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Letter from the Editor

Developments at the outposts of the chemical industry

Although chemical firms also feel the omnipresent demand for growth and profitability, they often lack the internal ability to develop successful new products or services. While having already largely exhausted classical levers for reducing costs and improving efficiency and in spite of their dependency on the constant generation of innovations, they are developing fewer really new molecules. Tackling this challenge has in the recent past often meant beginning to search for ideas beyond their own factory gate and utilizing the tremendous technological developments in the chemical sector's neighbouring disciplines. Examples of this development are fading industry boundaries at the outposts of the chemical industry, such as chemistry and electronics (more efficient production, storage and usage of energy through e.g. lithium-ion batteries, organic photovoltaic cells or OLEDs, organic light-emitting diodes) or chemistry and the agricultural sector (e.g. genetically modified crops, production of renewable feedstocks for polymers or fuels).

But while some see a new opportunity in the emerging fields like bio- or nanotechnology, others identify problems for these sectors' innovativeness as well. Thus, many firms might try to strengthen their internal innovativeness through incentives for innovative employees or new ways of organizing and structuring innovation and the innovation process in their firm, while others will look for external sources of new ideas, either through collaborative projects with academia and other industrial partners, or by acquisition of innovative firms.

The current issue of the Journal of Business Chemistry discusses these approaches, starting with a commentary on merger and acquisition activities in the light of REACH due diligence. While many aspects of REACH have been covered already, Bernd Schneider and Matthias Kuschel shed some light on the rarely discussed topic of the importance of REACH for due diligences in the middle of M&A processes.

Aurora A. C. Teixeira continues with a focus on the human side of the innovation equation. Discussing her findings of a large survey among students on entrepreneurship, she reports that the main determinant of entrepreneurial potential is a student's propensity to take risks. We are convinced our readers will find her article highly interesting not only for designing academic classes or for streamlining a human resources strategy, but also for improving the entrepreneurial atmosphere of their individual organizations.

Edeltraud Glänzer presents results of a study on job opportunities in the growing biotechnology industry. While this study has concentrated on Germany, many of the findings will be interesting for other countries as well. She argues that finally biotechnology jobs might outpace those in the "classical" chemical industry.

Finally, presenting less promising findings, Enrique Esteban, Frank Lien and Richard Youn discuss ways around the "biopharmaceutical industry innovation crisis". They conclude their examples of successful non life science innovation processes with 10 recommendations regarding the structure of the process as well as the necessary innovation culture.

Next to thanking all authors and reviewers for their contribution, we would like to take the opportunity to welcome our new executive editors Irina Klioutch (ik@businesschemistry.org) and David Große Kathöfer (dgk@businesschemistry.org) who will be taking over the executive editor function from Benjamin Niedergassel (bn@businesschemistry.org) and me. Now enjoy reading the second issue of the Journal of Business Chemistry in 2008. If you have any comments or suggestions, please send us an e-mail at contact@businesschemistry.org

Clive-Steven Curran

Editor

(csc@businesschemistry.org)

Commentary

REACH due diligence – Extended scope of M&A services in the framework of REACH

Dr. Bernd Schneider*, Dr. Matthias Kuschel**

* PricewaterhouseCoopers Corporate Finance GmbH, Marie-Curie Strasse 24-28, Frankfurt am Main, bernd.w.schneider@de.pwc.com

** PricewaterhouseCoopers Corporate Finance GmbH, Marie-Curie Strasse 24-28, Frankfurt am Main, matthias.kuschel@de.pwc.com

Market participants expect that transactions will continue to play a significant role in the chemical industry since the industry is still fragmented in many segments. Professional transactions in the chemical industry include Due Diligence processes with a focus on topics specific for the chemical industry.

The Financial Due Diligence focuses on the determination of future cash flows. Depending on the subsector of the chemical industry in which the target operates, the dynamics of the corresponding markets and consumers are highly different. Growth in sales and margin development of chemical products are different, depending on whether they are used e.g. in the textile-, the construction-, the automotive industry or in medical engineering. Furthermore, turnover and sales are depending on the targets', segment-specific cyclicality and its competitors activities, nowadays in particular competitors in China, India and the Middle East. In order to forecast the bottom line, it is important to understand in which cycles raw material and energy price fluctuations affect the target's financial ratios and whether the target is able to pass increasing costs on to its customers. It is necessary to evaluate if the target can be hedged against raw material fluctuations efficiently. Analysis of the fixed and variable characters of production-, marketing- and administration costs are in the foreground to determine the break-even point of the target. The costs for research and development (R&D) are analyzed with a focus on the determination of the R&D share allocated to specific close-to-market-applications.

The operational Due Diligence in the chemical industry focuses on the analysis of the num-

ber, arrangement ("Verbund"), flexibility and condition of the production facilities. An inspection is mandatory, especially to discover capex back-logs.

Considering the stipulation of REACH as the new EU chemicals regulation with dramatic impacts on many chemicals businesses, REACH Due Diligence has to be seen as a new Due Diligence discipline. During the M&A process it will be critical to know how the target is positioned and prepared for the REACH regulation. Although direct registration costs are known, concluding a transaction in the middle of a registration process could still be difficult when results of the registration application cannot be foreseen and/or restrictions can be expected. In addition to that sellers have to provide information about the current status of the registration process. A conflict might evolve, where the target will have an interest in presenting the registration process as less complicated and having less impact than in reality the case. Thus, in this period of the REACH process, the Due Diligence team is required to analyze the portfolio of substances produced or imported thoroughly and assess to what extent the portfolio is subject to REACH or not affected. In which phase/step of the process are the substances currently? Are they already pre-registered or even registered and which additional steps are still necessary in order to fulfill all registration requirements? Another question is what is the risk, if the target is not compliant with the REACH obligations within a specific timeline? Could it be expected that the production or manufacturing of substances will be prohibited? As a downstream user it should be considered, whether appropriate

steps have been taken to ensure that the substances that are purchased and worked with are subject to REACH and whether they will be adequately registered and authorized respectively. It is also fundamental to know, if appropriate risk management tools have been implemented coping with REACH. In the framework of a REACH Due Diligence it has to be reviewed, if the target is sustainably complying with the obligations out of the REACH regulation. REACH is definitely a quite sore process to go through and will impact M&A deals to a significant extent. Particularly buyers are in a precarious situation. In many cases they cannot receive detailed information from the sellers about the target since the sellers in many cases are unable to give a clear statement about the current situation. Otherwise, a big potential for buyers is implied in entities affected by REACH. In case they are already in a registration process for impacted substances, buyers will have to pay the registration fee anyway and can buy the targeted entity with a potential discount. In the future, REACH could be a support to the success of transactions, in particular those involving hazardous products – once the companies have fulfilled the obligations and once they are done with their registrations. REACH Due Diligence will therefore not only extend the Due Diligence perspective by „just another legal regulation“, but become a critical part of all data room documents and be a decisive core discipline of Due Diligence of chemicals and downstream user assets. This will not only be valid for strategic but also – and probably even more relevant – for financial buyers. In the middle of the ongoing credit crunch crisis, a more than ever thorough look on the target's risks will be mandatory to ensure the sustainable success of a transaction.

Research Section

Entrepreneurial potential in chemistry and pharmacy. Results from a large survey

Aurora A.C. Teixeira*

* INESC Porto; Faculdade de Economia Porto; CEMPRE; Universidade do Porto, Rua Dr. Roberto Frias, 4200-464, Porto, Portugal, ateixeira@fep.up.pt

Abstract: Nowadays entrepreneurship has become an unavoidable issue. Given its documented relevance for regions' and countries' economic growth, increasingly governments, educators, and scientists try to uncover the determinants of entrepreneurship seeking ultimately to promote entrepreneurial skills amongst our youngest. Notwithstanding such trend, studies targeting entrepreneurial potential among students, namely university students are not abundant. In general, those few that exist focus on one school/one course, often from business related areas. To our best knowledge no study has analyzed the entrepreneurial potential of students from chemistry and pharmacy courses. The empirical results, based on a large-scale survey of 2,430 final-year students, 194 of whom are from chemistry (science and engineering) and pharmacy courses at the largest Portuguese university, reveal that the latter have higher entrepreneurial potential than students from other courses and that no statistical difference exists in this regard among chemistry and the other students (excluding those from pharmacy). In chemistry and pharmacy courses the main determinant of entrepreneurial potential is students' propensity for risk taking. Creativity, leadership and innovative traits failed to explain these students entrepreneurial propensity. In an economic environment which increasingly demands for novelty and creativity this is likely to constitute a troublesome finding and is an important point to be addressed both by policy makers and educators.

1. Introduction

The idea of becoming an entrepreneur is more and more attractive to students because it is seen as a valuable way of participating in the labor market without losing one's independence (Martínez et al., 2007). The most common values amongst graduates facing the new labor market are linked to those of the self-employed: independence, challenge and self-realization (Lüthje and Franke, 2003).

While there has been significant research on the causes of entrepreneurial propensity (Brandstatter, 1997; Greenberger and Sexton, 1988; Learned, 1992; Naffziger et al., 1994), only a limited num-

ber of studies have focused on the entrepreneurial intent among students. Those that exist tend to focus on US and UK cases and are mainly restricted to small samples of business related majors (cf. Table 1).

Despite the heterogeneity of sampling methods and target population, the existing studies on the issue (see Table 1) report that, on average, one quarter of students surveyed claimed that after their graduation they would like to become entrepreneurs (starting their own business or being self-employed). It is not widely known (and is currently subject to intense debate) whether contextual founding conditions or personal traits drive the students' career decision towards self-

Table 1 Magnitude of entrepreneurial potential among students

Studies/ authors	Degree	Courses	Countries	Number of students	Entrepreneurial potential (starting business/self-employment), %
Scott (1988)	Undergraduate	Business	UK, US, Ireland	436	50.0
Hatten and Ruhland (1995)	Undergraduate	Business	US	220	-
Kolvereid and Moen (1997)	Master	Business	Norway	303	-
Ede, Panigrahi and Calcich (1998)	Undergraduate	Business	US (African-American students)	171	24.5
Kourilsky and Walstad (1998)	Youth: 14-19 years old	Not specified	US	917	66.9
Henderson and Robertson (1999)	Undergraduate and MSc	Business	UK	138	23.2
Oakey, Mukhtar and Kipling (2002)	Undergraduate and MSc	Physics, Biology and Mechanical engineering	UK	247	17.0
Lena and Wong (2003)	Undergraduate	Science, Engineering, Computing and Business	Singapore	11,660	6.0 ⁽¹⁾
Luthje and Franke (2003)	Undergraduate	Engineering	US	524	54.6
Franke and Luthje (2004)	Undergraduate	Business	Austria, Germany, US	1,313	36.0 25.0 50.0
Gurol and Atsan (2006)	Undergraduate	Business	Turkey	400	18.0
Klapper and Léger-Jarniou (2006)	Undergraduate	Business and Engineering	France	538	25.0
Levenbrug et al. (2006)	Summer course students	9 majors	US	728	23.0 ⁽²⁾ - 38.7 ⁽³⁾
Teixeira (2007a)	Undergraduate	Economics/ Business	Portugal	985	24.9 23.3
Teixeira (2007b)	Undergraduate	Engineering 60 majors	Portugal	2,430	10.6 - 66.7

Note: (1) Effectively started a business; (2) starting a business; (3) self-employment

employment (Luthje and Franke, 2003). In order to design effective programs, policy makers have to know which of these factors are decisive (Scott and Twomsey, 1988).

While new venture opportunities exist within nearly all academic disciplines (e.g., graphic arts, nursing, computer science, chemistry and pharmacy), the majority of entrepreneurship initiatives at universities are offered by business schools (Ede et al., 1998; Hisrich, 1988) and for business students (e.g., Roebuck and Brawley, 1996). In fact,

most studies that have been conducted to explore entrepreneurial intent among university students have focused on business students (e.g., DeMartino and Barbato, 2002; Ede et al., 1998; Hills and Barnaby, 1977; Hills and Welsch, 1986; Krueger et al., 2000; Lissy, 2000; Sagie and Elizur, 1999; Sexton and Bowman, 1983). However, Hynes (1996) advocated that entrepreneurship education can and should be promoted and fostered among non-business students as well as business students. Picker et al. (2005) refer that entre-

preneurial led measures have been recently implemented, through the establishment of new graduate programs, in the Cambridge-MIT Institute, the Stockholm School of Entrepreneurship, and the International Graduate School of Chemistry (Münster, Germany). Consequently, if a goal in designing entrepreneurial programs is to assist students within and outside the business school, it is important to understand students enrolled in other majors that not business.

The aims of the present paper are threefold: first, to examine the magnitude of entrepreneurial intention among final year students (namely comparing students of chemistry related majors (bio-chemistry, chemistry science, chemistry engineering) and pharmacy with students of the remaining courses); second, to explain students entrepreneurial intentions, that is to assess the relevance of potential determinants (demographic, psychological and context) influencing the entrepreneurial intention and again test for the (eventual) differences in this regards between students of chemistry related majors (bio-chemistry, chemistry science, chemistry engineering) and pharmacy and the remaining students; third, to analyze the relationship between courses and students' interest in further education on entrepreneurship.

The paper is structured as follows. In the following section a brief review of the literature on students' entrepreneurial intentions is presented. Then, in Section 3, we detail the methodology and describe the data. The estimation model and results are presented in Section 4. Some conclusions are summarized in Section 5.

2. Student entrepreneurship potential. A brief review of the literature

The traditional mainstream view of the entrepreneur is as a 'risk-taker' bringing different factors of production together. The Austrian school takes a more dynamic perspective with entrepreneurship crucial for economic development and as a catalyst for change. In particular the Schumpeterian entrepreneur is an innovator who introduces new products or technologies. Frequently the notion of entrepreneurship is associated with predominant characteristics such as creativity and imagination, self-determination, and the abilities to make judgmental decisions and coordinate resources (Henderson and Robertson, 1999). Adapting Carland et al.'s (1984: 358) definition of "entrepreneur", we define 'potential entrepreneur' as "an individual [final year student] who [admits] establish[ing] and manag[ing] a business for the principal purposes of profit and

growth".

According to several authors (e.g., Carland et al., 1984; Hatten and Ruhland, 1995), entrepreneurs are characterized mainly by innovative behavior and employment of strategic management practices in the business.

A relevant body of literature on entrepreneurial activities reveals that there is a consistent interest in identifying the factors that lead an individual to become an entrepreneur (Martínez et al., 2007). Several pieces of evidence show that these are similar, with the most frequent analyzed as age, gender, professional background, work experience, and educational and psychological profiles (Delmar and Davidsson, 2000).

Broadly, three factors have been used to measure entrepreneurial tendencies: demographic data, personality traits (Robinson, 1987), and contextual factors (Naffziger et al., 1994). Demographic data (gender, age, region) can be used to describe entrepreneurs, but most of these characteristics do not enhance the ability to predict whether or not a person is likely to start a business (Hatten and Ruhland, 1995). The second method of assessing entrepreneurial tendencies is to examine personality traits such as achievement motive, risk taking, and locus of control. McClelland (1961) stressed need for achievement as a major entrepreneurial personality trait, whereas Robinson (1987) asserted that self-esteem and confidence are more prominent in entrepreneurs than the need for achievement. Several authors (e.g., Naffziger et al., 1994), however, argue that the decision to behave entrepreneurially is based on more than personal characteristics and individual differences. Accordingly, the interaction of personal characteristics with other important perceptions of contextual factors needs to be better understood.

Dyer (1994) developed a model of entrepreneurial career that included antecedents that influenced career choice. Antecedents to career choice included individual factors (entrepreneurial traits), social factors (family relationships and role models), and economic factors. This author asserted that children of entrepreneurs are more likely to view business ownership as being more acceptable than working for someone else. Baucus and Human (1995) studied Fortune 500 firm retirees who started their own business and found that networking, their view of departure, and prior employment experience positively affected the entrepreneurial process. Carroll and Moskowski (1987) asserted that children with self-employed parents likely work in the family firm at an early age. That experience, coupled with the likelihood of inheriting the firm, led the indivi-

duals to move from a helping situation to full ownership and management. Van Auken et al. (2006) found that the importance of family owned businesses and the influence of family (including parental role modeling) in Mexico suggests that Mexican students may be more interested in business ownership than US students. Earlier, Scott (1988) also found that children of self-employed parents have a much higher propensity to become self-employed themselves. He conjectured that perhaps the influence of parents was twofold: first, as occupational role models, and second, as resource providers.

In Section 4, for the selected students, we assess which of the three groups of determinants of entrepreneurial intention – demographic, psychological, and contextual – emerges as more relevant. Before embarking on this analysis, the next section details and describes the methodology and data gathered.

3. Methodology and descriptive statistics

A questionnaire was developed and pre-tested during spring 2006. Final year students of all subjects at the largest Portuguese university (Universidade do Porto) were surveyed regarding their entrepreneurial potential. The survey was mainly conducted in the classroom, but when that was impossible (some final year students did not have classes as they were in internship training), the survey was conducted through an online inquiry. The final year students totaled 3,761 individuals, spread over 60 courses, offered by 14 schools/faculties. The survey was carried out from September 2006 up to March 2007. A total of 2,430 valid responses were gathered, representing a high response rate of 64.6%. Of these responses, 107 were from chemistry related majors (bio-chemistry, chemistry science, and chemistry engineering), and 87 from pharmacy (totaling 194 individuals). The response rates of these groups were, respectively 80.6% and 70.7%.

The questionnaire contained 17 questions, which include a specific demographic descriptors (such as gender, age, student status, and region); participation in extra curricula activities, professional experience, academic performance, and social context; statements designed to measure fears, difficulties/obstacles and success factors concerning new venture formation to which students responded using a 5-point Likert scale.

The entrepreneurial potential or intent was directly assessed by asking students which option they would choose after completing their studies: starting their own business or being exclusively self-employed; to work exclusively as an employee; to combine employment and self-employment. Although such procedure is widely and extensively used in the literature on this subject (see, for instance, Scott, 1988; Ede et al., 1998; Lüthje and Franke, 2003; Franke and Lüthje, 2004; Gurol and Atsan, 2006), it is important to point out the potential bias that it might involve as we are basing our argument on a general statement to a possible action in future.¹ It would probably be more accurate to examine our research questions by employing an ex-post observation (e.g. 5 years later when these students are entrepreneurs or employees), but this would constitute not a measure of entrepreneurial intent but rather a measure of effective entrepreneurial behaviour. Moreover, to have such measure would require cohorts of students, which was not materially possible at this stage of the research.

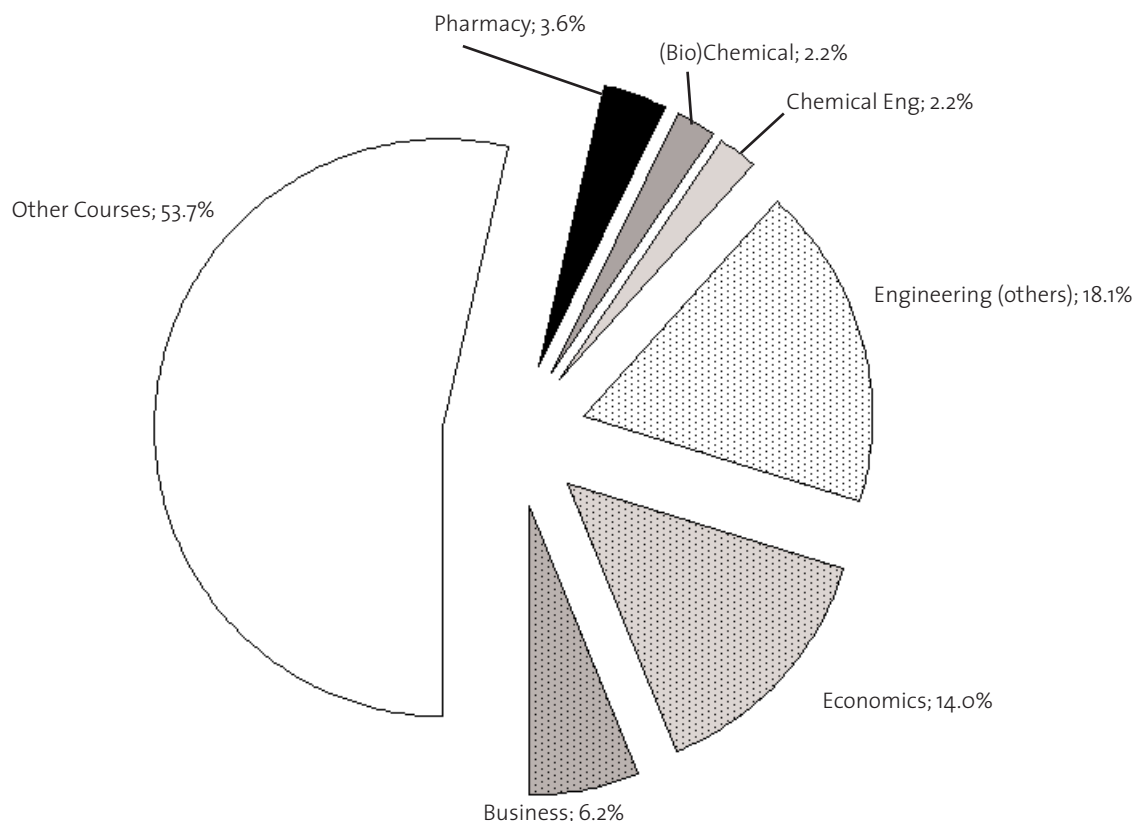
Chemistry and Pharmacy related courses account for 8% of total respondent sample. This is a small percentage when compared with other courses - 14% of respondents are from Economics course and 6.2% from Business; in engineering the most representative courses are Computing, Electronics and Civil engineering, encompassing, respectively, 4.5%, 3.5% and 3.4% of the total number of selected students. Nevertheless, such percentages fairly represent the whole population.

On average, 34.6% of (bio)chemistry science students surveyed claim that they would like to start their own business after graduation, a much higher value than that of chemistry engineering students (14.8%). Pharmacy students are the most entrepreneurial led – on average, 36.8% would desire to become entrepreneurs after graduation.

It might, at first glance, be puzzling the wide difference between Pharmacy/(Bio) Chemical Science and Chemistry Engineering. Industry's entry barriers and labour market issues might be relevant for explaining such evidence. In pharmacy and chemical science the most probable employment outlet are (Commercial) Drugstores and Chemical Labs. Although the regulation entry barriers are not negligible, financial/capital entry barriers are relatively low compared with other

1) We acknowledge a referee for raising such pertinent issue.

Figure 1 Distribution of final year students by courses



types of industry (Portugal-Autoridade da Concorrência, 2005), namely chemistry engineering related industries. Moreover, in Portugal, chemistry engineering jobs convey a relatively high entry salary and the employment rate is low (Portugal, 2004), which might discourage entrepreneurial intents.

It is interesting to note that, in general, male students are statistically significant (using Kruskal-Wallis test) more entrepreneurially driven than their female counterparts - 31% of male students would like to start their own business after graduation, whereas in the case of female students, that percentage is around 23%. Differences by course are particularly acute in Economics and Other Engineering courses. In Pharmacy and Chemistry related courses there is no evidence that statistical significant differences exist. A remarkable exception to the overall pattern - male more entrepreneurial than female students - is (Bio)Chemistry, where 37% of the female students claimed to desire start their own business after graduation against 29% of the male counterparts. Nevertheless, such difference failed to reveal statistical significance.

In general, older students (over 26 years old) are

more entrepreneurial than their younger colleagues. Differences between age groups are particularly evident in Economics whereas in Pharmacy and Chemistry related courses differences are not statistically significant.

At first sight, there seems to be a relationship between the status of the student, namely to be involved in academically related issues (student association members) or professional occupation - part time status - and the desirability to be an entrepreneur in pharmacy and chemistry related courses. Notwithstanding, the differences are not statistically significant. Figure 5 shows that the status for the whole sample does not discriminate between entrepreneurial led and other students.

Correlating entrepreneurial potential with some psychological attributes associated with an entrepreneur (cf. Section 2) - risk taking, no fear of employment instability and uncertainty in remuneration; leadership wishes; creative focus; and innovative focus - we obtain an interesting picture by course.

Risk taking behavior was computed by considering the scores of the four items regarding the fear associated with new business formation -

Figure 2: Entrepreneurial propensity by courses

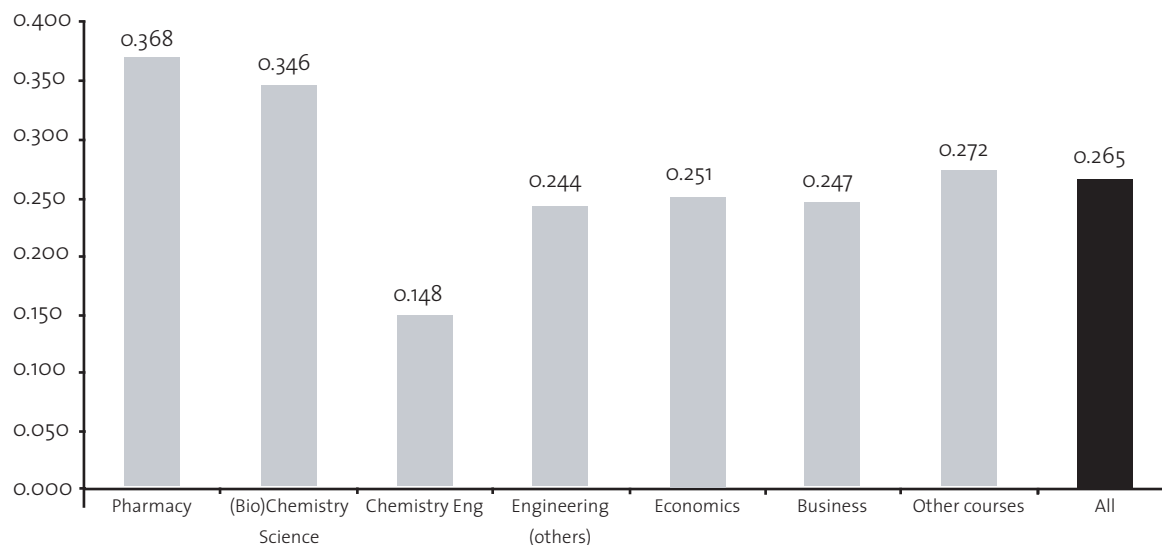
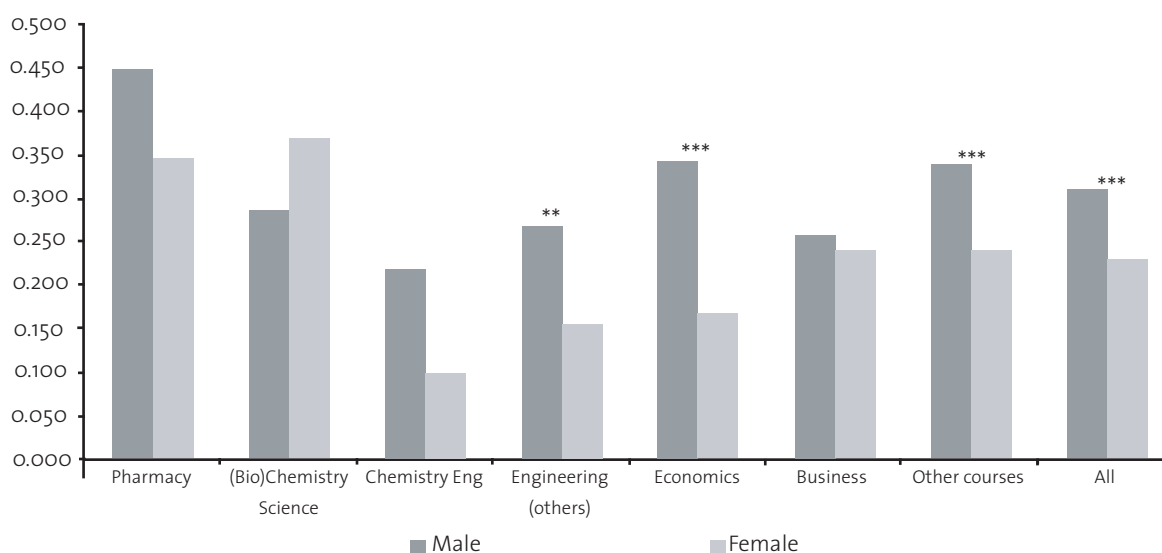


Figure 3: Entrepreneurial propensity by gender and courses



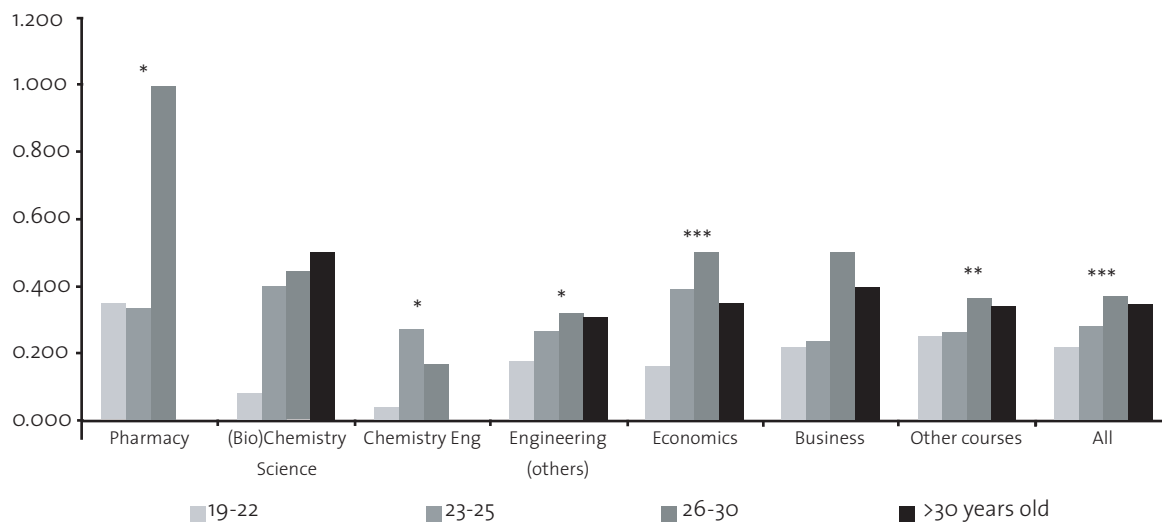
Note: ***(**)[*] significant at 1% (5%)[10%], according to Kruskal-Wallis Test

uncertainty in remuneration; employment instability; possibility to fail personally; possibility of bankruptcy. Firstly, dummies were computed for each item attributing 1 when the student responded small or no fear. Then we added up the four dummies and computed a new one which scored 1 if the sum variable totaled 3 or 4.

Today's businesses, workers, and educational institutions are making large investments in identifying and developing a personal characteristic called leadership. Some studies (e.g., Kuhn and Weinberger, 2005) identify 'potential leaders' as those students who reported that, within a given

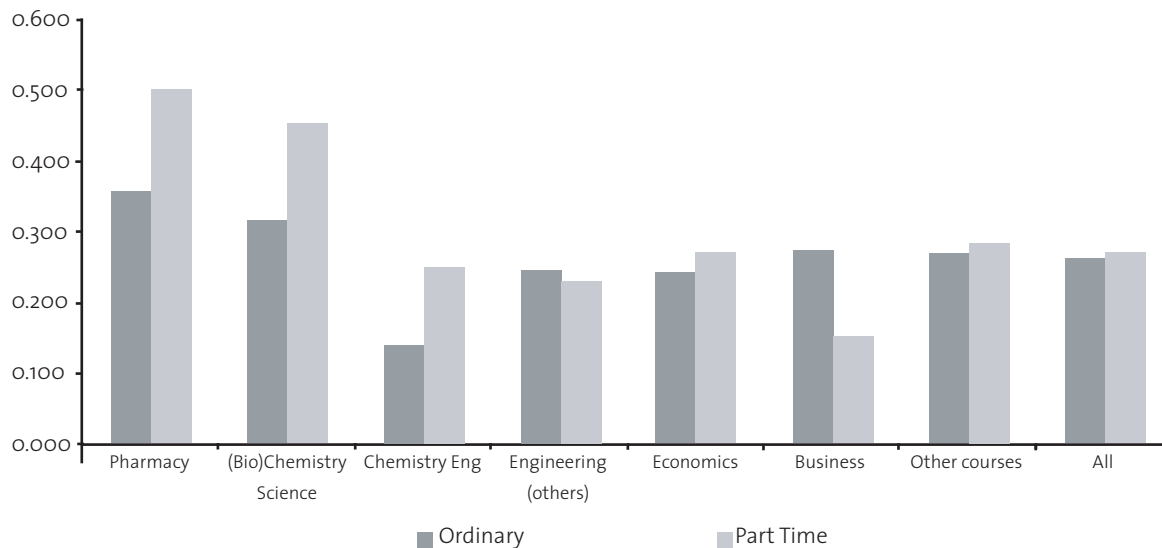
period, they were team captain or club presidents. Although we recognize that this might constitute a reasonable proxy, in the Portuguese university context these high school leadership activities are quite inexpressive. Thus, we devise an alternative proxy, based on the future desired occupation as employee. Baker and Aaron (1999) found evidence that one of the main skills associated to Chief Executive Officers (CEOs) occupations is leadership. Accordingly, we consider 'potential leaders' students that chose the option 'Directors/CEOs' (of firms or other organizations) when asked which occupation they would aspi-

Figure 4: Entrepreneurial propensity by age and courses



Note: ***(**)[*] significant at 1% (5%)[10%], according to Kruskal-Wallis Test

Figure 5: Entrepreneurial propensity by student status and course



re in the case they were employees after graduation. In other words, leadership is a binary variable that assumes the value 1 when students identify Director as his/her future desired occupation (in case they were employee) and 0 otherwise.

Creativity is becoming more valued in today's global society (Florida, 2005). As in leadership, in the case of creativity behaviour, the proxy was based on students' answers to the future desired occupation. However, the occupation based procedure used here relies on Richard Florida's (2002) measure of creative class. Florida's work propo-

ses that a new or emergent class, or demographic segment made up of knowledge workers, intellectuals and various types of artists is an ascendant economic force, representing either a major shift away from traditional agriculture- or industry-based economies, or a general restructuring into more complex economic hierarchies. The creative class is a class of workers whose job is to create meaningful new forms. The creative class is composed, for instance, of scientists and engineers, university professors, poets and architects. Their designs are widely transferable and useful on a broad scale, as with products that are sold

and used on a wide scale. Another sector of the creative class includes those positions which are knowledge intensive (Florida, 2005; Boschma and Fritsch, 2007). While by no means perfect, the procedure undertaken here enables, based on students indication of what type of occupation they would choose in case they opted by working as employees after graduation, to have a (rough) indicator of students' creativity potential/trait. In operational terms, creativity assumes the value 1 when students' future desired occupation is classified (in the taxonomy described above) as a creative occupation and 0 otherwise.

The literature concerning innovation-related classifications of industries is surprisingly scant and tends to be dominated by the Pavitt's (1984) taxonomy and the OECD's popular High-tech/Low-tech dichotomy. This OECD's has recently been applied with regard to the concept of Knowledge Based Economy (KBE). The notion of KBE revolves around the tripod "use-production-distribution of knowledge". The OECD (1999) has focused on the first leg of this tripod and has not only adopted a working definition of knowledge-based sectors based on the intensity of inputs of technology and human capital but also has empirically identified the set of knowledge-based sectors. The OECD defines knowledge-based sectors as "those industries which are relatively intensive in their input of technology and/or human capital", and identifies the set of knowledge-based sectors with High-technology industries, Communication services, Finance insurance, real esta-

te and business services, and Community, social and personal services (OECD, 1999: 18). Based on this study, we categorize sectors by degree of technology intensity and knowledge intensity. Thus, in the case students refer a sector classified as 'high tech- high knowledge intensive' (cf. OECD taxonomy), the variable 'innovation' assumed the value 1 and 0 otherwise.

As it is apparent in Figure 6, considering the whole sample, risk taker students ('Yes') present, on average, a higher entrepreneurial potential than their non-risk taker ('No') colleagues - 39% of students with risk taker behaviour would like to start a business after graduation whereas in the case of non-risk taker students the corresponding figure is only 23%. For creativity this difference is also substantial - 44% of students classified as having creativity behaviours ('Yes') are potential entrepreneurs whereas for non creativity prone students ('No') the corresponding percentage is almost halved. Leadership and innovative behaviors do not seem to discriminate between potential entrepreneurs, albeit in the case of leadership, students with this trait ('Yes') are more likely to aspire to become an entrepreneur after graduation.

For our baseline courses - pharmacy, chemistry science and chemistry engineering - students' traits differ in what respect leadership and innovativeness, but are similar regarding risk propensity and creativity. More specifically, we observe that in these courses, students that present a higher entrepreneurial propensity are, on average,

Figure 6 Entrepreneurial propensity by student psychological traits

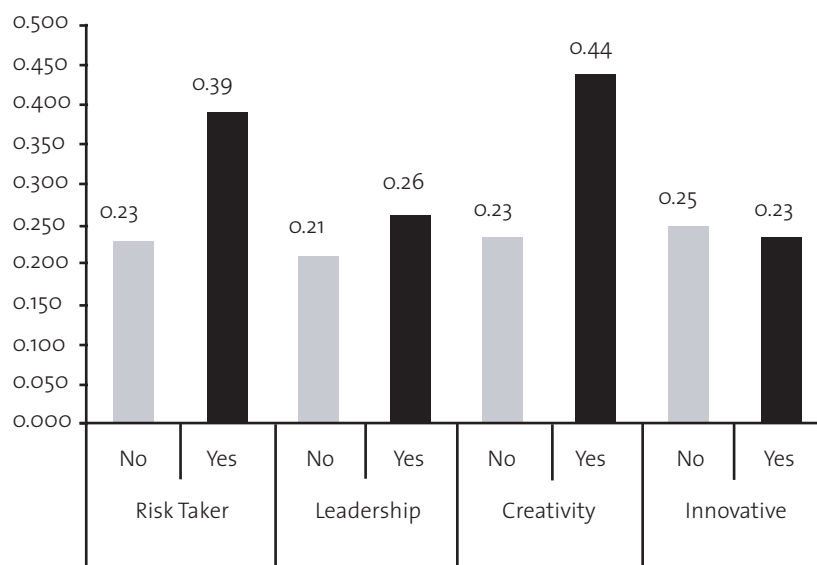


Table 2 Relation between entrepreneurial propensity and student's psychological traits, by course

	Risk	Leadership	Creativity	Innovative
Pharmacy	++	-	-	o
Chemistry Science	++	+	--	+
Chemistry Eng.	++	+	-	o
Civil Eng.	++	+	++	+
Mining Eng.	++	++	-	-
Electronics Eng.	++	+	+	+
Computing Eng.	+	+	++	-
Mechanical Eng.	o	+	--	+
Metal Eng.	-	-	--	++
Industrial & Management Eng.	+	+	++	+
Economics	+	+	++	+
Business	+	-	o	-

riskier but less creative than their lower entrepreneurial led colleagues. Concerning leadership we might point that this is a trait of entrepreneurial led students of Chemistry (science and engineering) but not from those of Pharmacy. Finally, innovativeness emerges as a characteristic of Chemistry science students that are entrepreneurial led, whereas in Pharmacy and Chemistry Engineering the propensity to entrepreneurship does not differ between innovative and non-innovative students.

In courses such as Economics, Civil Engineering, Electronics, and Industrial and Management Engineering, students presenting higher risk behavior, leadership traits, focus on creativity and innovative sectors reveal, on average, higher entrepreneurial potential. Nevertheless, risk behavior is associated with low entrepreneurial propensity in Mechanical and Metal courses; in Business and Metal Engineering leadership traits are essentially associated with non entrepreneurs; creativity is negatively associated with entrepreneurial potential in Mining, Mechanical, Metal and Chemical industries, which, given their business focus, is not really surprising. More surprising is the fact that focus on innovative sectors is not associated with entrepreneurial propensity in the Computing course.

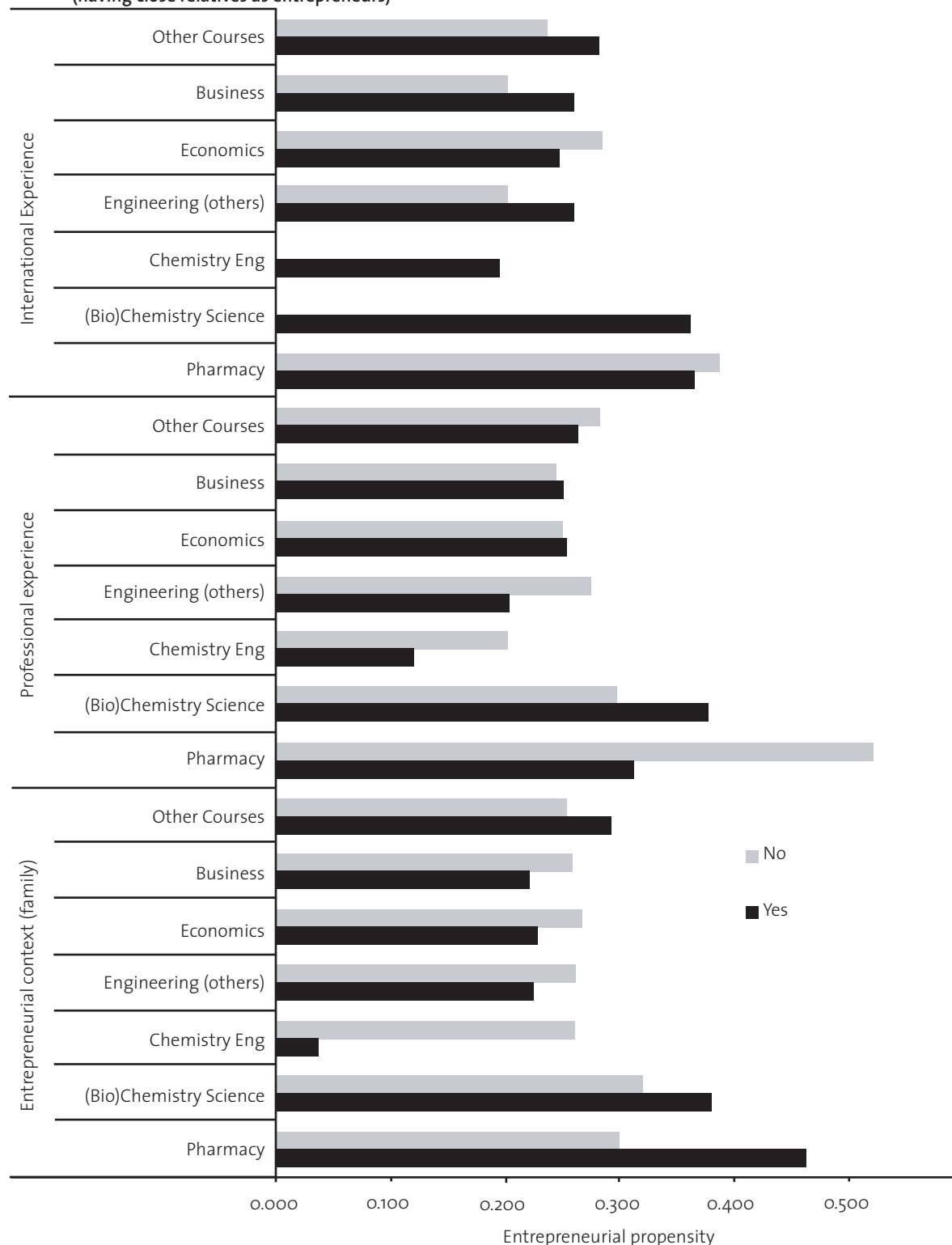
The role of experience at the level of associations, and other extra curricula activities, having international experiences, and professional activity experience is mixed with regard to entrepreneur-

rial potential. Only in Economics and Pharmacy is the entrepreneurial propensity positively correlated with students' international experience. Regarding the professional experience, those students that claimed to have (had) a paid job tend to be more entrepreneurial led in Chemistry engineering and other engineering as well in pharmacy courses. Family models (to have close relatives entrepreneurs) are particularly important, that is, seems to be highly (positively) correlated with students entrepreneurial potential in Chemistry engineering and (in a lesser extent) in Business, Economics and other engineering courses.

4. Estimation model and results

The aim here is to assess which are the main determinants of the student's entrepreneurial propensity. The nature of the data observed relative to the dependent variable [Opt to start a business after graduation? (1) Yes; (0) No] dictates the choice of the estimation model. Conventional estimation techniques (e.g., multiple regression analysis), in the context of a discrete dependent variable, are not a valid option. First, the assumptions needed for hypothesis testing in conventional regression analysis are necessarily violated – it is unreasonable to assume, for instance, that the distribution of errors is normal. Second, in multiple regression analysis, predicted values cannot be interpreted as probabilities – they are not con-

Figure 7 Entrepreneurial propensity by student's international and professional experience and family background (having close relatives as entrepreneurs)



strained to fall in the interval between 0 and 1. According to the literature (cf. Section 2) there is a set of factors, such as student's demographic descriptors (gender, age, student status, and region of residence), psychological traits (risk, leadership, innovative and creative focus, and academic performance), and context factors (participation in extra curricula activities, international experience, professional experience, and family background), and university course. The empirical assessment of the propensity to contact is based on the estimation of the following general logistic regression:

$$P(\text{entrepreneur}) = \frac{1}{1 + e^{-Z}}$$

with $Z = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{Age} + \beta_3 \text{Status} + \beta_4 \text{Region} + \beta_5 \text{Risk} + \beta_6 \text{Innovative} + \beta_7 \text{Leadership} + \beta_8 \text{Creativity} + \beta_9 \text{Performance} + \beta_{10} \text{Organization} + \beta_{11} \text{International} + \beta_{12} \text{Professional} + \beta_{13} \text{Family} + \beta_{14} \text{Course} + \varepsilon_i$

In order to have a more straightforward interpretation of the logistic coefficients, it is convenient to consider a rearrangement of the equation for the logistic model, in which the logistic model is rewritten in terms of the odds of an event occurring. Writing the logistic model in terms of the odds, we obtain the logit model

$$\log\left(\frac{\text{Pr ob}(\text{entrepreneur})}{\text{Pr ob}(\text{Non-entrepreneur})}\right) = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{Age} + \beta_3 \text{Status} + \beta_4 \text{Region} + \beta_5 \text{Risk} + \beta_6 \text{Innovative} + \beta_7 \text{Leadership} + \beta_8 \text{Creativity} + \beta_9 \text{Performance} + \beta_{10} \text{Organization} + \beta_{11} \text{International} + \beta_{12} \text{Professional} + \beta_{13} \text{Family} + \beta_{14} \text{Course} + \varepsilon_i$$

The logistic coefficient can be interpreted as the change in the log odds associated with a one-unit change in the independent variable.

Then, e raised to the power β_i is the factor by which the odds change when the i^{th} independent variable increases by one unit. If β_i is positive, this factor will be greater than 1, which means that the odds are increased; if β_i is negative, the

Table 3 Descriptive statistics

		Mean	SD	Min	Max
Entrepreneurial propensity		0.264	0.441	0	1
Individual characteristics	(1) Gender (Fem=1)	0.558		0	1
	(2) Age (ln)	3.155		2.9	4.1
	(3) Student status (Normal=1)	0.814		0	1
	(4) Region (North=1)	0.888		0	1
Psychologic characteristics	(5) Risky	0.077		0	1
	(6) Innovative	0.515		0	1
	(7) Leadership	0.359		0	1
	(8) Creativity	0.141		0	1
	(9) Academic performance (ln)	2.590		2.3	3.0
Context	(10) Extra curricula activities	0.296		0	1
	(11) International experience	0.170		0	1
	(12) Professional experience	0.532		0	1
	(13) Family background (entrepreneurs=1)	0.545		0	1
Course	Chemistry Science	0.021	0.143	0	1
	Chemistry Engineering	0.022	0.147	0	1
	Pharmacy	0.036	0.185	0	1

factor will be less than one, which means that the odds are decreased. When β_i is 0, the factor equals 1, which leaves the odds unchanged. In the case where the estimate of β_i emerges as positive and significant for the conventional levels of statistical significance (that is, 1%, 5% or 10%), this means that, on average, all other factors being held constant, female students would have a higher (log) odds of entrepreneurial potential.

The estimates of the β_s are given in Table 4. In this table we present two different models. The first model illustrates the estimated econometric specification relative to students of all (60) courses, grouping them into Chemistry Science, Chemistry Engineering, Pharmacy and Others courses (the default category). The second model restricts the sample to Chemistry Science, Chemistry Engineering, and Pharmacy students,

Table 4 Determinants of students' entrepreneurial propensity

		Model I Complete model	Model II Reduced model
Individual characteristics	(1) Gender (Fem=1)	-0.378***	-0.543
	(2) Age (ln)	1.544***	4.624**
	(3) Student status (Normal=1)	0.215	0.168
	(4) Region (North=1)	0.031	-0.139
Psychologic characteristics	(5) Risky	0.665***	1.663***
	(6) Innovative	-0.142	0.364
	(7) Leadership	0.256**	0.026
	(8) Creativity	0.398***	-1.022
	(9) Academic performance (ln)	-0.280	-1.506
Context	(10) Extra curricula activities	-0.164	-0.401
	(11) International experience	-0.306**	-0.921
	(12) Professional experience	0.071	0.496
	(13) Family background (entrepreneurs=1)	-0.076	-0.301
(13) Chemistry Science		0.395	-0.810
(14) Chemistry Engineering		-0.476	-1.307***
(15) Pharmacy		0.781***	
Constant		-5.253***	-10.905
N		2,359	185
Entrepreneurs		623	55
Others		1,736	130
Goodness of fit statistics			
% corrected		73.8	72.4
Hosmer and Lameshow test (p-value)		7.008 (0.536)	6.212 (0.623)

*** significant at 1%; ** significant at 5%; * significant at 10%; N=2,359

considering Pharmacy course the default category.

In Table 3, some descriptive statistics of the variables involved in the estimation procedure, as well their bivariate linear correlations estimates, are presented.

Considering all (2,431) final year students, on average, 26.4% stated that after graduation they would like to start their own business or be exclusively self-employed.

Around 56% are female and have an average age of 23. The vast majority (over 80%) are ordinary students and live in the North region.

Only a small percentage of students (8%) may be classified as risk prone (no or little fear of employment instability, uncertainty in remuneration, and failure).

Over a third (35.9%) present a leadership conduct, admitting that if they could choose an occupation, they would like to be firm's or other organization's directors/CEOs. Although 51.5% would invest in high-tech or high knowledge intensive industries in the event of starting a new business, only 14.1% would invest in creative industries.

On average, students present a reasonable academic performance (with an expected grade of 13 out of 20), the majority (53.2%) have or had some professional activity, 29.6% were or are involved in extra curricula activities, and a few (17%) had some sort of international experience (e.g., Erasmus mobility program). More than half (54.5%) have close relatives that are entrepreneurs.

As we referred earlier, Chemistry science, Chemistry engineering and Pharmacy encompass, respectively 2.1%, 2.2% and 3.6% of total students. In Model I, which includes (2,359) students from 60 majors, females reveal a much lower propensity for entrepreneurship than their male colleagues. Such gender differences are not evident in the restricted model, that is, when we consider only students from Chemistry science, Chemistry engineering and Pharmacy courses. Whereas the first result ties in with other studies (e.g., Martínez et al., 2007), which indicate that entrepreneurship activities are more related to males, the second result finds some echo with the earlier study of Ede et al. (1998), who found no difference between male and female African American students in their attitudes toward entrepreneurship education.

All other characteristics and determinants being constant, and similarly to Ede et al. (1998), more senior students are more likely to be a potential entrepreneur. Student status only emerges as a relevant determinant of entrepreneurial propensity for the restricted model. However, the esti-

mate indicates that among business/economics and engineering students, normal or ordinary students (i.e. full-time students) tend to be more entrepreneurially driven. Regional origin of the students does not seem to impact on the propensity which might be at least in part be explained by the fact that the vast majority (almost 90%) live in the North (the region where the University of Porto is located).

In the complete model (Model I), psychologically related factors, such as risk propensity, leadership behavior and creativity focus, emerge as critical for explaining students' entrepreneurial intent. In these competences the scores of potential entrepreneurs are much higher than those of the remaining students. When we restricted the sample of students to Chemistry science, Chemistry engineering and Pharmacy courses, the only psychological trait that remain statistically (and positively) significant is risk. This result corroborates our previous analysis (Table 2) and underlines that for these types of courses creativity, leadership, and innovative features might not be determinant for starting new ventures. Nevertheless, this might be worrisome if one takes for granted that the new tendency for business creation in general, and chemistry in particular (EPSRC, 2006), requires creativity and innovation.

The expected average grade does not explain the entrepreneurial propensity of students both in the complete and restricted models.

Surprisingly, almost none of the contextual factors turn out to be relevant. In contrast to some previous evidence (e.g., Martínez et al., 2007), potential entrepreneurs do not differ from other students in the time they spend on other activities. Controlling for individual and psychological factors, potential entrepreneurs and others spend a similar amount of time working to acquire professional experience, and on extra curricula activities. Moreover, the role model stressed by the literature concerning the importance of family and contextual background does not prove to be important in this study. We do not confirm, therefore, the results of other entrepreneurship studies (Brockhaus and Horwitz, 1986; Brush, 1992; Cooper, 1986; Krueger, 1993), which found that students from families with entrepreneurs have a more favorable attitude toward entrepreneurship than those from non-entrepreneurial backgrounds.

Finally, controlling for all the variables likely to impact on entrepreneurial propensity, Model I shows that Pharmacy students are more prone to entrepreneurial intents than students from other majors such as economics, business, and (other) engineering, to name just a few. This result

proves to be quite unfortunate given the focus that previous studies on entrepreneurship placed on these two majors, and the fact that a substantial part of entrepreneurial education is undertaken in business schools (Levenburg et al. 2006). Additionally, differences emerge (Model II) between Chemistry Engineering and Pharmacy majors with regard to entrepreneurial propensity – students of Chemistry engineering tend to be much less entrepreneurial led than their colleagues from Pharmacy. At least in part, as we referred earlier, such difference might be explained by industries characteristics (relatively low regulation and financial/capital entry barriers in pharmacy retail distribution) and labour market issues (relatively high entry salary and low employment rates for chemistry engineers).

5. Conclusions

In this paper, the entrepreneurial intentions of undergraduates in Portugal are examined along with their related factors. The findings have insightful implications for researchers, university educators and administrators as well as government policy makers.

First, the entrepreneurial propensity of undergraduates of Pharmacy and (Bio)Chemistry Science is quite high (around 35%), well above the Portuguese and other European (Germany and Austria) countries averages (around 25%). Notwithstanding, the corresponding figure is extremely low (15%) in Chemistry Engineering.

Second, for the whole sample, two demographic factors – gender and age – and three psychological traits – risk, leadership, creativity - are found to significantly affect interests in starting one's own business, while contextual factors, such as

family background, are found to have little independent effect. In the case we restrict the sample to Pharmacy and (Bio)Chemistry Science, and Chemistry Engineering only age and risk propensity emerge as significant determinant of entrepreneurial potential. Creativity, leadership and innovation seems not to be a characteristics of (potential) entrepreneurs in Pharmacy and Chemistry related courses, which given the worldwide economic features of business creation is likely to constitute a quite worrisome evidence. Although a reasonable amount of students of Pharmacy and Chemistry (Science) would like to run their own businesses, their intentions are hindered by inadequate preparation. A substantial percentage of students (90% in Chemistry Science, and over 70% in Pharmacy) recognize that their course failed to supply them the required knowledge and tools for starting a business. Moreover, excluding Pharmacy, between 50%-60% of students are aware that their technical and (especially) business knowledge is insufficient for starting a business.

Excluding students from Pharmacy, the vast percentage (around 60% or more) of students, particularly in Chemistry related courses, would like to attend further studies in innovation and entrepreneurship targeting their area of specialization.

We do agree with Hatten and Ruhland (1995) and Kent (1990) when they claim that more people could become successful entrepreneurs if more potential entrepreneurs were identified and nurtured throughout the education process. They demonstrate that students were more likely to become entrepreneurs after participation in an entrepreneurially related program. In this context, and as Kolvereid and Moen (1997) suggest,

Table 5 Courses adequacy and entrepreneurial (postgraduate) education prospects of students, by course

	% of students that agree a lot or completely with the statements			
	All courses	Pharmacy	Chemistry Science	Chemistry Eng
My course supplies me the tools and knowledge required for starting a business	21.5	26.4	9.5	22.2
I feel that I lack technical knowledge for starting a business	47.8	33.3	43.4	46.3
I feel that I lack management knowledge for starting a business	53.9	26.4	50.9	43.4
I'll like to attend a postgraduation in innovation and entrepreneurship in my area of specialization	56.4	18.6	66.1	57.4
I'll like to attend a postgraduation in innovation and entrepreneurship of general character	45.8	26.4	58.5	48.2

entrepreneurship, at least to some extent, might be a function of factors which can be altered through education.

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Practitioner's Section

A motor for future-proof jobs

The results of the study "Biotechnology in Germany - Employment Potential and Competitiveness".

Edeltraud Glänzer*

* German Miners', Chemical and Energy Workers' Union, IG BCE, Königsworther Platz 6, 30167 Hannover, Germany, edeltraud.glaenzer@igbce.de

Several hundred thousand people are already employed in biotechnology and gene technology in Germany. In the future, this industry will continue to create jobs. By 2020, the biotechnology industry will generate work and wealth for more people than are currently employed in the entire chemical industry. The study "Biotechnology in Germany - Employment Potential and Competitiveness" confirms that this industry is capable of becoming an engine for future-proof jobs.

Biotechnology plays an important role as a leading-edge and cross-disciplinary technology for innovation and growth. A country like Germany, poorly endowed in natural resources yet with a highly-qualified workforce, must invest in this innovative future technology in order to ensure its long-term competitiveness. It is already hard to imagine a world without biotechnology and gene technology. They form the basis for medical and pharmaceutical products and for agricultural and environmental technology. They offer vast potential for optimising existing processes as well as for the development of new products and services.

In addition, biotechnology and gene technology are among the most important fields for investment in the 21st century. The German Miners', Chemical and Energy Workers' Union, IG BCE, does not emphasize this fact from an uncritical belief in progress, but from a familiarity with those who do research and work in these future-oriented fields.

IG BCE says "yes" to biotechnology and gene technology. We are committed to this sector and do not only strive to secure existing jobs, but seek the creation of others in Germany.

By stating our position so clearly, we do not only meet with approval. A common question posed refers to the actual job-creation potential of the biotechnology sector; for it is often assumed that

this technology will not make a considerable impact on the development of the job market.

As no comprehensive studies had been carried out in this field, IG BCE, together with the German Association of Biotechnology Industries, DIB, and financially aided by the foundation Hans-Böckler-Stiftung, commissioned a study in order to fill the research gap.

Two renowned research institutions, the Fraunhofer Institute for Systems and Innovation (Fraunhofer ISI) and the German Institute for Economic Research (DIW) started their research study entitled "Biotechnology in Germany – Employment Potential and Competitiveness".

The principal aim was to gain reliable figures and assessments on the current economic and political importance of biotechnology in Germany. For the first time, not only were the direct employment effects covered, but also the upstream and downstream economic sectors included. This comprised research institutions, small and medium-size enterprises, the chemical and pharmaceutical industries as well as foodstuffs.

Not only was the question of the current and future economic importance of the individual biotechnology areas in Germany placed at the forefront of the study, but also the role and function of biotechnologies for the entire value-added chain as well as possible future scenarios for the creation of value. Furthermore, production and

sector structures in the biotechnology areas were listed and analysed – also taking its interconnectedness with traditional sectors into account - in order to assess international competitiveness. With the aim of devising a concrete and recommended course of action, the critical constraints and the key success factors in research, development, production and the distribution of products and processes in biotechnology were identified. Additionally, the question to what degree biotechnology is accepted or rejected by German society, and to what extent this affects its chances for economic success was also incorporated into the study.

Design of the study

In order to analyse the employment potential of biotechnology, an investigative model consisting of three variables (“pillars”) was utilised which takes the different employment impacts into consideration. The calculation of the employment effects was carried out by means of the input-output model ISIS, developed at the Fraunhofer ISI. It is based on the up-to-date input-output

tables of the Federal Statistical Office for the year 2002. They divided the German economy into 71 production and service sectors and six end-user sectors (among others, private consumer demand and export). For certain elements, (the formation of “biotechnology micro-segments”, the updating of productivity indices) an adjustment was made for the years 2004 and 2020, using appropriate statistical sources.

By means of an elaborate “top-down/bottom-up” procedure, employment scenarios were developed. A variety of methods was applied, among others, written surveys, expert interviews as well as patent analysis and techno-economic studies.

Employment potentials

With the study of relatively new technology fields, the actual market penetration contains a number of uncertainties. Employment effects are therefore given with lower and upper limits, which can be considered as pessimistic and optimistic market share estimates, respectively. The lower and upper limits for the year 2020 can be interpreted as resulting from slow or rapid market

Figure 1 “Three Pillar Concept” for the Analysis of the Employment Effects of New Technologies, Applied to Biotechnology

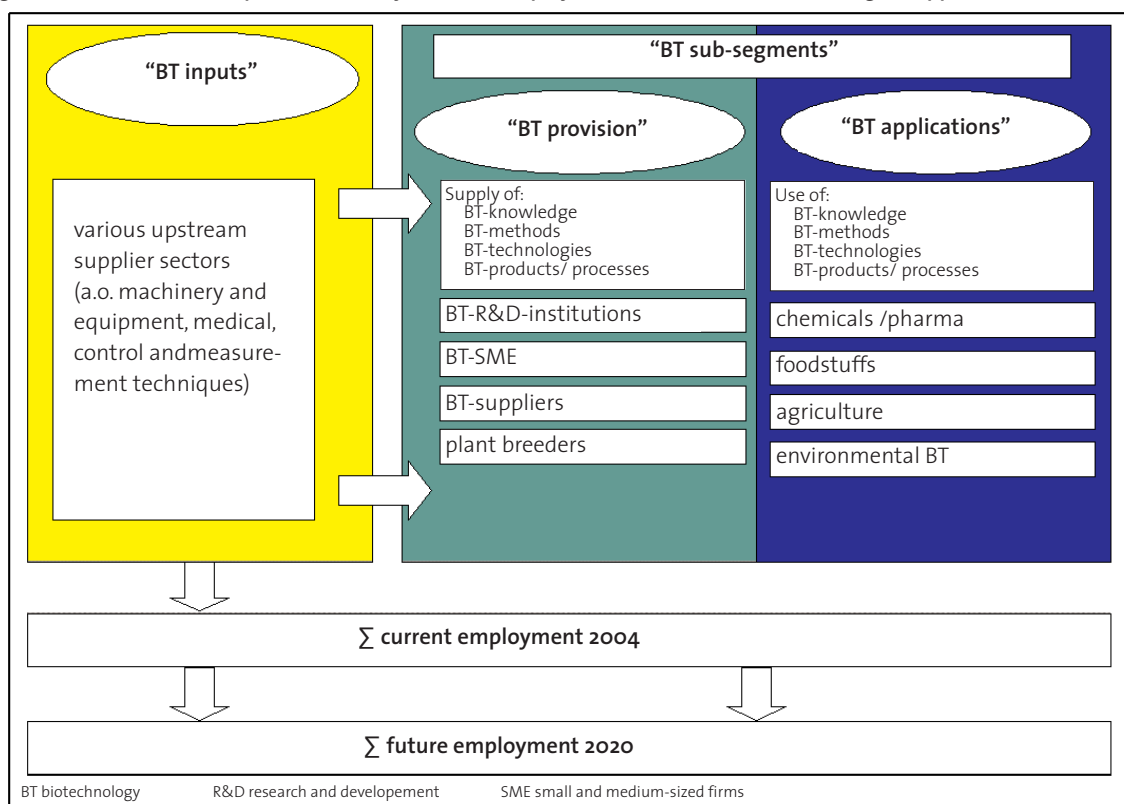
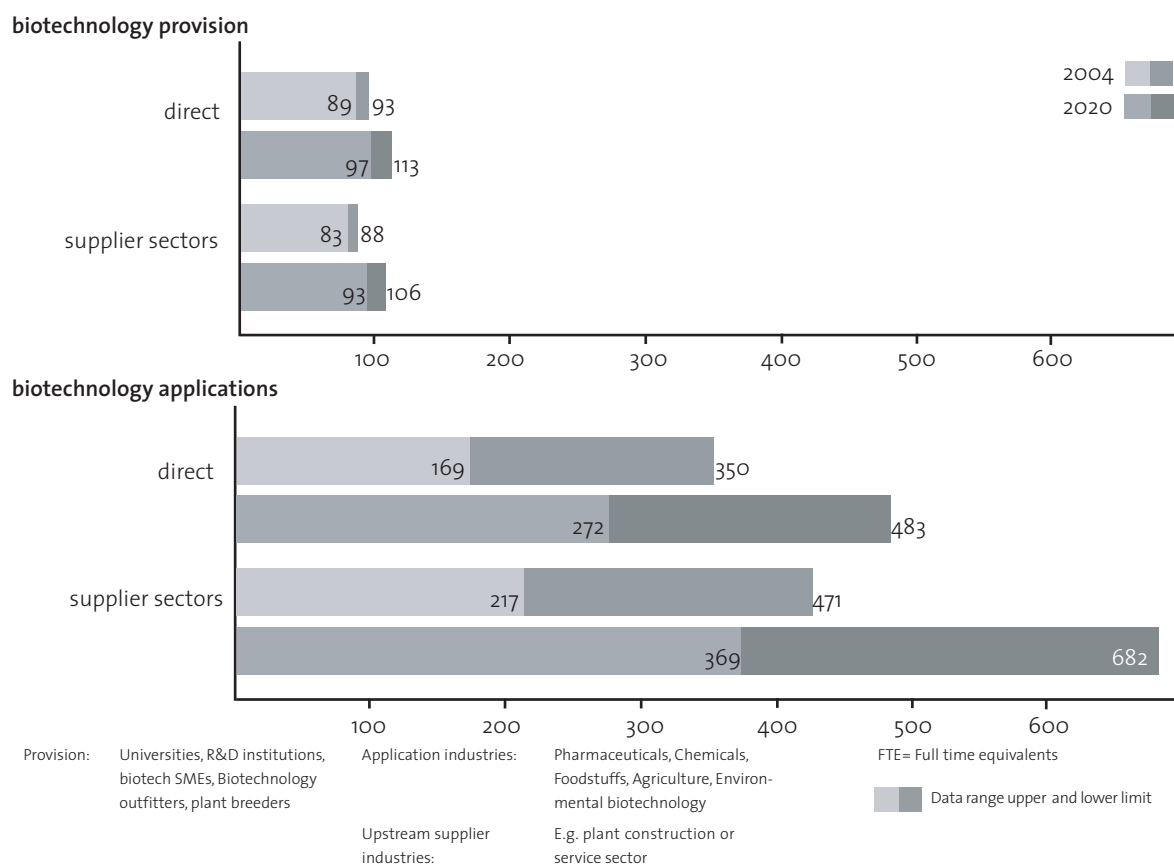


Figure 2 Biotechnology Direct employees and Employees in supplier industries (Provision and Application industries, in thousand FTEs)



Source: Calculations Fraunhofer ISI 206 (Errors possible in rounding up)

penetration.

Generally, an increase in employment can be expected in all three sub-segments: provision, application and input. For the provision of biotechnology know-how by universities, R&D institutions, biotech outfitters, small and medium-sized enterprises as well as plant breeders, an employment potential of 89,000 to 93,000 direct employees was shown. About 97,000 to 113,000 direct employees can be expected for the year 2020, thus an increase of 10 – 20%.

In the field of application, a considerably greater employment potential has been identified. The biotech application industries comprise pharmaceuticals, chemicals and foodstuffs industries as well as agriculture and environmental biotechnology. These industries apply biotechnological methods, processes and products. The sum of direct employment effects in these industries amounts to 169,000 to 350,000 jobs in 2004. In

2020, this figure may rise to 272,000 to 483,000 employees.

Biotechnology application industries have a considerable impact on employment in the supplier industries, such as, for example, mechanical engineering and plant construction. In 2004 and 2020, these indirect employment effects were greater than direct employment impacts. The data range shows employment figures of 217,000 to 471,000 in 2004 and even 369,000 to 682,000 in 2020.

Besides positive gross employment effects, we also have to consider negative employment impacts. They arise, for example, due to the substitution of traditional processes and products (e.g. chemical-based pharmaceuticals, fossil-based energy sources) and the expenditures and investments thereby forgone. In addition, compensatory and budget effects arise, as e.g., extra costs (among others for research funding, subsidies and tax exemptions for biofuels) must be

compensated in the entire economy by reducing expenditures in other places. These negative effects were not calculated within the framework of this study. A calculation of such effects would be very time and cost intensive.

An evaluation of Germany as a location for biotechnology – SWOT analysis

As well as site conditions, the international competitiveness of the stakeholders in the sub-segments of biotechnology represents another important factor for the realization of employment potentials. Therefore, strengths and opportunities, as well as weaknesses and threats for Germany as a location for biotechnology were examined by the study.

We can summarize the findings as follows:

Strengths and opportunities are mainly:

- The availability of highly-qualified personnel (among others scientists, engineers, technicians)
- A broad knowledge-base in all biotechnology areas – primary and applied research
- A large stock of technological assets (many patents)
- Dynamic, high-quality and highly regarded scientific publications
- A good research infrastructure with a differentiated research landscape
- A broad and competitive industrial basis – in both application as well as supply industries
- Large domestic markets and a well-established access to major export markets
- A good infrastructure (among others energy, transport/logistics, IT)
- Germany's central geographical location within the EU
- Public acceptance of biotechnology in the field of health and medicine as well as in industrial production

Weaknesses and threats are among others:

- An unwillingness of industry stakeholders to take risks and to invest compared to international competitors
- A paucity of venture capital in gestation periods despite existing private capital
- Relatively low R&D expenditures in German biotech enterprises compared to international competitors
- A lack in labour mobility between science and industry – especially from industry to science
- Future bottlenecks for (highly) qualified personnel (among others scientists, engineers, technicians)
- Increasing competition in the production area

mainly, especially from Asia

- A highly complex structure of national and international laws lacking in complementarity, related elevated bureaucratic costs and frequent poor service orientation of public authorities
- Low levels of public acceptance for biotechnological products in agriculture and food
- Strong overseas orientation of leading enterprises in the area of green biotechnology

Conclusions

Today, a high-performance society is based on a highly complex and interdependent economy. We have to embrace this complexity to be able to assess, for example, the likely impact of job losses in one sector of the German economy on other industries and sectors.

The results of the study show that several hundred thousand people are already employed in biotechnology and gene technology. Furthermore, the study confirms that this sector possesses enormous powers of innovation capable of generating enormous employment potential, in particular in the applied (manufacturing and production) industries. For example, by 2020, more people will work in biotechnology-related fields than are currently employed in the entire chemical industry.

It was found that biotechnology has to be understood and appreciated as a cross-sectional technology. The progress made in biotechnology and gene technology plays an important role in many core industries. Biotechnology has implications via the chemical and pharmaceutical industries for the environment, agriculture and food production. Despite market penetration developing at different pace in individual industries, penetration is set to increase.

The SWOT analysis illustrates the areas for action that need to be addressed by politicians, entrepreneurs and scientists. Nothing less than a concerted effort by all stakeholders is required if the full potential of biotechnology for innovation, growth and employment is to be realised.

In order to sustain and strengthen the performance of the German economy amidst international competition, we need to accelerate the application of the full spectrum of biotechnology. The upsurge in innovation triggered by this cross-sectional technology creates new products and markets, but not only that. Innovation in biotechnology and gene technology safeguards, at the same time, the future of research-intensive and export-oriented industries. They form the basis for the cutting-edge role of chemical and

pharmaceutical production.

The result: biotechnology sustains and creates hundreds of thousands of jobs, many of which in the future-proof research and service sectors. Biotechnology and gene technology are indispensable if we want to remain competitive at an international level.

If Germany as an industrial location wants to benefit from this opportunity, research and production need to be both welcomed and nurtured and - needless to say - German safety and environmental standards must be applied.

Biotechnology and gene technology are difficult issues. The complex interconnections are not always easy to understand and objections dominate the public mood. We need to deal with these ethical issues and the fears they engender in the population at large. Enterprises need to communicate openly about their work and especially about their products. We need an open and fair dialogue about the opportunities and risks. Only if we succeed in convincing people of the benefits of these products, we will manage to create acceptance for biotechnology in Germany in the long term.

As a country poor in natural resources, we need to focus on know-how and technology in Germany. Innovation can act as a driving force for our economy. We can thus ensure prosperity and create urgently-needed employment. The trend towards losing jobs, especially in traditional production sectors will probably continue over the coming years. In order to remain competitive, we need innovation, new products and new markets. The growth in the industry of biotechnology is therefore likely to play an even greater role here. The results of the study presented thus serve to both encourage and confirm the views held by IG BCE. We have always emphasized that biotechnology and gene technology offer great opportunities for German know-how and technology, and that investment in this technology is worthwhile. We will continue to commit our resources to this end.

This study was commissioned by Hans-Böckler-Stiftung, the German Miners', Chemical and Energy Workers' Union and the German Association of Biothechnology Industries.

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Practitioner's Section

Unbiased Insight on Biopharma's Innovation Crisis

Enrique Esteban, Frank Lien, Richard Youn*

Bogart Delafield Ferrier LLC, 91 Washington Street, Morristown, NJ 07960, USA.

* corresponding author: ryoun@bdf.com

The pharmaceutical industry is at a crossroads. In 2010, it faces one of the biggest waves of proprietary patent expirations yet lacks a viable pipeline to replace these soon to be generics. Furthermore, R&D expenditures have more than doubled from 1995 to 2006 without commensurate increase in NMEs (new molecular entities, Martinez and Goldstein, 2007). In 2007, the FDA (Food and Drug Administration) only approved 19 novel drugs, the lowest number since 1983 (Blum, 2008).

At this critical juncture, pharma would benefit immensely from a dose of "new thinking" and "expert insight" on ways to reinvigorate its innovation model within R&D. The authors assert that there is much to learn from the pro-

blems and successes of non-pharma peers, who at one point faced a similar crisis, that of incremental innovation and falling new product introductions. Their stories offer the pharmaceutical industry an invaluable perspective that will shed light on pharma's own case for re-thinking its approach to drug discovery and development.

What follows are eight mini-cases, each one representing a distinct non-life science industry corporation, and the programs they initiated to reinvigorate their product development efforts:

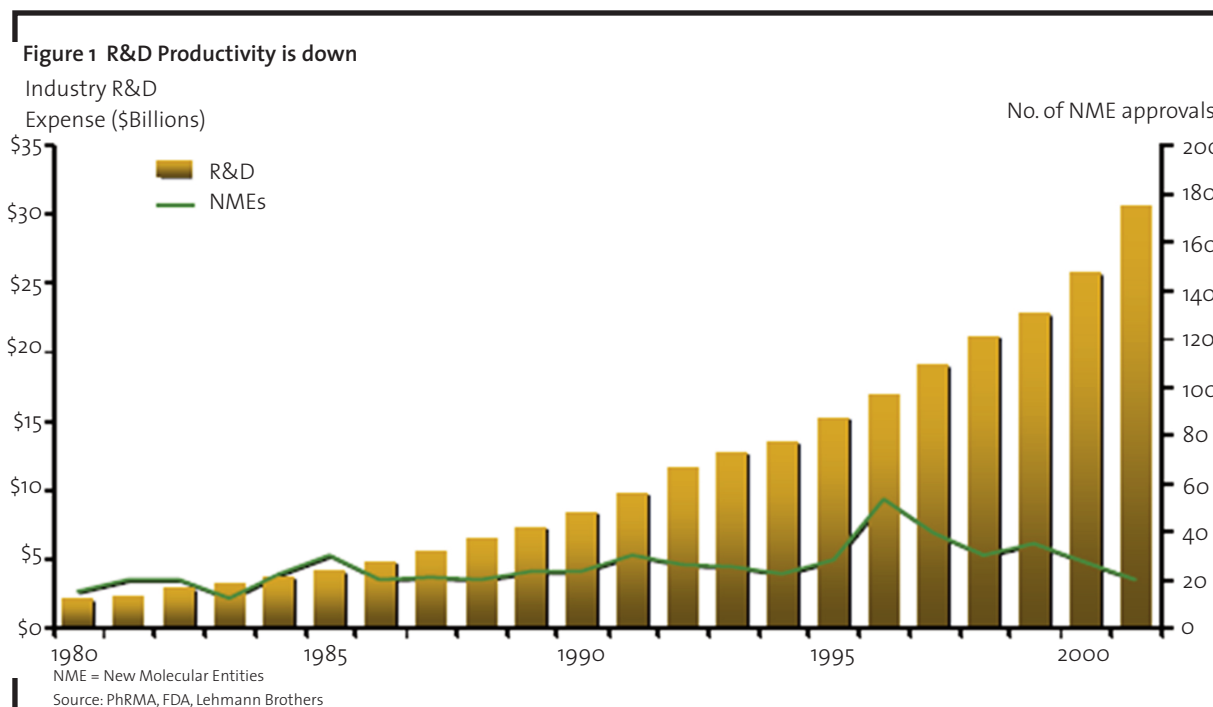


Figure 2 Motorola's Revenue 2001-2005

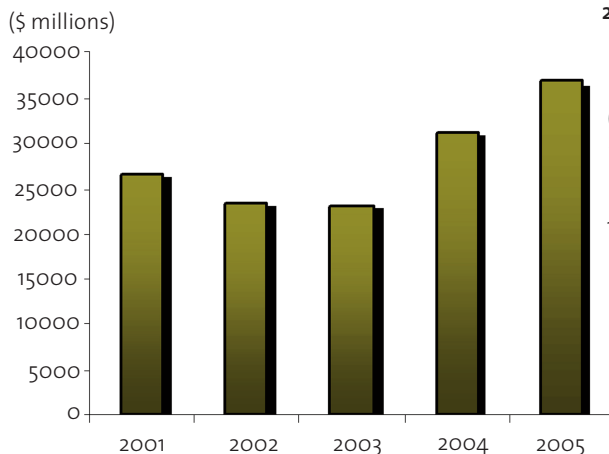
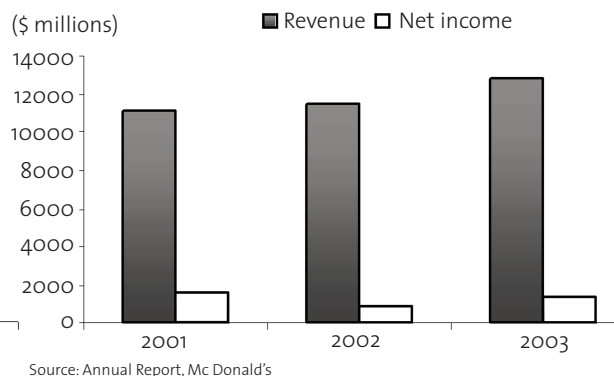


Figure 3 Mc Donald's Total Revenue and Net Income 2001-2003



Motorola

Change Implemented: Appointed, empowered, and made a manager accountable for each product development program.

"Although world-renowned as a leader in quality control, Motorola insiders believed stringent processes, although critical to maintaining quality and monitoring costs, stifled the company's innovation process."

Motorola's turnaround, from producer of unappealing mobile phones to the creator of the "iconic" RAZR phone was facilitated by drastic change in product development decision making.

The pioneer of mobile phones that once dominated the communications industry fell upon difficult times when competitors such as Nokia, Samsung and LG entered the market offering products with greater consumer appeal. Although world-renowned as a leader in quality control, Motorola insiders believed stringent processes, although critical to maintaining quality and monitoring costs, stifled the company's innovation process. The main culprit: Motorola's consensus based decision-making process utilized to develop a new phone; a process in which representatives from each major region were required to establish a position on a new product concept. "The regions would request the sorts of features and functions they wanted included in the design. Each region would then forecast how many units of the model they thought they could sell. The aggregated regional plans would help Motorola decide whether to invest in a phone's introducti-

on" (Anthony, 2005). Although it provided consensus amongst all the regions, it was time-consuming, cumbersome, and ultimately produced products that lacked any consumer appeal.

Incoming CEO, Ed Zander (2004), dramatically altered this decision-making process by transforming the organizational structure of new product development teams by empowering decision making to its managers. The results were simplified decision making, faster project cycle turn-around times, and accelerated go/no-go project decision making (Shinn, 2007).

The culmination of these efforts was birthed in the RAZR phone, "iconic" and "hip", shattering Motorola's stodgy product image. At its introduction, the RAZR was the world's slimmest phone with enhanced features such as a camera and internet capabilities. Over one million units were sold during its first six months on the market (Anthony, 2005).

McDonald's

Change Implemented: Refocused on the customer experience

"...change occurred only after [McDonald's] returned to its roots of providing the best experience for its customers."

McDonald's reclaimed the title of the world's largest fast food restaurant chain after it returned to its roots, to provide the best possible experience for its customers.

Same-store sales experienced a sharp decline in early 2003, resulting from failure to fulfill important McDonald's processes, such as "full-field" evaluation standards (Tilson, 2003). The failure to ensure cleanliness, quality and consistency, resulted in a negative "McDonald's" customer experience. Furthermore, McDonald's ignored the market's shifting tastes toward a greater emphasis on "healthier" fast food selections. At the end of first quarter 2003, McDonald's announced its first-ever quarterly loss (Horovitz, 2004).

Newly appointed CEO, Jim Cantalupo, initiated "Plan to Win" (BusinessWeek, 2007). The program scaled back opening of new restaurants, required better service from its employees, and introduced new and healthier menu items (Gibson and Grey, 2004). McDonald's also slashed capital spending by 40% while addressing mounting customer complaints by speeding up drive-thru service and ensuring surly employees were disciplined (Gibson and Grey, 2004). Food studios were developed in the different regions served by McDonald's to create products that focused on meeting regional-specific consumer demands.

Eleven months after Cantalupo took charge, "Plan to Win" brought customers back into McDonald's restaurants and delivered impressive results: 2003 net income rose to \$1.471 billion from \$893.5 million (Gibson and Grey, 2004); system-wide sales increased 11.1% in September of the same year; and same store sales increased by 10% (Tilson, 2003).

Apple

Change Implemented: Eliminated "silo mentality" within R&D. Consolidate all R&D functions into one product development group accountable to one manager. Better understood and focused on customer experience.

"Jobs reorganized R&D into product groups that included in them all the functional areas needed to deliver on the consumer's product experience. They were accountable to one manager."

Apple's reemergence as the global innovator of computer products occurred once its original founder, Steve Jobs, returned as CEO. Prior to his return, Apple suffered from senior management missteps that included investing heavily on ill-fated projects and repeated large-scale funding on dead-end projects. Pro-

fits began to erode and by 1995 Apple's once 9% market share declined to 7.4% and it suffered a \$69 million loss in the fourth quarter of 1994 (Hormby, 2006).

Jobs returned to Apple in 1997 and instituted drastic change. He made significant cuts in Apple's product portfolio, discontinued products that were underperforming (Linzmayr and Chaffin, 2005) and opted for a streamlined product offering of products he believed to be highly innovative. Jobs also restructured his product development organization, which, until his return, was divided into highly-siloed functional groups that did not work cohesively. He dismantled these disparate functional groups and integrated them into separate product (iPod, iMac, etc.) development groups which all reported to one manager. Designers, hardware and software engineers, and manufacturers, all worked to seamlessly integrate every aspect of a product's functionality that captivated the complete user experience (Grossmann, 2005). The reorganization has produced groundbreaking products such as the iPod, iPhone, and iMac.

Although the company launches fewer new products today and only spends 4% of revenue on R&D (Wolverton, 2006), its revenues in fiscal year 2007 stood at \$24 billion, a 348% increase since fiscal year end 2001, the year the iPod was launched. Apple ended fiscal year 2007 with \$15 billion in cash and zero debt (Apple Inc., 2007). As of January 2007 the iPod garnered 73% market share of mp3 players sold globally (Wikipedia, 2008).

Walt Disney

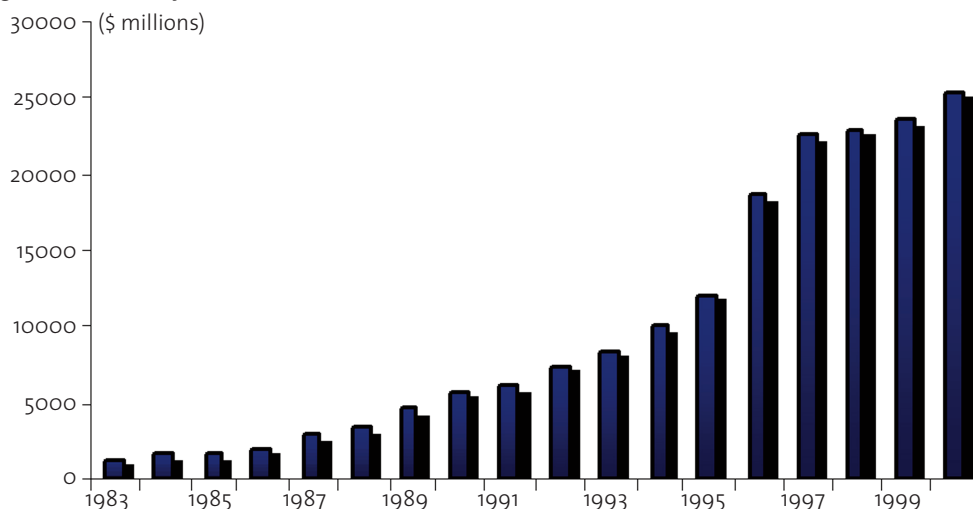
Change Implemented: Nurtured and leveraged corporate synergies while preserving corporate values

"[Michael Eisner] managed the ambitious turnaround by leveraging Disney's brand and nurtured creativity by accessing previously untapped corporate synergies."

Following serious declines in profits after the death of its creator, Walt Disney in 1966, CEO Michael Eisner transformed Walt Disney Inc. into the world's largest entertainment empire (Weber, 1998).

As the chief source of creative efforts within Walt Disney Inc., the death of Mr. Disney took a significant toll on the quality and depth of the company's product pipeline. When Eisner

Figure 4 Walt Disney's Revenue 1983-2000



Source: Annual Report, Walt Disney

assumed the role of CEO in 1984, Disney's box office shares were a paltry 4%, the lowest amongst all major studios (Walt Disney Inc., 1984).

Eisner steered the ambitious turnaround by leveraging Disney's brand and nurtured creativity by accessing previously untapped corporate synergies. His turnaround revolved around building Disney's brand while preserving the corporate values of "quality, creativity, entrepreneurship, and teamwork" (Rukstad and Collins, 2005). To achieve this, Eisner centralized many corporate functions, such as corporate marketing, engendering important synergies within Disney. Corporate wide strategic planning events were jointly coordinated by senior management, bringing departments together to generate novel ideas. The results from these ideation exercises were then coordinated by a corporate events department, designed specifically to disseminate "Disney synergies" enabling each strategic business unit to benefit from each other and bolster lagging units. Eisner cultivated creativity using Disney's most vital corporate skill, "managing creativity". He fostered expansive and innovative ideas by readily approving spending in concept-generation, while expecting business units to deliver against well-defined strategic and financial objectives, pitting creative and financial forces against each other as each business developed its market position. With corporate synergies and creative management processes in place, Eisner was able to ramp up movie production from two per year in 1984 to 15 to 18 per year four years later. During this

period animation movie production was also expanded to a new animated feature every 12 to 18 months instead of one every two years (Rukstad and Collins, 2005).

Eisner's turnaround efforts raised revenue from \$1.65 billion in 1984 to \$25 billion by 2000 and net earnings rose from \$0.1 billion to \$1.2 billion during his first 15 years, generating a 27% annual total return to shareholders during this period (La Franco, 1999). He exceeded his original promise of generating at least 20% annual shareholder returns and also managed one of the greatest corporate turnarounds in history.

Procter & Gamble

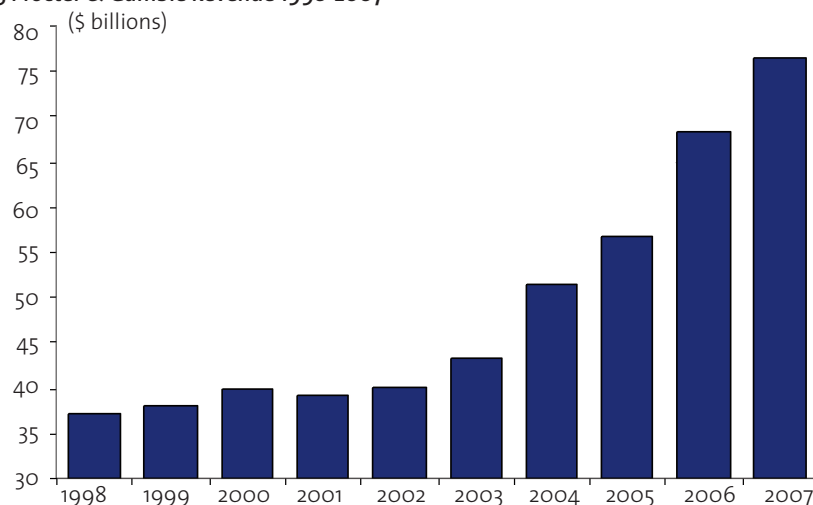
Change Implemented: Sourced innovation wherever it can be accessed; internally and externally

"New leadership immediately recognized the need to restructure their R&D organization and the "Connect and Develop" innovation model was established."

Procter & Gamble reinvigorated new product development and engendered growth by transforming their R&D organization and implementing a novel innovation strategy in "Connect & Develop".

P&G traditionally based much of its success on new product innovation and its deep understanding of consumer needs through its pioneering market research activities which studied consumer preferences and buying habits

Figure 5 Procter & Gamble Revenue 1998-2007



Source: Annual Report, Procter & Gamble

(Procter & Gamble, 2007). By 2000, the company was facing a crisis, their internally focused innovation model was producing flat product success rates of 35%, resulting in a pipeline too weak to sustain its expected 4% annual growth rate (Huston and Sakkab, 2006). P&G saw their sales growth rate flatten over a four year span beginning in 1999 and their stock price dropped by more than 50% in 2000 alone (Huston and Sakkab, 2006).

Facing this situation, newly appointed CEO A.G. Lafley and CTO G. Gil Cloyd, placed P&G under new direction called "Job One", to return P&G to historical dominance in product development and improve sales growth rates above the industry average (Colvin, 2006). The new leadership immediately recognized the need to restructure their R&D organization and the "Connect and Develop" innovation model was established. The "Connect and Develop" model enabled P&G to become more connected internally by enabling technologies and ideas to move more easily across existing business units, more unique and invaluable was P&G's new found ability to gain an intimate understanding of consumer needs and access to innovators outside the company through a much larger network of both proprietary and non-proprietary relationships.

The model effectively increased P&G's R&D staff from 7,500 internal members to include an estimated 1.5 million external staff members. As a result, R&D productivity has since risen 60% and over 35% of all new products commercialized have been developed externally. Internal innovation success rates have

doubled, total sales has grown 90% from 2002 to 2007, and their stock price has doubled since 2000 (Huston and Sakkab, 2006).

3M

Change Implemented: Applied discipline, focus, and accountability to the innovation process

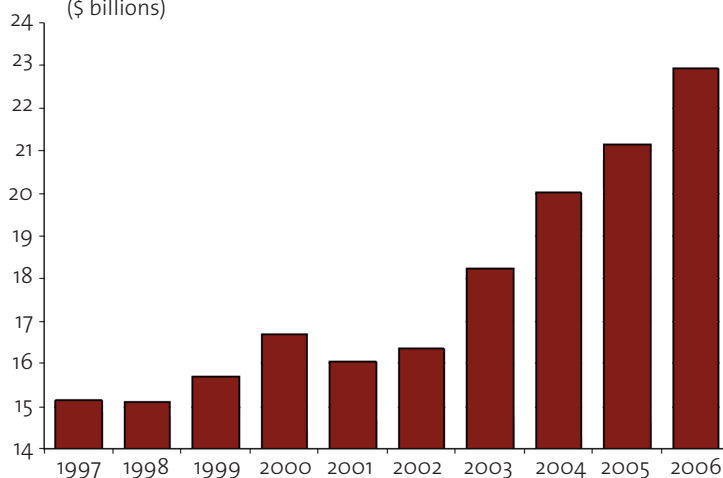
"The focus was not to just survive in existing product niches but to continue to innovate and develop new ideas."

3M transformed their product development organization by instituting Six Sigma discipline to overcome slower new product introductions and sales growth.

3M corporate image has long been built on innovative and unique products, constantly seeking to fill unmet product niches by devoting up to 25% of sales to new product development (3M, 2002). This intense focus on innovation enabled 3M to create such groundbreaking products as Scotch® tape and Post-It® notes which contributed to the company's healthy topline growth.

In the late 1990s, 3M's stock price began to stagnate as competition grew in its traditional product niches and number of new product introductions slowed (BusinessWeek, 2004; Funding Universe, 2007). Although 35% of revenues generated in 2000 were attributed to products introduced within the past four years, 3M had not produced a blockbuster product since the introduction of the Post-It® note in

Figure 6 3M Revenue 1997-2006
(\$ billions)



Source: Annual Report, 3M

1980. By the late 1990s both revenues and profits were declining as a result of fierce competition from lower priced substitutes (Funding Universe, 2007).

New CEO, Jim McNerney, arrived in 2001, and as his first order of business, instituted Six Sigma practices to cut costs and streamline product development efforts resulting in layoffs of over 6% of the workforce (Funding Universe, 2007). Utilizing Six Sigma, McNerney sought to bring discipline and focus to the R&D organization - the focus was not to be more competitive in existing product niches but to continue to innovate and develop new ideas by transforming 3M into a nimbler and leaner innovative corporation (Arndt and Brady, 2004). R&D was consolidated by closing fourteen technology centers, transferring staff to a newly formed Corporate Research Laboratory or to the company's 40 divisions and funds were channeled programs that exhibited a higher probability of potential success instead of access to equal funding across-the-board (Funding Universe, 2007). Furthermore, researchers were pushed to work more closely with marketing to transform existing in-house technologies into commercial products in order to stay ahead of their competitors (Arndt and Brady, 2004).

The R&D reorganization efforts delivered profit growth of 22% per year while McNerney was CEO and increased operating margins from 17% in 2001 to 23% in 2005 (Arndt and Brady, 2004).

Cadillac

Change Implemented: Embraced risk and tolerance for failure as a key requirement for innovation process to succeed

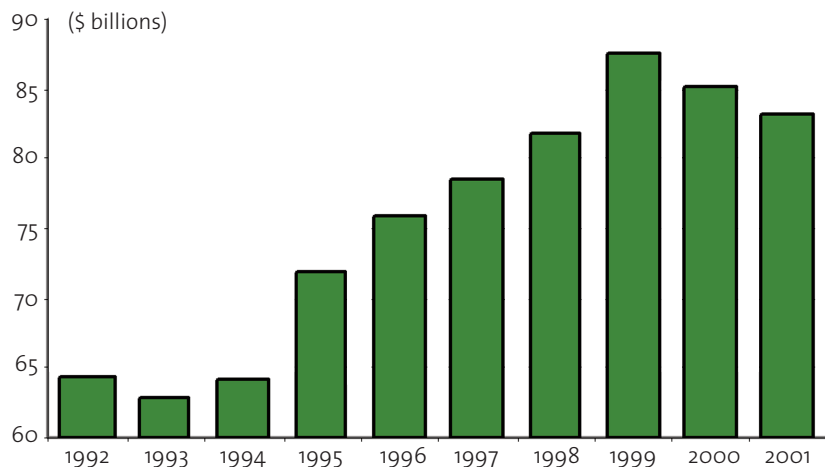
"The success of "art and science" can not be measured in sales, which have been slow to respond, but by the reinvigorated reputation and brand image."

Cadillac's willingness to take an "all or nothing" attitude towards the complete overhaul and redesign of its fleet enabled the company to reestablish its reputation and brand as the icon of American automobile industry.

Soon after World War II, Cadillac was viewed as the classic American automobile - superior and innovative engineering coupled with distinctive style and high performance (Lamm, 2002). The early 1980s saw the backlash towards Cadillac reach its peak as rising fuel costs and demands on better fuel economy hurt Cadillac's sales (Welch and Khermouch, 2002). In response to changing consumer demands, Cadillac decided to downsize vehicles and utilize platform cross-sharing with other GM brands, resulting in loss of build quality, brand identity, and lower sales. Although these quality issues were resolved long ago, the damage done to its brand image was enormous.

In the late 1990s, senior management at General Motors, owner of the Cadillac brand, became serious about saving the fallen icon (Welch and Khermouch, 2002). Senior GM executives

Figure 7 IBM's Revenue 1992-2001



Source: Annual Report, IBM

were presented with two routes: The safe option, a redesign of the fleet following European modalities. And the risky route, a radical redesign of its fleet that evoked memories of the classic distinctiveness that was representative of the ostentatious Cadillac style. To save the icon, Cadillac took the high-risk route and developed “art and science”, the blueprint which introduced innovative design complemented by smart, targeted marketing. Cadillac introduced the 2003 CTS, the first Cadillac model to embody “art and science”, sharp and distinct lines which established it in a class of its own in the luxury sedan category. The success of “art and science” can not be measured in sales alone, which have been slow to respond, but by the reinvigorated reputation and brand image: The average Cadillac buyer’s age has dropped from 64 in 2000 to 57 in 2005. The 2008 CTS recently won Motor Trend’s 2008 Car of the Year award (Antoine, 2007). The Cadillac Escalade SUV is an icon amongst rap stars, young urbanites and professional athletes, the antithesis of Cadillac buyers until its introduction (McCarthy, 2005).

IBM

Change Implemented: Eliminated “silo mentality” within R&D. Sourced innovation wherever it can be accessed; internally and externally.

“Lou Gerstner sought to save the company by implementing a cultural change at IBM from

one that was individual-centric to a team-centric approach to product development.”

IBM transformed its R&D organization and instituted a company-wide cultural change upon recognition of their dated R&D structure and self-limiting culture.

By 1993, IBM was considered the largest computing company in the world, but was simultaneously reporting a net loss of \$8.1 billion, the third straight year in which losses were reported (Kannelos and Spooner, 2002; Knowledge at Wharton, 2007). Their “ingrown” company culture was proving to be an obstacle to innovation as research was kept highly secretive and siloed and working with external vendors was shunned (DiCarlo, 2002).

In 1993, incoming CEO Lou Gerstner sought to save the company by implementing a cultural change at IBM from one that was individual centered to one that encouraged a “team centered” approach to product development (Knowledge at Wharton, 2007). Internally, the company changed its focus from stand-alone product development initiatives to product development offerings focused on bundled products that provide business problem solutions (DiCarlo, 2002). Furthermore, compensation incentives were instituted to reward team efforts rather than focus solely on individual accomplishments; and overall compensation was directly linked to company performance as opposed to divisional achievements.

The corporate culture transformation has enabled IBM to consistently file the most number of patents every year. In 2001, IBM earned \$8

billion in profits from \$85.9 billion in sales, marking the eighth straight year of profit growth since Gerstner took office (Routson, 2002).

Conclusion

The mini-cases highlight eight programs that successfully implemented new processes to significantly transform the product development efforts of the featured companies. The programs delivered increased R&D productivity, higher product success rates, portfolio of innovative products and services, which in some cases established or redefined their respective industries, and higher sales and profit results.

Two common themes emerged from the mini-cases:

- Existing leadership or new leadership identified the urgency to implement change in all eight companies
- All transformation programs centered around the R&D organization

The eight mini-cases surfaced ten key changes that defined the success of programs implemented:

- Appoint, empower, and make accountable, a manager to oversee each product development program
- Strengthen product/service focus on customer/customer experience
- Streamline product portfolio; discard underperforming products and focus on innovative products with a high probability of success
- Eliminate “silo mentality” within R&D. Consolidate all R&D functions into one product development group accountable to one manager
- Nurture and leverage corporate synergies while preserving corporate values
- Communicate “change plan”, assign a name/catch phrase that embodies its objective
- Source innovation wherever it can be accessed; internally and externally
- Apply discipline, focus, and accountability to the innovation process
- Embrace risk and tolerance for failure as key requirements for innovation process to succeed

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