIT should be set up on the basis of a radically different university model.

Using the identified requirements as guiding principles we argue that it will be difficult for the EIT to begin as a selection of existing top European institutions or as a network of selected existing universities. We find that the two options with the highest potential for success are (i) setting up the EIT as a European branch of MIT or Caltech, or (ii) building an EIT from scratch (greenfield). The second option involves another decision, namely about developing an EIT at one location or at multiple locations. We have made a brief assessment of the advantages and disadvantages of each option. In addition, we have identified a number of support measures and strategic implications that apply to each option, such as an integrated approach to teaching, research and technology transfer, the value of commitment by the EU, and the risks associated with large investments and political involvement.

After exploring the key requirements, core features, and potential formats, several formats come forward as desirable. Additional research is needed to make a careful and evidence-based decision on the choice for a specific option and on the steps that have to be taken to realize it. We have identified a number of unresolved issues and open questions.

Background

As the self-proclaimed “knowledge society” of the future, Europe is challenged to address the still largely unbroken supremacy of the United States in the realm of higher education and research as well as the rapid rise of new institutions in Asia. Higher education policy in EU Member States has often focused on and successfully achieved affordability and accessibility of higher education.[2] Yet, these egalitarian policy goals may have come at the expense of Europe’s global competitiveness in research and education at the absolute top of the scientific ladder.

Global science is dominated by the US. American universities employ some 70% of the world’s Nobel Prize-winners and produce about 44% of the most frequently cited articles.[3] Of the top 20 universities in the world, 17 are in the US, 2 in the UK and 1 in Japan.[4] Various indicators suggest a decline in the dynamism of European research and education.[5] There is no top-20 university in continental Europe: the Swiss ETH Zürich is the highest-ranking continental European university at a meagre 27th place. Europe’s share of Nobel Prize winners used to be very high (73% over the period 1901 to 1950) but has currently dropped to only about 20% (1995-2004). Europe has a smaller pool of researchers (per thousand of the labour force) than the US and Japan.

US excellence in education and research also contributes to Europe’s brain drain. Europe is losing a significant amount of its top scientists and managerial talent to the US as scientists and researchers stay on for longer periods after completion of their US education, and many of them stay permanently.[6] For example, in science and engineering a large proportion of European Ph.D. students in American universities remain in the US and this proportion is increasing.[6] European universities on the other hand offer little attraction to US researchers.

Excellence in research and education is key in achieving sustained economic growth, competitiveness and innovation. Universities are part of a larger ecosystem in which they provide the intellectual capital and talent to companies, thereby stimulating growth and innovation, which in turn attracts talent to universities and to businesses in the region. The economic benefits of science are very real. For an average firm, 5 articles co-authored by an academic “star” and the firms’ scientists result in about 5 more products in development, 3.5 more products on the market, and 860 additional employees.[7] And this talent need not only come from within the EU.

In Europe the notion exists that the EU plays a leading global role in terms of top-level scientific output, but European firms nevertheless do not benefit due to failures in the “innovation value chain”. Great research does not translate for some reason into economic

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[2] Global Higher Education Rankings 2005 – Affordability and Accessibility in Comparative Perspective, Educational Policy Institute http://www.educationalpolicy.org/.

[3] Economist Sept 8th 2005 (Higher Education Survey).

[4] Academic Ranking of World Universities – 2005; Institute of Higher Education, Shanghai Jiao Tong University; see also the Economist of September 10th-16th 2005.

[5] “3rd European Report on Science and Technology Indicators”, European Commission, 2003.

[6] Nearly 60% has firm plans to stay in the US after their Ph.D. and that proportion has increased from 44.5% at the beginning of the 1990s to 57.5% around 2000 (European Commission, *Key Figures 2005 on Science, Technology and Innovation: Towards a European Knowledge Area,* July 2005). More than 50% of the 8,760 European Ph.D. students in the US between 1988 and 1995 were still in the US five years later (Johnson, J. M. & Regets, M., *International Mobility of Scientists and Engineers To the US- Brain Drain or Brain Circulation?,* NSF Issue Brief 98-316, June 22, 1998). National Science Foundation data on European doctorate holders show that in 1995 there were around 17,000 Europeans who had remained in the US after having completed their Ph.D. Of these around 11,000 had become naturalized citizens, and about 3,900 of them had become permanent residents (National Science Foundation, http://www.nsf.org).

[7] Zucker, L., Darby, M., Armstrong, J., *Intellectual Human Capital and the Firm: The Technology of Geographically Localized Knowledge Spillovers*, NBER Working Paper No. 4946, 1994.

value (products, technologies, etc). This notion, the so-called "Innovation Paradox", however can be debated. A comparison between the United States and the European Union in terms of innovation performance suggests that Europe does not only trail the US in economic growth and productivity, but has also structural lags in top level science vis-à-vis the US.[8] This would suggest that improvements in the quality of scientific production in combination with improvements "downstream" in the innovation value chain should have priority to policy makers. In short, Europe needs to seek scientific and educational excellence.

It has been suggested that the European lag in scientific performance relative to the US is caused to a considerable extent by the nature of its university system. American universities are different from their European counterparts in that they are often very selective in attracting students, postdoctoral scholars, and faculty, provide attractive salaries, research facilities and career opportunities to attract top scientists, have ample financial resources and research facilities, charge substantial tuition fees, and are not biased in any local sense: students and faculty are attracted from all over the world. They also display a larger ability to transfer scientific discovery and technology into commercial applications, through targeted support systems, cooperation with industry, and effective intellectual property right (IPR) rules.

European universities, on the other hand, have large student populations, are rarely selective in student admission, receive significantly less funding for research and education, are subject to significant state regulation, pay much lower salaries to their staff, are generally not permitted to charge tuition fees, and largely serve a national student population.

> "The basic problems with the universities are the same across Europe: too much state control and too little freedom to manage their own affairs. Governments have forced universities to educate huge armies of students on the cheap, and have deprived them of the two freedoms that they need to compete in the international marketplace: to select their students and to pay their professors the market rate for the job..." (*Economist*, September 8, 2005)

If Europe is to achieve scientific excellence and reap the associated economic and social benefits, a bold initiative will have to be taken. The idea of a European Institute of Technology has been put forward as having the potential to be that initiative and to give a boost to the renewal of the European scientific base. Assuming that this is indeed the case (though this is debated[9]) it becomes vital that its design and creation be carried out carefully and based on sound, evidence-based analysis. This paper presents a first analysis of essential requirements and key features of an EIT and sets out the options.

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[8] Dosi, G., Llerena, P., Labini, M.S., *Evaluating and Comparing the innovation performance of the United States and the European Union*, Expert report prepared for the *Trendchart* Policy Workshop 2005

[9] See for example the Financial Times of February 13, 2006 "*EU plan for technology institute put to test*"

A European Institute of Technology

> "… the Commission proposes the creation of a "European Institute of Technology" to act as a pole of attraction for the very best minds, ideas and companies from around the World." ("Working together for growth and jobs: A new start for the Lisbon Strategy", Commission Communication from Commission President Barroso in agreement with Vice-President Verheugen to the Spring European Council 2005, Brussels, 2 February 2005 (COM (2005) 24))

The European Commission has formulated a bold vision: the creation of a European Institute of Technology (EIT) that should become the most prestigious institute of technology in the world, with access to world-class research facilities, hosting top scientists from across the world, and training the researchers of tomorrow. The EIT would be a world-class "research-engine", conducting world-class fundamental and applied science as reflected in publications in top scientific journals, prestigious prizes (e.g., the Nobel Prize), funding, rankings, and other forms of recognition, and generating innovation as reflected in start-up companies and patents that can be traced to the EIT. The EIT should act as a magnet of global talent and become the institution of preference for scientists as well as students.

Realizing this vision will require considerable effort. We feel that it is important to carefully consider the essential requirements for the establishment and successful development of an EIT and to define the key features it should have. This paper presents a first analysis of essential requirements and key features based on a comparison with leading European and global science and technology institutes, particularly the Massachusetts (MIT) and California (Caltech) Institutes of Technology, on interviews with experts (faculty and business leaders), a focus group with (former) students of technology, and on a survey of preferences and requirements among students and scholars (see Appendix for more detail).

In this paper, we occasionally compare European universities with "the world's top universities", "US top universities", and MIT and Caltech in particular. The latter two are natural benchmarks for the EIT. They carry out world-class research, are home to top scientists (including a significant number of Nobel Prize winners), are highly selective, focus on engineering and the "hard" sciences, maintain strong links with industry, spin out lots of innovative small companies, and rank 5th and 6th in the 2005 Academic Ranking of World Universities.[10] Although there is an emphasis on US universities, given their top ranking status, the findings presented here have greater validity and are not intended to necessarily advocate a US model: the universities of Cambridge and Oxford are excellent examples of top European universities. Nor are the findings limited to private as opposed to public universities: the top 20 of the world's universities contains numerous public schools.[11] Yet, the standards for an EIT are defined by global competitors and the Institute should be designed accordingly.

Essential requirements for a globally competitive EIT

One of the main challenges faced by the EIT is that it will need to establish *excellence, prestige, brand name, and scientific credibility*. Our research has identified that the world's top universities achieve this by meeting four essential requirements:

- Access to world-class research facilities
- Concentration of faculty talent
- Concentration of student talent

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[10] Academic Ranking of World Universities – 2005; Institute of Higher Education, Shanghai Jiao Tong University; ranking published in the Economist of September 10th-16th 2005.

[11] Examples are the UC schools: UC Berkeley, UCLA, UCSD, UCSF.

- Concentration of financial resources

World-class research facilities: Globally competitive research facilities are essential in order to attract top faculty and top students and to conduct world-class research. Researchers at MIT and Caltech often have access to superior facilities. For example, since 1993 Caltech's astrophysicists have had 50% of the observing time on the W.M. Keck telescopes, the two largest optical telescopes in the world. In contrast, a consortium of eleven European countries has had access to the four Very Large Telescopes since 2001. In other words, a single institute (Caltech) commands a single world-class telescope, while each and every astrophysics department in eleven European countries has to compete for access to only four telescopes. Moreover, Caltech obtained access eight years before the European universities, allowing it to build a dominant position in astrophysics.

Concentration of faculty talent: The world's top universities are able to attract or involve the best faculty in the world, such as (future) Nobel Prize winners and similarly renowned and outstanding researchers. In addition to bringing their own excellence, talents of world renown often have significant influence within the scientific and political communities. World-class researchers can generate prestige, brand name and credibility for the Institute, and provide world-class research and education. Top researchers also attract money. In the competitive US scientific research system, top faculty are better positioned to acquire research funding and, hence, are better "revenue generators" for the institution. The US research model has a natural tendency to seek excellence as excellence generates maximum revenue.

Concentration of student talent: The ability to attract the highest quality of undergraduate students, graduate students, and postdoctoral scholars is an essential defining feature shared by the world's top universities. Top student and scholar talent is the backbone of the institution's research activities. To ensure the attraction of the best, the net is cast as wide as possible. Unlike European universities, US universities draw from the global talent pool of students and scholars.[12] For example, foreign citizens make up 31% of science and engineering graduate enrolment and 57% of science and engineering postdoctoral scholars.[13]

Concentration of financial resources: World-class universities require a concentration and scale of research that is incomparable with what we have in Europe today. For example, Caltech and MIT have significant resources with operating revenues of \$0.4 and \$1.7 billion and assets and endowed funds of \$2.0 and \$5.2 billion dollars, respectively. The interest on such funds alone is already more than the budget of many European universities.

Top universities in the US receive significantly more funding than those in Europe. First, the countries of the EU only spend 1.2% of GDP on higher education as against 2.6% in the US. Second, whereas Europe's 4,000 universities receive fairly evenly distributed research funding, in the US 95% of federal university research funding (representing 60% of total US university research) is spent in no more than 200 universities (out of the US total of 3300).[14] This has resulted in research excellence in a number of knowledge "gravity centres".

Students in higher education cite the quality of research and education as the most important reason for choosing a university.[15] The highest quality research and education require top faculty staff, which comes at a substantial cost as they require top salaries, top research funding and top research facilities.

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[12] Notable exceptions in most of the discussion here are the Universities of Cambridge and Oxford in the UK. The term "European university" refers generally to continental European universities.

[13] S&E Indicators, National Science Foundation, 2004.

[14] Soete, L., Activating Knowledge, Discussion paper prepared for the UK presidency, 2005.

[15] Galama, T., Mundstein, S., Pawel, G., *Eurotech - a feasibility study for a European Institute of Technology*, INSEAD, 2003.

Key features

In short, the EIT will need: (i) access to world-class research facilities, (ii) a very high concentration of the world's best researchers, and (iii) of the world's best students, and (iv) superior financial means.

How do the world's top universities achieve these aforementioned four essential requirements? A comparison with the world's top universities, and in particular with MIT and Caltech, suggests the following key features:

- A broad funding base including tuition fees
- Performance-based payment
- Highly selective admission process
- Competition in research funding
- Independence, and
- Focus

A broad funding base, including tuition fees: Apart from access to very significant research funding and public financial support (see "concentration of financial resources" above), US institutions generate substantial revenue through private donations (9% of total revenue) and student enrolment (33% of total revenue) with tuition fees of around $20-30,000 per annum at top universities.[16]

Performance-based payment: The market for scientific talent is global and institutions need to offer globally competitive packages (salaries and research funds). In the US, professors with similar title and tenure are compensated vastly different ("market" rates) on the basis of their scientific qualities. For example, top-performing professors receive several hundreds of thousand dollars in annual salary, while others earn only $50-70 thousand. Paying for performance and aggressive competition for talent is common practice in the US.[17]

Highly selective admission process: The quality of the student and scholar population at the world's top institutions is ensured by a rigorous and highly selective admission process. Admission is based on academic record, results of standardized tests (such as SAT College Board scores), recommendation letters, application essays, curricula vitae (demonstrating scientific and engineering interests, extracurricular activities, special talents, and personal qualities), and may even include interviews with faculty, alumni or current students. Selectiveness of programmes, apart from ensuring the quality of the student and scholar population, also generates prestige, brand name and credibility for the institution. For example, from its early years in the 1950s, INSEAD, a top European business school, has recognized the importance of selection and has focussed successfully on an image of rigorous and highly selective student admission to gain prestige.[18] The Indian Institutes of Technology (IITs) provide another example. They may not have the financial resources that US institutions have, but the alumni of the IITs are very well regarded by industry and academia in large measure due to one of the most selective admission programmes in the world (only about 2% of student applications are accepted).

Competition in research funding: It is not sufficient to simply provide financial resources. Scientists at US universities are continuously pushed to perform by a competitive system of

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[16] Brewer, D.J., Gates, S.M., Goldman, C.A., *In Pursuit of Prestige – Strategy and Competition in U.S. Higher Education,* RAND publication, 2002.

[17] Attractive offerings can indeed attract top talent. For example, when Steven Weinberg of Harvard received the Nobel Prize in Physics, he accepted an offer of the University of Texas, which doubled his salary and arranged a position for his wife as well.

[18] INSEAD – From intuition to institution, Jean-Louis Barsoux¸ Macmillian Press, 2000.

grants; their level of funding is never guaranteed. Europe is moving towards a similar system of research funding and a European Research Council may further promote such competition as long as funding is awarded strictly on the basis of scientific merit.[19]

Independence: Scientists need to be able to conduct research without bureaucratic restrictions hindering efficiency (of, e.g., research, hiring, admission, etc) and without financiers influencing the direction or outcome of research or the governance of institutions (thus compromising research and / or governance). Further, academic freedom and a lack of bureaucracy are the most precious goods for scientists and essential in attracting top scientific talent.

Focus: Top universities are often quite focussed. Caltech for example started a programmed decline in the field of nuclear astrophysics (how elements form in stars) at a time when Caltech's William Fowler received the Nobel prize (1983) in this area. The decision was made as Caltech felt the re was still a future, but not anymore a *big* future in nuclear astrophysics.

> "If a single factor can be called responsible for this [Caltech's excellence], it is Caltech's absolute unwillingness to compromise on excellence: excellence of faculty, excellence of students, excellence of facilities... To be accepted as a student, you need near-perfect SAT scores, so you are immediately among the elite. Invitations to join the faculty come only after the most excruciating examination. There are no good appointments at Caltech - only superb ones" (Marvin L. Goldberger, President emeritus, Caltech, in "Millikan's School – a history of the California Institute of Technology", J.R. Goodstein, W.W. Norton & Company, 1991)

What format should a European Institute of Technology have?

The main ingredients for prestige and acknowledged excellence require that a future EIT be set up on the basis of a radically different university model. The above findings suggest that the EIT should seek a broad funding base, adopt performance-based payment and a highly selective admission process, ensure its independence and be focussed.

The current debate on the possible models of an EIT tends to be influenced by the use of political arguments rather than on an objective assessment of the merits of each possible option. Various stakeholders are legitimately defending their interests. This section describes and compares various options, and provides an objective assessment of their potential for success when tested against the requirements and features of the world's top universities. In doing so, we also provide a brief assessment of possible risks and discuss strategic implications.

Existing universities and networks

Various participants in the EC's consultation process have argued that the EIT should be based on existing universities or on networked constellations of existing universities (either at the departmental or university level).

However, it will be difficult for the EIT to begin as a selection of existing top European institutions.

1) These universities are of the traditional European format and have vested interests, which will make change slow and unlikely to succeed. Any drastic departure from the existing model is more likely to succeed when built from scratch, i.e. as a greenfield institution.

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[19] "Seeking scientific autonomy", The Economist, November 12th, 2005.

2) The requirement of significant funding and highly selective student admission will require focus and a relatively small-sized institute. European universities generally have large student populations and cover a wide range of scientific interests, which make it unlikely that selective student admission and significant resources per capita can be achieved without significant costs.
3) There is the problem of designating "top down" which universities will be included and receive extra funding, and which ones will be excluded.

In addition to the fact that a network is a selection of existing universities (or departments at different universities) and is, hence, according to the above argumentation an undesirable starting point, network approaches have their own problems:

1) Europe's approach of enhancing coordination of research has resulted in allocating funds over very broad fields of research and many institutions, whereas focus and concentration of talent and resources is essential.[20]
2) Creative processes require proximity and informal interaction, such as a conversation over coffee, a shared lunch, an internal seminar, or a daily half-hour group meeting. Even with current day information technology, this environment cannot be created at a distance.
3) Networks add a layer of bureaucracy. There are costs associated with the additional communication required to maintain sufficient coherence and alignment between networked universities (or departments).

However, the EIT should have close relations and perhaps even be affiliated with existing universities (we expand on this further below).

Alternatives for an EIT that delivers on its promise

An analysis of the essential requirements to ensure excellence in research and education suggests two alternative and potentially successful formats:

1) The EIT as a European branch of MIT or Caltech
2) Building an EIT from scratch (greenfield)
    a. Developed at a single location
    b. Developed at multiple locations

The EIT as a European branch of Caltech or MIT: A viable and most "laissez faire" way to begin the EIT would be as a European branch of an established institution such as Caltech or MIT. Not only does this provide brand name and recognition but these institutions can also provide financial resources and human capital, for example through the Nobel Prize winners and other top scientists who would then teach at the EIT. Being a branch of a private US school would ensure independence of the institution as well as the alignment of objectives (being part of just one institution will minimize the complexity of the organization). As an affiliate of a foreign entity, though, access to EU resources may be difficult. The EU would have to provide incentives to encourage establishment of European campuses.

An interesting initiative in this respect is the Cambridge-MIT Institute (CMI), set up in 2000 and jointly owned and controlled by Cambridge University and MIT. A review of the institute by the UK National Audit Office[21] provides a mixed picture. The report concludes that many

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[20] Soete, L., Activating Knowledge, Discussion paper prepared for the UK presidency, 2005.

[21] *Cambridge-MIT Institute*, NAO report by the controller and auditor general, HC 362 Session 2003-2004: 17 march 2004

of CMI's key outcomes are complex and intrinsically difficult to measure, and will not be realised for some time (though there have been some early successes); and, that aspects of CMI's establishment could have been better managed and proved to be a much bigger task than anticipated. CMI provides an interesting case study in how an EIT might be (or should not be) set up. In being a joint venture, CIT is different though from a European branch of a top technology institute that is envisioned to be fully owned by its mother institution.

Building a European Institute of Technology from scratch: Building the entity from scratch (greenfield) is the most effective way of creating a drastically different university model and ensures independence from vested interests. Further advantages of a newly built institution are its potential to develop core research areas in which it can acquire critical mass (as opposed to existing universities with multiple disciplines that all need to be elevated). The need for substantial concentration of talent and resources (per capita) suggests each core research institute should (at least initially) be relatively small and focused, and grow gradually in proportion to its success.[22]

- **Single location**: The advantages of building the EIT at a single location are mostly felt in the concentration of resources, support facilities and the interdisciplinary exchange of knowledge, which would enhance creativity and technology transfer. Moreover, a single site is more likely to develop an 'esprit de corps' among its students, faculty, and alumni, which is an important factor in establishing the prestige of the EIT. Disadvantages are its reduced flexibility, the complex political decision making on the geographic location of the Institute, the limited impact on Europe as a whole due to reach and scale, and missing out on access to existing dispersed infrastructures and facilities in leading European research departments.
- **Multiple locations**: Some of the disadvantages of a network approach based on existing universities are also valid for a new institute at multiple locations, albeit with much less prominence. The same can be said for the advantages of a single-location greenfield option. The main strengths of a greenfield development at multiple locations are that such diversification reduces the risk of failure and that more effective use can be made of existing facilities and networks. A major political advantage will be that the choice of location should be less of an obstacle to move ahead than in the single location option.

To avoid large upfront costs, a newly formed institute should not "reinvent the wheel" and should use the strengths of European research and facilities. Existing universities may play a crucial role in the formation of the EIT. Two very similar Anglo-Saxon style universities, the German International University of Bremen (IUB) and the Dutch University College Utrecht (UC) have recently appeared in the European educational landscape and can provide interesting insight in this respect (see text box).

German International University of Bremen (IUB)
In 1997 the city of Bremen invited Rice University in the US to enter into a collaborative venture to build a new university, which is:

- private,
- independent

and has:

[22] The EIT could begin very small, and start out with only one or a couple of research disciplines, and limited numbers of faculty, scholars and students, eventually growing to several hundreds of faculty, about a thousand post-graduate students, and about five-hundred postdoctoral fellows per institute. For comparison, MIT has some 600 professors, about 370 associate and assistant professors, 440 senior lecturers, lecturers, and professors emeriti, and about a 1000 teaching assistants and graduate instructors. In addition, approximately 2,800 researchers work with faculty and students on projects funded by government, foundations, and industry. Total enrollment for the year 2002-2003 was 6139 graduates. Caltech hosts some 300 full-time professors and approximately 800 members in the positions of emeritus, visiting professor, research associate, visiting associate, senior research fellow, instructor, lecturer, and research fellow. Caltech has some 1100 graduate students. In addition close to 600 postdoctoral scholars perform research at the institute.

- an international orientation
- a highly selective admission process for its recruitment of students
- a favourable student-to-faculty ratio (12 to 1)
- performance pay for faculty
- a campus, where undergraduates live in residential colleges
- tuition fees of around €15,000 per annum

The IUB provides financial assistance to admitted students whose financial circumstances otherwise do not permit them to enrol. The faculty conducts research as well as teaches. Research is a central component of the teaching and learning process. The operating budget of the university is supported by income from a sizeable endowment, and the city of Bremen provided start-up capital of about €110 million. The university depends entirely on tuition fees and endowments. The student body is multinational and relatively small with about 930 students. The IUB enjoys close cooperation with Rice University (US), the University of Bremen and the Alfred-Wegener-Institut für Polar- und Meeresforschung. Agreements govern collaboration in the areas of teaching and research as well as the shared use of resources.

These universities share a great number of attributes with an EIT, but there are also a number of important differences: (i) the EIT is envisioned to be truly international and will not have a national base such as the IUB and UC have with, respectively, Germany and the Netherlands, (ii) the EIT will focus on engineering and the "hard" sciences, and (iii) the EIT will be a "research-engine" and focus more on postgraduate education (Masters and Ph.D.).

Similar to the IUB, the EIT should have agreements in place to cooperate with the best European universities in the rigorous selection of their top undergraduate students, in sharing research facilities and faculty, and in gaining access to facilities of European research consortia, such as the European Organization for Nuclear Research (CERN) and the European Southern Observatory (ESO). This would provide credibility and brand name, access to laboratories and scientific equipment, and access to human capital.

Strategic implications

The development of an EIT is a bold initiative and will be a politically and financially risky endeavour, regardless of the option that is ultimately chosen. In the discussion below, we discuss in detail the various risks that the EIT will be exposed to. They are:

- the temptation to choose the lowest risk profile solution (given size of the investment and uncertainty of the outcome),
- the temptation to appease political lobby groups with vested interests compromising the optimal solution,
- the need for cultural (and thus sensitive) changes (such as adopting "paying for performance", a highly selective admission process, and seeking additional forms of funding including tuition fees),
- the risk of financiers and politicians compromising the optimal solution for political or financial motives, and
- the risk that the EIT's output does not efficiently lead to desirable outcomes.

These risks (as further detailed below) can be overcome by: an ex-ante evaluation of the policy aim (i.e., do we need an EIT, an ERC, or both or nothing?), guiding the ultimate decision on the EIT's format on further evidence-based research of the options, sticking to the guiding principles and adopting a radically different university model (if possible in cooperation with existing universities), ensuring support structures for technology transfer, starting the EIT small and focussed (few fields of research), and using a cautious stepped approach, and lastly finding a financially strong and credible institution that backs the EIT (the EU is a plausible candidate).

The EIT will involve substantial financial investments, while it is as yet unpredictable how it will establish itself in the existing European scientific landscape and whether it will be able to become a competitive institution at a global level. Choosing for an option based on the *lowest risk profile* might not result in the most successful outcome. Europe cannot afford failure at any level of investment. The deciding criterion should therefore be the expected return on investment. The option with the highest likelihood of delivering the vision of excellence should be selected rather than the option that is politically or economically least risky. The decision should ultimately be evidence-based which will require further research (see “unresolved issues and open questions”).

Further, large upfront investments and the difficulty of establishing prestige, brand name and credibility in a relatively short time period, require that the EIT be backed by a financially strong and credible institution that shows a clear commitment to the concept of the EIT. An EIT supported by the EU can raise the profile and quality of European research by setting a successful example. The EU would be the EIT’s natural supporting partner. The EIT should be financially accountable to the European Commission, and have a strategic accountability towards the European Research Council and the European Parliament.

Building an institution from scratch requires significant initial investments, but expert interviews and a comparison with MIT and Caltech suggest that capital expenditures in the order of several hundred million euros per location will go a long way, if a cautious stepped approach is taken in which the EIT’s growth follows its success.

The European Commission should resist the *temptation to appease different political lobby groups* with vested interests, which are insisting that the EIT should rely on existing European structures. It is fair to say that existing universities, research institutes and facilities do have a significant role to play in the creation of the EIT. And, perhaps existing universities could each build their own “elite” universities, separate from the “mother” institution but closely related (such as the relation of the UC with the U. of Utrecht and the IUB with the U. of Bremen). However, it will be insufficient to merely increase Europe’s research funding or to build a networked constellation of (selected) existing institutions. Instead, as we have argued, a radically different university model is required which is unlikely to be achieved with existing universities or by greater cooperation.

At the moment, *paying for performance* is more or less taboo in Europe: it is generally not done to compensate –in salary or research funds– professors with similar title and tenure vastly different on the basis of their scientific qualities. Paying for performance and aggressive competition for talent is common practice in the US and the EIT may have to adapt in order to be competitive with US institutions. The introduction of *a highly selective admission process* may be controversial too. These “taboos” will require a *cultural change*, but by starting small and focussed these could be overcome (as the examples of INSEAD and the Indian Institutes of Technology show).

Another *cultural change* is required in European funding. In order to acquire substantial resources and achieve the necessary independence the EIT may have to *seek additional forms of funding* beyond those provided by the EU and national governments. Outside funding through endowments is a possibility, but Europe has no tradition of private donations and tax systems are not as favourable to charity as in the US. Also, *tuition fees* are generally low or even absent at European universities. However, it would be acceptable for the EIT to charge (relatively high) tuition fees.[23] First, although higher education is relatively cheap (and sometimes free) to students, European students express a willingness-to-pay and the level of

[23] However, tuition fees should not deter student talent from underprivileged backgrounds and from developing countries. Scholarships similar to those in the US will be needed to overcome this obstacle.

tuition fees does not appear to have a significant impact on access to higher education per se or on the selection of a specific institution.[24] Second, demand for international education is growing worldwide, fed by demographic trends and by the growing orientation towards the needs of an increasingly global economy. Non-EU students could become a major source of income and talent for the EIT. The demand for mobile international education is projected to be in the order of three million students by the end of the decade, with the steepest growth still ahead.[25] Inhabitants of the most populous and rapidly developing countries in the world, China and India, are expected to be interested in a European alternative to an English-language education in the US, the UK, Canada or Australia.

Financiers and politicians may be *tempted to compromise the optimal solution for political or financial motives.* But, independence is crucial to the EIT and cannot be compromised. The scientific community should be given significant independence in shaping the EIT, and have the ultimate say in its structure, research focus and in hiring and admitting its global talent. Scientific creativity and the market should determine the direction of research, with an additional stimulus provided by funding through the European Research Council. The European Commission should limit itself to ensuring that the outputs translate into social value (e.g. knowledge) and economic value (e.g. patents, applications, inventions).

There exists the risk that the *EIT's output does not efficiently lead to innovation, new technologies and new products.* The EIT should therefore have an integrated approach of teaching, research and technology transfer. Hence, once the EIT is operational and world-class research and education is being conducted, technology transfer will need to be ensured. At this stage, the EIT should begin to build a support structure for spin-offs and be encouraged to collaborate with industry by means of financial and other incentives.

It is argued that institutions such as MIT, Cambridge and Oxford do not acquire their fame overnight: they have been around for quite some time. Yet the success of the International University of Bremen, the Indian Institutes of Technology, and the business school INSEAD shows that prestige can be acquired on a fairly short timescale by attracting top scientists (e.g. Nobel Prize winners), through rigorous student selection, and with access to superior facilities. Official sponsorship by the EU will certainly add to the prestige of a newly created EIT and be of great symbolic value to the European Union.

Unresolved issues and open questions

It is clear that Europe will benefit from a European Institute of Technology. We have explored its key requirements, core features, and potential formats. The options are clear. However, additional research is needed to make a careful and evidence-based decision on the choice for a specific option and on the steps that have to be taken to realize it.

The following unresolved issues and open questions have to be resolved and answered before final decisions on the EIT can be taken:

- What would be the pros and cons of broadening the EIT to education?
- What will be the effect of the EIT on European education and research?
- Is it desirable for policy to influence the research process?
- Should the EIT focus on engineering and hard sciences only or should the EIT curriculum also offer economics and social sciences?

[24] Galama, T., Mundstein, S., Pawel, G., *Eurotech - a feasibility study for a European Institute of Technology*, INSEAD, 2003.

[25] IDP Education Australia, Ltd., 2002. Forecasts a fourfold increase in the number of international students by 2025

- What are the more subtle consequences of differences between the European and US policy environments?
- Will Europeans be able to recover the cost of high tuition fees in a labour market that is not used to such levels of human capital investment?
- How can we ensure that talent educated at the EIT remains in Europe? Which immigration policies should be in place to enable highly talented non-Europeans to become European citizens or permanent residents?
- Do the benefits outweigh the costs?
- How will the EIT aid in the transformation of knowledge? Which support structures need to be developed in parallel?
- How do differences in the legal environment of American and European universities affect the creation of economic value?
- What can we learn from the efforts of the emerging economies of the world to create top universities and create high-tech industries, such as China, India and Singapore?

The main obstacles to achieving the vision of an EIT are likely to be of a financial and political nature. This paper sets out to develop ideas based on the ambition to develop a European institution of global excellence. We have given an overview of what we believe will be required. It is up to key stakeholders at the EU, national, regional and local level –in government, academia and business– to take up the challenge, if Europe is to have its EIT.

Appendix

Methodology

Initial research was conducted at (business school) INSEAD in 2003[26] and subsequently refined at RAND Europe. The sources used to discern the key requirements and key features essential to the success of the world's top universities and to collect expert (faculty and business leader) opinion on potential format, risks and opportunities associated with an EIT were as follows:

- Desk based research
- Student focus group
- Face-to-face and telephone interviews with science and education experts, faculty and business leaders
- Online student survey

Below we provide more detail on each source. For full details on the results of each source (for example the complete answers to the student survey), please contact the authors.

Desk based research: all questions for which information was publicly available were examined by means of preliminary desk research, focused on web sources, articles and books. The sources of these findings have been appropriately identified in this paper.

Student focus group: as a first step, a focus group was held of students with a strong educational background in the sciences or in engineering from the student body of business school INSEAD in 2003. The focus group was a means to gauge the interest in the idea on a

[26] Galama, T.J., Mundstein, S., Pawel, G., *Eurotech – a feasibility study for a European Institute of Technology,* INSEAD 2003 (Prof. P. Turner)

general level, brainstorm about possible characteristics of the school, and get some in-depth discussions on higher education in general and on higher science education in particular.

Face-to-face and telephone interviews with science and education experts, faculty and business leaders: for both faculty and business managers in industry, in-depth interviews were the best means of gathering information and ideas. The selection of faculty was made by leveraging the contacts of the authors in the academic community, and asking for referrals and introductions. Contacting relevant business managers in industry proved more difficult, resulting in relatively few data points.

Online student survey: the results of the student focus group were used as input to design a web-based questionnaire, which was published through surveyworld.net, a web service based in the Netherlands. The online survey was conducted to gauge the interest and potential issues of prospective students with an EIT. The survey consisted of 25 questions and focused on the respondents' background, preferences and attitudes. The key purpose of the survey was to understand the willingness of students to attend an institution such as the EIT, and to obtain an understanding of the key drivers of attractiveness of educational programs and of the prospective students' willingness to pay.

The campaign returned 42 useable responses (after exclusion of bogus answers). The composition of the sample was quite balanced, but with a clear dominance of the field of engineering, of Ph.D. students and of males, as shown below:

- *Field of study:* 41% Engineering, 10% Chemistry, 8% Biology, 18% Physics, 6% Mathematics and 16% Other
- *Degree pursuits*: 20% B.Sc. 32%, M.Sc. 41%, Ph.D., 5% Postdoc and 2% Other
- *Gender*: 66% male and 34% female
- *Age*: ages of participants ranged from 18 to 44 years, with a mean age of 27.
- *Geographic location*: 45% of respondents were based in the US, 40% in Europe and 14% in Asia.