Towards explaining academic entrepreneurship: A critical realist analysis of intellectual property commercialization at the University of San Carlos

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Abstract

The purpose of the research was to use a critical realist philosophy of science to investigate academic entrepreneurship and the causal mechanisms which enable the commercialization of a university-based intellectual property such as a manufacturing process. The paper employed a critical realist case study methodology on the creation of a joint-venture manufacturing company between University of San Carlos, a Catholic university in the Central Visayas region of the Philippines, and external business entrepreneurs. Findings reveal the importance of a conducive environment produced by the institutional entrepreneurship of top university administration combined with the inventiveness and zeal of a faculty researcher in enabling successful invention commercialization. It is recommended that future research look in greater comparative detail at related mechanisms supportive of academic entrepreneurship and the sustainability of such enterprises.

Key Words: academic entrepreneurship; critical realism

Background of the study

Higher educational institutions have traditionally been called upon to fulfill a three-proned mission: teaching, research and community extension. In the past few decades, however, an emerging role for universities, which may be considered an evolution of its community extension role, is the production and commercialization of intellectual products and innovations for the public interest. In the US, this development was partly fueled by the enactment of the Patent and Trademark Law Amendments Act, P.L. 96-517, more commonly known as the Bayh-Dole Act, in 1980 which encouraged the licensing of federally-funded university research to industry for socially beneficial purposes (Friedman & Silberman, 2003).

Pilegaard, Moroz, & Neergaard (2010) defined academic entrepreneurship as:

> *the involvement of academic scientists and organizations in commercially relevant activities in different forms, including industry-university collaborations, university-based venture funds, university-based incubator firms, startups by academics, and double appointments of faculty members in firms and academic departments. (p. 46)*

There is scant literature on academic entrepreneurship in the Philippines. The Philippine Technology Transfer Act (RA 10055) was only passed in 2009. In one of the rare local investigations into this area, Javier (2011) analyzed the role of academic entrepreneurship in the University of the Philippines-Los Baños. Based on a review of the literature, he recommended four strategies for the university to be more entrepreneurial. First, the university needs to rethink its basic intersection with society so that knowledge creation, generation and application can be collectively implemented to answer societal needs. Secondly, the university needs to enhance the marketing functions of its various entrepreneurial offices so that these can pro-actively engage in the marketing of university technical expertise. Thirdly, the university needs to pursue innovative administrative process in support of entrepreneurship by simplifying and communicating processes to faculty and staff in order to motivate them to generate and create knowledge. Finally, the university needs to open new academic markets for its knowledge, products and services. This needs to be done within a geographical distance where the university has no presence but where its expertise is needed.

Habaradas (2008), reflecting on the experiences of Malaysia and Thailand in implementing their national innovation systems, provided some recommendations for the Philippine case which may have some relevance for academic entrepreneurship. He argued that visionary leadership is critical in developing a national innovation system. He cited the example of Malaysia's Prime Minister Mahathir bin Mohamad in galvanizing the country by driving a number of cutting edge and high profile projects such as its modern airport, national car and the Multimedia Super Corridor. He likewise cited the Thai practice of focusing its accelerated innovation strategy on a few priority areas, namely, bio-business, energy and environment. He contrasted this with the Philippines' 12 priority areas. By implication, a strong message from Malacañang on selected core areas for innovation can inspire higher education institutions to focus academic entrepreneurship efforts high-impact areas given the country's limited resources.

Much more needs to be done if academic entrepreneurship is to be understood and to flourish. Pilegaard, Moroz, and Neergaard (2010) argued for a more fine-grained analysis of what actually happens within universities and among key actors during the process of academic entrepreneurship:

> *… we must refocus our research efforts on how academic entrepreneurship takes place by understanding the relationship between process and the heterogeneous socio-spatial environments where entrepreneurship happens. In other words, we need to understand the persons involved in academic entrepreneurship, their interaction with their environment, and how both persons and environment change over time. (p. 46)*

This is supported by Rasmussen (2011) who argued that more process-oriented theories can lead to a more holistic understanding of academic entrepreneurship. He observed that theories of university spinoffs often used deterministic stage models which assume that the environment is predetermined. Such positivist studies often employed statistical techniques to identify causal drivers of academic entrepreneurship (Yusof, 2009) without surfacing mechanisms which explicitly explain the proposed relationships, leading to weak theories (Dyer & Wilkins, 1991; Shepherd & Suddaby, 2017). Rasmussen recommended the adoption of a critical realist perspective in order to move beyond the limitations of deterministic, positivist stage models. This

approach simultaneously considers the influences of both actors' actions and the deep structures in which they are embedded.

This study aimed, firstly, to investigate the case of a joint venture spinoff of a mango waste processing enterprise, Green Enviro Management Systems, Inc. (GEMS), by the University of San Carlos in Cebu. The university's share in the venture is a patented process technology developed by one of its faculty members, Dr. Evelyn Taboada, with university support. Secondly, following Rasmussen (2011), the study aimed to use a critical realist approach to explore and understand the underlying causal mechanisms that enabled the formation of GEMS. This approach avoids the explanatory limitations of mainstream positivist approaches to the study of academic entrepreneurship.

The research inquired into the following questions:

1. How was the technology developed? What was the chronology of events and who were involved?
2. What support from the university made the technology development possible? Other support?
3. What were the challenges in developing the technology? How were these overcome?
4. How did the joint-venture business develop? What was the chronology of events? What support from the university led to the organization of the venture?
5. What were the challenges in organizing the venture? How were these overcome?
6. What systems and processes within the university made the venture possible?
7. Who were the key actors in the organizing of the venture? What were their roles?

Review of literature

Academic entrepreneurship

Rothaermel, Agung and Lin (2007) classified the literature on academic entrepreneurship from 1981 to 2005 into four major research streams: entrepreneurial research university, productivity of technology transfer offices, new firm creation, and environmental context including networks of innovation (p. 691).

Academic entrepreneurship is a challenge for administrators and faculty in higher education because institutional values and university arrangements are not typically aligned with the risks and profit-seeking that are inherent in commercial ventures. For this reason, there has been increasing research interest in the phenomenon of academic entrepreneurship in the last few decades, especially evidenced by special journal issues of *Management Science*, *Journal of Technology Transfer, Research Policy* and *Journal of Business Venturing* (Yusof & Jain, 2010). Shane, one of the leading scholars in entrepreneurship (Shane & Venkataraman, 2010), has particularly called attention to the role of university spinoffs which is "a new company founded to exploit a piece of intellectual property created in an academic institution" (Shane, 2004, p. 4).

Louis, Blumenthal, Gluck, & Stoto (1989) investigated academic entrepreneurs in the life sciences and categorized them into five types: (1) engaging in large-scale science (externally

funded research), (2) earning supplemental income, (3) gaining industry support for university research, (4) obtaining patents or generating trace secrets, and (5) commercialization (forming or holding equity in private companies based on a faculty member's own research). Local norms were found to be a strong predictor of academic entrepreneurship. Interestingly, they found little influence by individual characteristics and supportive university policies and structures on academic entrepreneurship. They did speculate that the latter finding may have been overwhelmed by the impact of local norms which may have been themselves the result of structures and policies not covered in their study. In any case, they suggested that institutions cannot easily engineer entrepreneurship. Based on their findings, they hypothesized that the influence of individual characteristics on academic entrepreneurship is moderated by institutional location, particularly at the level of department or division.

Hayter (2015) similarly studied the motivations of academic entrepreneurs and found that they are motivated by different but related reasons and that spinoffs are viewed as a way to pursue awards and consulting opportunities that can support academic teaching and research responsibilities.

In analyzing a successful case of an academic spinoff, Pilegaard, Moroz, and Neergaard (2010) showed "the importance of bridging innovation … to balance research and commercial goals, and the need for codifying knowledge capacities and creating new or changing existing institutional structures to legitimize and facilitate entrepreneurial activity" (p. 46).

In Asia, the role of academic entrepreneurship has been linked to national innovation and development systems as a whole. Wong, Ho & Singh (2011) studied several higher education institutions across several Asian countries at various stages of development, namely Japan, Korea, Singapore, Taiwan, China, India, Malaysia and Thailand. They observed that a key driver of technology commercialization was the greater push of governments for academic institutions to engage with industry especially in the area of technology. Secondly, they noted that Asian universities have initially tended to copy parallel practices in leading North American universities although some have begun to adopt more refined localized practices.

Despite the above broad insights on drivers of academic entrepreneurship (Friedman & Silberman, 2003; Wong, 2011), it has not flourished as widely as expected. Some researchers have looked deeper into specific leadership dynamics within the institutions themselves. Among Malaysian public research universities, for example, Yusof (2009) found that entrepreneurial behavior among academic leaders can be an enabler of academic entrepreneurship, especially when these leaders apply their entrepreneurial mindset in supporting commercialization opportunities. This is consistent with findings on institutional entrepreneurship where leaders create new social arrangements in order to cause a shift in practices (Leca & Naccache, 2006).

Critical realism and the development of theoretical explanations

This study adopts critical realism (CR) as a philosophy of science for theory development. Critical realism adopts a realist ontology which posits that a "world exists independently of our knowledge of it" (Sayer, as cited in Easton, 2010, p. 119; Miller & Tsang, 2010, p. 144). Unlike positivism which rejects metaphysical and constructivist as well as value-laden ideas, critical

realism embraces a fallibilist epistemology wherein the researcher's knowledge of the world is socially constructed (Miller & Tsang, 2010; Krauss, 2005) as in interpretivist research. Tsoukas (1989) was among the earliest to argue for the validity of critical realist theoretical explanations based on case studies within the management and organization field while Tsang (Miller & Tsang, 2010; Tsang, 2010) is among the most consistent recent advocate.

Tsoukas (1989), explained that CR does not aim for empirical or statistical generalizability in theories. Rather, CR-based theories "deal with necessity, namely with the workings of real social structures and their causal capabilities, irrespective of their individual manifestation in the domain of experience. Thus, the causal powers are externally valid, but their activation is, and thus their effects are, contingently determined" (p. 557). Thus, CR does not seek empirical generalizability and moves away from the deontological-nomological (D-N) norm of deducing hypotheses from existing literature for empirical testing.

CR is a relatively new approach in the study of management and organizations (Edwards, O'Mahoney, & Vincent, 2014; Fleetwood & Ackroyd, 2004; Ackroyd & Fleetwood, 2000). The study of Easton (2010) showed that only 2 of the 334 papers he reviewed employed the case study research method and critical realism as a philosophical stance. Although CR is a relatively new philosophical paradigm, this orientation has been adopted in economics, religious studies, history, environmental studies, information studies, sociology, psychiatry, criminology, geography, linguistics, social work, media studies, interdisciplinary studies, and marketing (Easton, 2010).

In critical realism, the basic theoretical building block is the entity which can be the organization, people, relationships, attitudes, resources, inventions, human, ideas, and technology, among others. The use of entities implies causal language, i.e., entities used for explanatory theories are considered to be causal mechanisms. According to Sayer "to ask for the cause of something is to ask 'what makes it happen', what 'produces', 'generates', 'creates', or determines' it, or more weakly, what 'enables' or 'leads to' it" (as cited in Easton, 2010, p. 120). Research methods that are apt to use such paradigm include case study research with the use of qualitative data. However, CR accommodates quantitative data as empirical evidence as part of 'extensive' research designs which can serve as starting point for developing theoretical explanations (Sayer, 2010)

The external or visible behaviors of people, systems, and things as they occur, or as they have happened, are what critical realists investigate. These are called events or outcomes which call for close attention to accounts of processes that "produce and reproduce the ordering of events and social institutions" (Easton, 2010). Thus, CR pushes for contextualized explanations with "a very particular view of causality as a complex and dynamic set of interactions that are treated holistically" (Welch, Plakoyiannaki, & Paavilainen-Mantymaki, 2011, p. 754).

Structure is an important element in critical realism research as it clarifies the "set of internally related objects or practices" (Easton, 2010). Structures may be nested or embedded within structures.

Blundel (2007) advocated for CR as an appropriate mode for conducting entrepreneurship research. He argued that:

1. CR can promote much-needed contextualization of entrepreneurial phenomena in research studies;
2. CR can facilitate greater theoretical integration between disciplines and across multiple levels of analysis;
3. CR can enhance the explanatory potential of existing qualitative research techniques, including the case study approaches; and
4. as a consequence, CR has the potential to contribute more 'useful' knowledge than rival paradigms. (p. 58)

Ramoglou and Tsang (2016) applied a CR-based actualization approach to develop a propensity theory of entrepreneurship. Their theory departs from the dominant "discovery approach" which defined entrepreneurial opportunities as "those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their cost of production" (Casson as cited in Shane & Venkataraman, 2000, p. 220). They also differ with the recently emerging "creation view" which argues that entrepreneurial opportunities "are not separate from the individuals that form them" (Alvarez, Barney, McBride, & Wuebker, 2014, p. 229) and "do not exist objectively but are actively created through subjective process of social construction" (Ramoglou & Tsang, 2016, p. 410). In contrast, Ramoglou & Tsang (2016) define entrepreneurial opportunity as "the propensity of market demand to be actualized into profits through the introduction of novel products or services" (p 416).

Vincent and Wapshott (2014) explained the important role of the case study in implementing a critical realist research methodology, especially in explaining organizational mechanisms. Exploratory case studies, in particular, aim to discover the consequences of a specific organization development on a specific level of organizational reality.

Sayer (as cited in Blundel, 2007) depicted the critical realist view of causation in Figure 1. Structured entities generate causal mechanisms which in turn bring about events. This causal relationship is not deterministic, however, as their actualization depends on other conditions or mechanisms which may happen to be active in the situation.

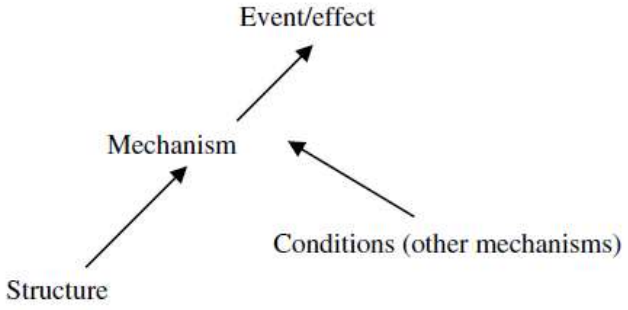

Figure 1. The critical realist view of causation
Source: Sayer, as cited in Blundel (2007, p. 52)

Methodology

This study adopted an explanatory case study design using a critical realist philosophy of science to identify (retroduce) causal mechanisms related to the formation of the GEMS joint venture enterprise emanating from academic research conducted in the University of San Carlos. It is a study of a single case (i.e., GEMS) that investigated the academic entrepreneurial process. The study aimed to identify causal mechanisms that encouraged or constrained the formation of GEMS.

A case study research method is one that involves the in-depth study of one or more cases to understand the nature of a phenomenon (Yin, 2009; Easton, 2010; Eisenhardt, 1989). The method may involve mostly qualitative data but may also include quantitative data. The critical realist perspective supports case study research (Easton, 2010) as it unearths and tries to explain a phenomenon through the study of a single case in depth and comprehensively. Yin (2009) proposed the use of how and why questions in case study research which demonstrates the nature of its explanatory goal.

Academic entrepreneurship is extremely rare in the Philippine setting, making a case study approach all but necessary. Fortunately, a CR approach enables the derivation of meaningful causal findings using a case study approach.

Data gathering procedure

The principal source of data is a semi-structured interview with Evelyn Taboada as the academic entrepreneur and inventor of the patented manufacturing process licensed to GEMS by the university. The interview was held in May 2016. A site visit of the GEMS manufacturing facility enabled the researchers to observe the manufacturing process first hand.

Analytic procedure

The study implemented a critical realist methodology which employed retroduction as the core analytic activity as part of its explanatory research process.

The explanatory research process described by Danermark et al. (as cited by Blundel, (2007) in Table 1 served as a guide. As Blundel (2007) explained, the process is not prescriptive nor strictly linear. This study mainly employed Activities 1 to 4.

Table 1
An explanatory research process involving retroduction

Activity	Nature of activity
1: Description	Prepare a description of the phenomenon, making use of actors' accounts and a variety of other sources
2: Analytical resolution	Distinguish various components, aspects or dimensions of the phenomenon and establish (tentative) boundaries to the components studied.
3: Theoretical redescription	Interpret and redescribe the different components, applying contrasting theoretical frameworks and interpretations in order to provide new insights (n.b. this activity is sometimes referred to as 'abduction').
4: Retroduction	For each component, seek to identify basic, or 'transfactual' conditions, including structures, causal powers and mechanisms, that make the phenomenon possible.
5: Abstract comparison	Elaborate and estimate the explanatory power of the structures, causal powers and mechanisms that have been identified during activities 3 and 4.
6: Concretization and contextualization	Examine how different structures, causal powers and mechanisms manifest themselves in concrete situations.

Source: Danermark et al. (as cited in Blundel, 2007, p. 8)

The diagramming method for representing the structure of causal explanations developed by Sayer (2010) was used to summarize the result of retroduction (Figure 2). The diagram, which is a conceptual detailing of Figure 1, depicts various components of a critical realist causal explanation: an object (X) with structure (S) which endows the object with causal powers (p) and liabilities (l) to yield a causal mechanism which, under specific conditions (c), trigger the events (e) manifesting as the phenomena under study. The focal phenomenon in this paper is the formation of GEMS.

The main causal object for the study will be the academic entrepreneur. Necessary relations refer to effects which are deemed naturally emanating from the causal object due to its nature and structure. Contingent relations refer to effects that are only actualized depending on the triggering presence of specific conditions in the situation under study. When such contingent effects are triggered, the event comes about and manifests as observable phenomena.

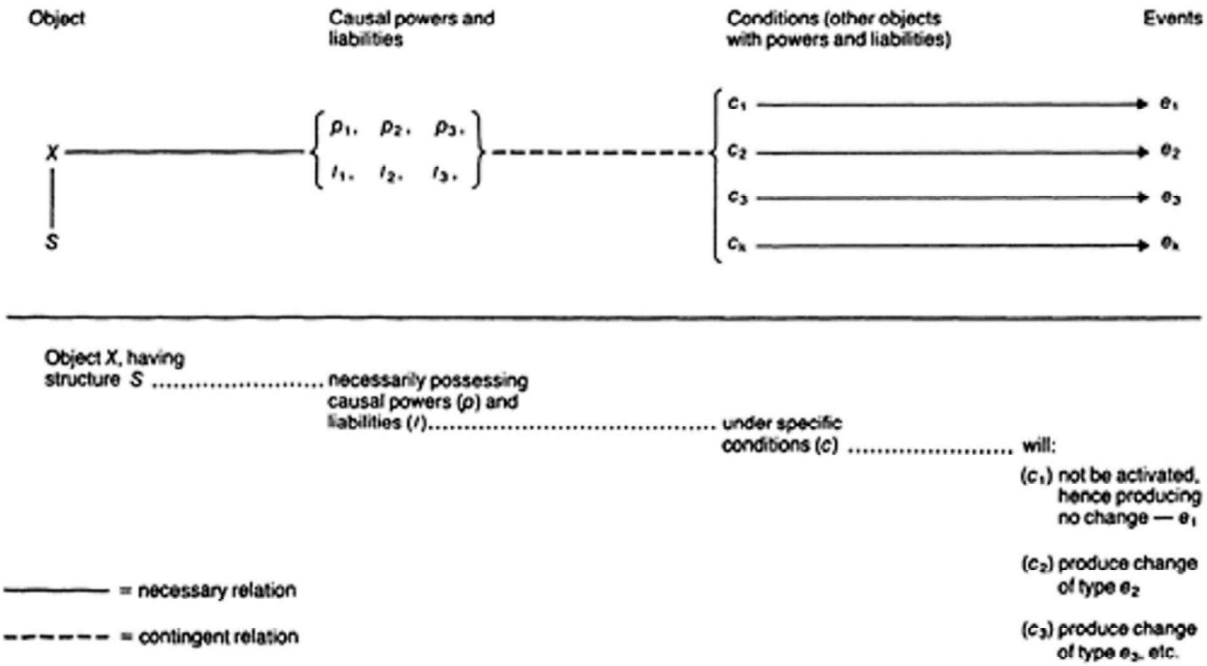

Figure 2. The structure of a causal explanation
Source: Sayer (2010, p. 74)

Limitations

This study is based mainly on the account of Evelyn Taboada. The explanatory emphasis was limited to Activities 1 to 4 in the process described by Blundel (2007), with the other activities being recommended for future research.

Findings and discussion

Profile of the university

The University of San Carlos (USC) is a private research and Catholic university in Cebu City which has been administered by the Society of the Divine Word since 1935. It provides basic education, undergraduate and graduate studies higher education for more than an estimated 27,000 students. It is the biggest university in Cebu City with five campuses distributed around the city.

Profile of the academic entrepreneur

Evelyn B. Taboada is Dean of the College of Engineering and a professor of chemical engineering at the University of San Carlos in Cebu City. She was twice conferred the World Intellectual Property Organization (WIPO) gold medal for investors and Outstanding Engineering Achievement Award from the ASEAN Green Award (Rodrigo, 2017). She obtained her BS in chemical engineering from USC, her MS in chemical engineering from the University of the Philippines and PhD in biochemical engineering from Delft University of Technology

(Netherlands). She has a Master of Laws in Intellectual Property degree from the University of Torino (Italy) and is a registered and practicing patent attorney

Taboada holds patents for technologies related to the treatment of fruit wastes. The process which she invented with USC support and commercialized through GEMS is depicted in Figure 3.

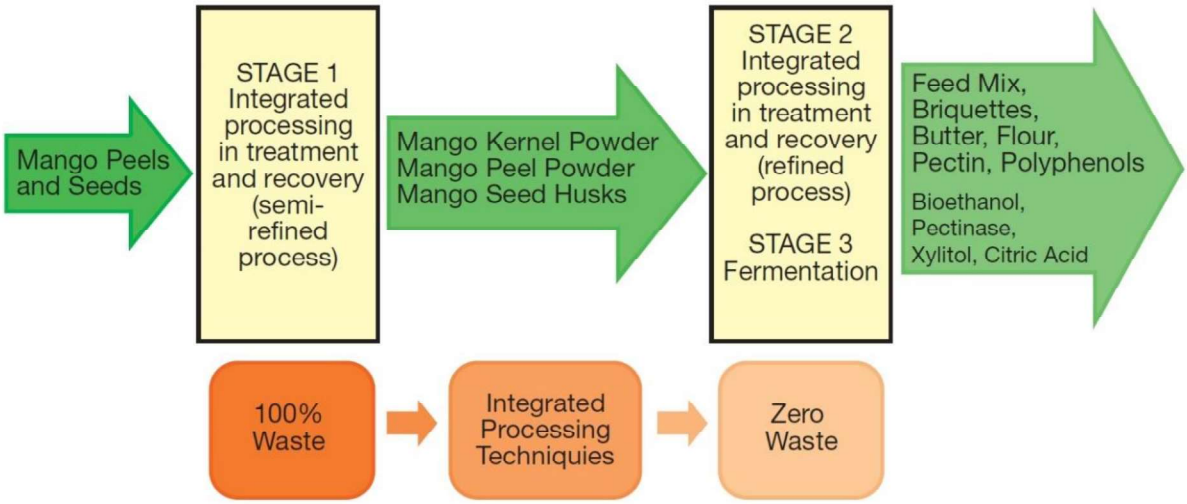

Figure 3. The Taboada-USC zero-waste process turns mango waste to valuable products
Source: Hlaing, Taboada, Bendik-Keymer, & Lacks (2015, p. 48)

Profile of the business

GEMS is a partnership between USC and a group of 3 investors. There is a board which is composed of USC representatives and the other partners. The management team is composed of a plant manager and Taboada as Chief Operating Officer (COO) and Chief Technical Officer (CTO). In the 5-member board, there are two representatives from USC: Taboada and USC administration representative, Fr. Rebayla. The other 3 seats are held by the 2 private partners but 1 is non-voting.

For the partnership, USC did not shell out cash but contributed the intellectual property, technology, and Taboada's and her team's technical expertise and time. The private partners provided the funds.

Production facility and Marketing Of the 7 product types, only 4 were produced. Special pieces of equipment are needed for the production of the other 3 products. The initial products created in 2012 underwent modifications and enhancements. The products coming out of the plant now has improved efficacy and overall product quality.

Plant capacity is 100 tons but utilization at the moment is only at 30%. There are 80 fulltime employees. Production is influenced by the availability of raw materials. As soon as the materials arrive at the plant, they are processed immediately. Taboada said, "we want to do it stage by stage

based on the collection of materials, which should be fresh. We have a window of 3 days maximum within which to process the raw materials or else the materials deteriorate. They have to be fresh". 'Process quickly while the raw materials are fresh' is their production mantra. After processing, the semi-processed product can be stored for 2 years at normal room temperature (shelf life).

At this stage, the business focus is marketing which is "the most difficult part for me because it is a new product", according to Taboada. "We need to raise the level of awareness of the people and go into advocacy."

Plant Operations Power consumption is relatively high with the plant operating 7 days a week, 24 hours (i.e., 24/7). Since the plant relies also on power generated from the solar panels and direct solar heat from the panels, monthly power bill is reduced dramatically to 10-20% of original costs. Solar power generation was also increased by adding solar panels, module by module.

The long processing time requires operating the facility for 24 hours. There are three shifts. The night shift has a 'skeletal' force to perform only the most crucial processes.

There is a viewing deck where visitors can observe the operation. GEMS is strictly implementing good manufacturing practice (GMP). There is open-viewing of the drying facilities.

The process of establishing GEMS

The following narrative description is based on the interview with Taboada.

How did GEMS start? The journey toward the establishment of GEMS started with the problem on waste. Taboada saw truckloads of mango waste dumped daily at dumpsites in Omapad, Mandaue, Consolacion, and Inayawan in Cebu City. There were 10-20 truckloads of waste dumped in these dumpsites every day. These obviously came from existing processing plants. She recalled that even scavengers eat some portions of the waste. The waste materials because of their very nature attract flies, pests, and other micro-organisms. Some mango processors approached her if she could handle this problem.

Initially, Taboada's motivation was how to do render the waste less "hazardous". As a chemical engineer, this kind of problem posed a challenge. In 2007-2008, the investigation on the mango waste became part of her research deloading project. The research proposal came under the scrutiny of the university Research Director for institutional funding approval. It came as an opportunity as the priority research project.

One of the first experiments in the USC laboratory reduced 1 kilo of waste mango peel and seed to zero. This meant that all the wastes were converted to some products.

Within the same year, Taboada attended a basic patent course by the Intellectual Property Office of the Philippines (IPO PHL) held at USC. After the course, it dawned on her that the outcomes of the research project were patentable.

A follow through of the patent course was an invitation to apply for a Master of Law course in intellectual property at the University of Turin in Italy sponsored by the World Intellectual Property Organization (WIPO), a UN agency. This stirred a strong interest in her as it was designed for professionals (engineers, scientist, doctors, and lawyers). She applied in February 2010 for fellowship. She was accepted in May and immediately left for Italy. The program which could be completed in a year involved a mixture of learning platforms: distance learning, online, meet up, then thesis, and a possible internship (for top students). There were 40 participants from all over the world: half were lawyers and half were professionals. The youngest was 28 up to 48 years old, mostly practitioners. The professors were experts on IP and interactions between and among participants were very intense. Problems, issues, and challenges involving IP the world over were tackled.

As one of the top students, she was offered an internship at WIPO in Geneva in 2011. The 2-month internship included a study tour and some courses and the chance to stay at the WIPO headquarters in Geneva. This extension of her study was granted under the auspices of USC (with approval from Fr. Miranda). She was assigned at the patent and technology transfer section. The internship exposed her to topics on negotiations, licensing, and raising capital for a startup. This internship exposure cemented in her the resolve to patent earlier works which she did while doing her PhD because most of them were patentable. She recalls that the topic she worked on for her first PhD could have been patented. Her thesis counsellor however advised her not to pursue the patenting route because aside from it being expensive to maintain in Europe, her research output was a seminal one from which further studies to advance science can be drawn.

She went back to USC in 2011 after finishing her internship at WIPO and completing her degree in Master of Laws in IP. In March 2012, the USC team filed for the first 2 patents on integrated mango products. In June of the same year, the GEMS executive team (Fr. Generoso "Jun" Rebayla and Dr. Taboada) found 3 groups of investors. Their personal networks came in handy in the process. The main driving force behind the selection of the investors was WIPO's tenet that "patent should benefit humankind. The business venture is just a vehicle".

How was the technology developed? The technology was developed and the prototype was created in the USC laboratory. As part of the agreement with the investors, a demonstration facility was built. This facility was housed in a leased warehouse in Mandaue. It was in June 2012 that the facility was built and made operational. The purpose of the demonstration facility was to show that the technology works as well as to show off to groups of investors the viability of the venture for commercial scale operations.

In November 2012, the second batch of investments intended for a large scale facility came in. The 1st round of investments was for the seed fund. By February planning for a bigger facility (100-ton capacity) in Bangkal, Lapu-Lapu City proceeded in earnest. The construction of the building facility was started in May 2013, module by module. This approach to construction expedited the construction process. Due to the strong typhoon that hit the country in 2013, construction was delayed. Construction was finally completed in 2015.

The plant occupies initially a total area of 2,500 square meters. Expansion of the work area by another 2,500 square meters was necessary for the drying process. This expansion was not a

problem since the land in which the plant stands is 1 hectare. This land is owned by one of the partners. The partner's contribution to the partnership was limited to the building, equipment, and working capital. Aside from Taboada's new-found knowledge on intellectual property, her background (PhD in Bio-Chemical Engineering) in chemical engineering particularly in designing a plant was put to practice.

What was the support contributed by USC and others? The biggest support from USC came in the form of materials, equipment, and paid time off from teaching to do research (i.e., research deloading), and scholarship. There was heavy reliance on USC's support in the early phase of development of GEMS as there was no external funding then.

USC provided the materials and use of the laboratory to develop the products. This expanded laboratory was the result of the 8-year development project funded by the Dutch government beginning in 1996. This included the improvement of facilities and equipment, development of curriculum, and training of faculty among others. It was a complete, state of the art laboratory located at the Bunzel Building in USC Talamban Campus. The whole USC community benefited from it.

There was a deliberate effort on the part of the USC Team to seek funders who do not meddle with the project as long as the funds are used according to set guidelines of the funding agency. Taboada said, "this is part of our strategy and we had to be careful in seeking external grant". The affiliation with USC facilitated the availment of grants from funding institutions. The first funding opportunity came in 2013 when USC got a total research grant of P10 million from the Philippine Higher Education Research Network (PHERNet) under the Commission on Higher Education (CHED). Another opportunity came through the United States Agency for International Development (USAID) grant assistance for the development of special products and technology. The fund from various sources was used in the development of the product and plant prototypes which happened during the demonstration stage in the small warehouse in Mandaue City. Further works including the monitoring of environmental conditions in the solar drying facility were funded by the Newton fund of the British Council, USAID, and CHED's PHERNet.

USC's biggest contribution to the formation of GEMS was encouragement. In Taboada's words, the GEMS team received "200% support especially from the USC cabinet and the Board of Trustees (BOT)". Her supervisor in research, Dr. Largo, and Fr. President Miranda, her supervisor for special projects, as well as Fr. Salas for academics gave their unwavering support. According to Taboada, "there were birthing pains but only the bed of roses is seen now". Referring to her superior, Taboada said, "I don't feel like I am getting special treatment. They were very professional in our dealings".

Startup Phase and Challenges In June 2012, the partnership was formed. No machineries were developed yet before 2012. The concept of frugal innovation came into play as product and technology (i.e., process) development were developed at laboratory scale at the initial stage of the project. Products were new and scaling up happened in stages from the laboratory to bench to pilot then to commercial scale.

There were challenges in developing the technology. Taboada said, “ours is slow compared to other countries”. The acquisition of supplies, chemicals, and other materials was through USC’s procurement system which was quite slow in the earlier years (mid-2000). Now, it is faster. According to Taboada, although USC has a state of the art facility, there are limitations. The need for the use of “high tech” and powerful equipment as well as the conduct of some chemical analyses had to be done in Singapore and/or in the US.

Because of government bureaucracy, there were delays in securing building and occupancy permits. The building permit alone requires 20 signatures. The occupancy permit was finally granted in May 2016, one year after the plant was built. The processing of permits from the Food and Drug Administration (FDA) was still ongoing at the time of the interview in the middle of 2016. The company is exempted from getting the environmental compliance certificate (ECC) but had to file anyway for formality to comply with regulations on sanitation. The export and import permits are being processed because these are needed for importing equipment and exporting products. Prior importations were done through USC. The imported equipment took some time to arrive because of the existing control process put in place in the university.

Ownership Structure and Challenges in the Formation of the Partnership Taboada pitched the business proposal to several investors and in investment fora before finally settling to discuss with the first batch of investors. It took 2-3 meetings within a month to seal the deal with the first four partners. The fifth partner, who contributed the seed fund, was ushered in by the four. Before the commercialization stage, the first four partners left the company. Another partner came in and put up the remainder of the fund needed for commercial operations.

Government incentives for pioneering projects. GEMS filed with the Board of Investments (BOI) for income tax holiday (TH). This entitles the company deferment in the payment of income tax until the 8th year (6 + 2) from start of commercial operations. The commercial operations should have started in 2014 but there were events like typhoon which delayed construction. GEMS asked that the reckoning year be moved to 2015 which was granted by BOI.

Retroducing causal mechanisms which enabled the creation of GEMS

Following Blundel (2007) and Sayer (2010), the narrative account of Taboada was analyzed to identify the components and causal mechanisms which potentially explain academic entrepreneurship in USC as manifested through the formation of GEMS (Figure 3). In the process of retroducing, Sayer (2010) advised that "we try to get beyond the recognition that something produces some change to an understanding of what it is about the object that enables it to do this" (p. 72)

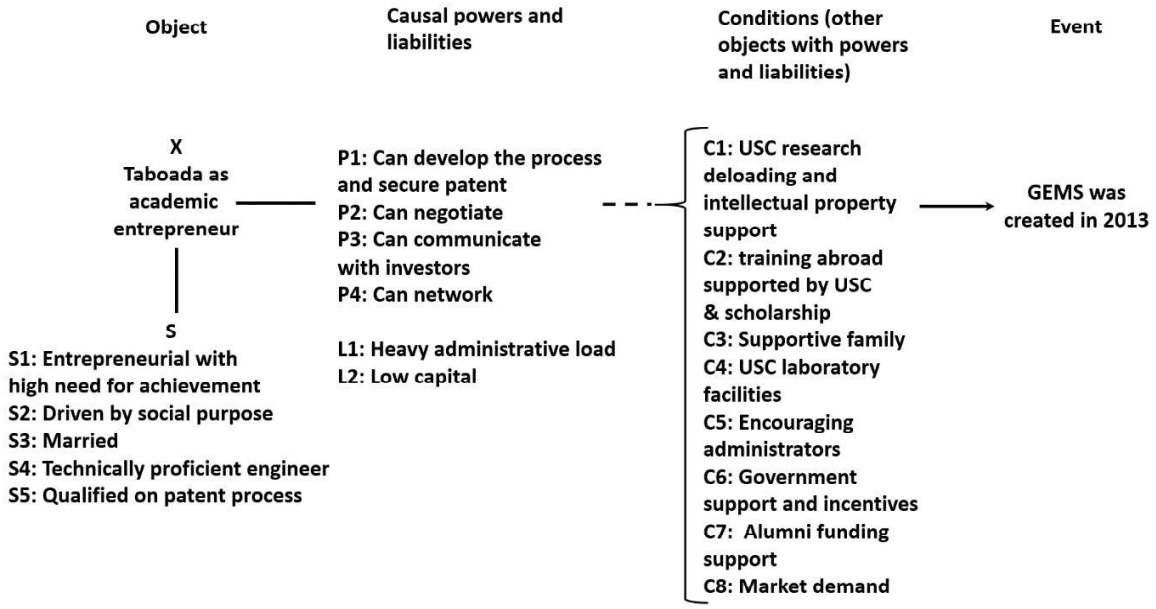

Figure 3. Retroduced explanatory model of academic entrepreneurship through GEMS

Based on retroduction, the main components of the emerging causal explanation for the formation of GEMS as an academic entrepreneurship event are Taboada as the academic entrepreneur, the structural and resource support capabilities of USC, the encouraging leadership of USC, government support and incentives, and family support for Taboada.

Following Pilegaard, Moroz, and Neergaard (2010), we looked at Taboada's enablements and limitations (powers and liabilities). The attributes of Taboada as a person, family woman, academic and IP advocate combined to build her nature as an academic entrepreneur with specific personality traits and skill sets. She is technically knowledgeable of both chemical engineering and patent processes. She is socially driven which spurred her to address the mango waste problem and the employment of youth from the dumpsites. She is entrepreneurial and willing to take the risk of investing her time on the venture. She also has spousal support.

These attributes enabled her to work on the needed process patent and seek the training and institutional support she needed from the university, despite her heavy administrative load and personal lack of capital.

Key conditions enabled Taboada's efforts to achieve fruition. The substantial support Taboada obtained from the university, including work load reduction for research (deloading), intellectual property training, actual patenting support, encouraging administrative supervision and adequate laboratory facilities were critical in supporting her efforts to commercialize. Outside of the university, family support, alumni funding and government incentives were likewise important supporting conditions which facilitated the creating of GEMS as a joint venture and made the commercialization of her process invention an actuality. The market demand for mango-derived

products enabled the venture to achieve sales (Ramoglou & Tsang, 2016) although the venture has yet to become profitable.

Conclusions and future research

The paper contributes to the literature by proposing a new mechanisms-based theory of academic entrepreneurship and enterprise formation underpinned by critical realist philosophy of science. The actualization of the GEMS joint-venture spinoff can be explained through the interaction of a number of causal mechanisms involving the nature of Taboada as an academic-inventor-entrepreneur-family person supported by university arrangements, government policies and market conditions.

Following a CR perspective, the study reveals transfactual causal dynamics and conditions which can account for an actualized university spinoff. The findings suggest that if universities have faculty with the qualities of Taboada, then a system of university and funding support and favorable market and government conditions may enable the creation of intellectual property which can be spun off into a commercial venture.

Future research can look deeper at the particular conditions identified in the study in order to assess their relative contributions to the actualization of joint ventures. The importance of social purpose in spinoff creation can also be further investigated since this was only minimally touched in the current study. Finally, the causal mechanisms that affect the sustainability of an enterprise such as GEMS beyond the formation stage need to be investigated.

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