AC 2012-3341: UNDERSTANDING THE EVOLVING RELATIONSHIP BETWEEN CHINA AND LATIN AMERICA BY EXAMINING ENGINEERING EDUCATION TIES

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Looking at China and Latin America through an academic lens

A Complex Relationship

Though many in the U.S. have posited the Chinese relationship between itself and Latin America from an imperial framework, the reality this paper discusses is that the relationship between China and Latin America is complex. While it is easy to focus on the economic drivers behind their relationship, we try to understand on a deeper level why China is going to Latin America. Using the Five Principles of Peaceful Existence, we illustrate how China and Latin America have built diplomatic relations. We will also examine core cultural values that are driving China's policies towards Latin America, primarily by understanding how China and Latin America are collaborating within education, concentrating on university-industry partnerships and shared research interests as indices of engineering education. Finally, we use China's Ministry of Foreign Affairs' Policy Paper towards Latin America as tool to compare China's proposed actions to reality to answer: is China predictable?

Five Principles of Peaceful Existence

China and Latin America have been developing relations since the 1950's[1]. Zhou Enlai, Prime Minister of China in the early 1950's, "suggested setting the Five Principles as a base for establishing friendly, cooperative relations between countries of different social systems[2]. The Five Principles are: 1) mutual respect for sovereignty and territorial integrity, 2) mutual non-aggression, 3) non-interference in each other's internal affairs, 4) equality and mutual benefit, and 5) peaceful coexistence. Using the Five Principles of Peaceful Coexistence, China has successfully established diplomatic relations with 21 Latin American and Caribbean countries. Today, China and Latin America "are at a similar stage of development and face the common task of achieving development. Both [China and Latin America] cherish the desire for greater mutual understanding and closer cooperation"[3].

Economic Drivers

Under the leadership of Deng Xiaoping, China focused on "avoid[ing] conflict, and build[ing] the economy rapidly"[4]. By focusing on trade and economic relations, China and Latin America have been able to continually strengthen their relationship. China's two primary interests for enhancing trade are: "[1] to secure access to the raw materials that [China] needs…to sustain its economic growth and [2] to find a market for Chinese-made products"[5]. In this paper, we will analyze how each of these motivators plays a role in the economic relations between China and Latin America.

Securing Raw Materials

China has been an active investor in resource-rich Latin American countries. China is securing raw materials in two different ways: direct foreign investment and joint ventures. Since 2010, China has invested $17 billion in Brazil, make it "Brazil's single largest foreign direct investor"[6].

China Development Bank recently invested $10 billion in Brazilian energy company, Petrobras[7]. With this loan, Petrobras will supply 200,000 barrels per day to China for the next ten years[7]. China and Latin America have been actively establishing joint ventures. For example, China Minmetals Corporation and Nacional del Cobre de Chile (Codelco), both major mining companies, have signed a $2 billion dollar joint venture to mine copper in Chile[8]. Through this joint venture, Codelco will give China 836,250 tons of copper over a 15-year span [8]. Other notable join ventures include: Baosteel and Vale Mining Company, Harbin-Embraer Aircraft Industry, Petrobras and Sinopec, and China National Offshore Oil Company and Bridas.

Two-way Street

At first glance, the China-Latin America relationship seems to be dominated by China. In reality, though, active interest by both sides has driven strong relations. Countries in Latin America "see China's rapidly growing economy not as a threat but as a good opportunity, and are showing more interest in increasing economic links with China"[1].

Chile and China

Of all the countries in Latin America, "Chile was the first country to recognize China's market economy status, the first to sign a free trade agreement with China, the first to establish diplomatic ties with China and the first to support China's WTO accession" [9]. Compared to its Latin American counterparts, Chile has "an explicit development strategy…that has committed to the promotion of competitive (versus comparative) advantage in global markets" [35]. China has become extremely important for Chile since becoming Chile's largest trading partner [9]. For these reasons, it is not surprising that Chile boasts about its close relationship with China, proving "Latin American nations are independent countries and they are no one's backyard" [9].

Harbin-Embraer Aircraft Industry

Latin America is also investing in China. Brazilian Aircraft manufacturer, Embraer, leads the world in the production of regional jets[10]. As Embraer has grown into a successful international company, it has, "become an aggressive foreign investor—in particular by launching a joint venture in China" [11]. In December of 2002, Embraer formed a joint venture with Harbin Aircraft Industry resulting in the production of 24 ERJ-145 jets annually[12].

Cultural Drivers

While economics continue to be the most obvious connection between China and Latin America, it is important to recognize that China's cultural choices dictate their economic choices. China's involvement in Latin America is driven by three core cultural values: mianzi, guanxi, and yin and yang.

Mianzi: Maintaining Face

Becoming a world superpower is important for the cultural idea of 'face', or external status or approval, in China. The idea of face can be best described as one's honor or reputation. As one goes through life, the goal is to maintain and enhance face. Face is important to explain China's value in rankings[13]. For example, China is very proud to be not only the world's largest exporter of goods but also the largest exporter of high-tech goods[5,1]. To stay in this position and sustain

economic growth, China must be able to compete through high value exports including cars, computer chips, cell phones, and other electronics[5,32]. Hence, the Chinese government targets these industries for assistance and prioritization of resources.

Not only is it important for China to be viewed by other nations as high ranking, it is important for China to interact with powerful countries. For example, "China has made Brazil an obvious political and economic priority, and its status as a fellow BRIC nation gives it further clout" [5]. In addition to Brazil, China recognizes the importance of Latin America:

> [Latin America] on the whole is growing in strength and its international influence is rising. Latin American and Caribbean countries have taken an active part in international affairs and contributed significantly to world peace and common development. They are playing an increasingly important role in regional and international affairs[3].

By making friends with lots of countries in Latin America, China is improving its mianzi.

Guanxi: Long Lasting Relationships

Another important cultural trait in China is guanxi, having a network of long lasting relationships. China has made a point of forming strategic relationships. Conscious of the volatile environment of the Middle East, China favors resource rich countries of Latin America and Africa[4]. Guanxi is built and maintained through the exchange of favors[13]. In order to secure the resources China needs, "China is capturing and integrating Latin America as much as it can, securing at least $65 billion in deals throughout the region since 2010" [6]. In exchange for raw materials, China is pouring money into infrastructure projects in Latin America. A perfect example is Venezuela's "oil for loan" deal with China. State owned oil company, PetroChina, will invest $20 billion in Venezuela over a 25 year span[14]. This investment will help Venezuela develop its infrastructure and in return, Venezuela will provide 2.9 billion barrels of oil[14]. Other joint ventures established between China and Latin America follow a similar pattern, with agreements lasting 10 to 20 years, ensuring China and Latin America will stay close for many years to come.

Yin and Yang: Finding the perfect balance

Much of China's balancing act comes down to their huge population. The gap between the few elite and the poor is only widening as the country becomes more industrialized. The difference in people's socioeconomic status is a major reason China needs to have economic sustainability. Following the Five Principles, China recognizes the importance of equality and mutual benefit especially as it applies to their export-driven economy. With Latin America, China is dedicated to, "achieve win-win results" ensuring "equality and mutual [benefits] to expand and balance two-way trade and improve the trade structure" [2]. China and Latin America need each other for globalization and thus, "China will never pursue hegemony" [15].

Academic Drivers

To analyze how China and Latin America were coordinating on the academic level, we focused on different types of partnerships and knowledge exchanges. One of the major challenges that China and Latin America face is a language barrier and a lack of cultural understanding[1]. To see how both sides were combating these challenges, we looked at the ways that China and Latin

America are promoting language proficiency and cultural exchanges. We also wanted to understand what areas of mutual interests drive collaboration in engineering related research. The collaborative research projects could include partnerships between universities, university and industry, and scientific institutions. Finally we looked at existing university-industry partnerships to understand how these partnerships are promoting competitive collaboration.

Culture and Language Links

Confucius Institutes

China promotes Chinese language and culture through the establishment of Confucius Institutes and Confucius Classrooms. Both Confucius Classrooms and Confucius Institutes offer classes in Mandarin, but Confucius Institutes also offer classes in Chinese culture and history. For foreign students interested in learning Mandarin, the Confucius Institute Headquarters will happily provide funding[16]. In Latin America, China has established 28 Confucius Institutes and Confucius Classrooms, with 17 established in conjunction with Latin American universities[16]. By comparing the number of Confucius Institutes for each Latin American country you can see which countries that most interest China. Chile leads the pack with a total of eight.

Study Abroad Opportunities

Where growing trade and economic ties are forcing China and Latin America to work together more frequently, the importance of cultural exchanges becomes more important. One of the best ways to promote cultural understanding is through study abroad exchanges. Recently, governments of Latin American countries have been aggressively pushing students to study abroad by increasing the number of scholarships available. Just this year, the Brazilian government announced, "it plans to give 75,000 scholarships for local students to study abroad by 2014" along with, "an additional 25,000…from the private sector, [exclusive] to…science, technology, and engineering" [17]. In Chile, a new program called Becas Chile "plans to offer 30,000 scholarships by 2018" with a particular emphasis in language proficiency[17]. China has been working with Latin America on, "mutual recognition of diplomas and academic degrees, and [increasing] the number of Chinese government scholarships for Latin American and Caribbean countries" [3]. China's Scholarship Council provides 225 full scholarships for outstanding foreign students to study at universities in China. According to the China-Brazil Joint Action Plan, China's Ministry of Education will provide 22 scholarships annually for Chinese students interested in studying in Brazil, scholarships which Brazil's government plans to reciprocate[18].

Mutual Interests in Science and Technology

By comparing areas of common interests in science and technology, we try to understand how China and Latin America are collaborating within engineering. China has already signed joint commissions for science and technology (S&T) cooperation with Argentina, Brazil, Chile, Colombia, Cuba, Ecuador and Mexico[19]. The S&T agreements outline areas of mutual interests including, aeronautics and astronautics, renewable energy, nanotechnology, information technology and agriculture[19,3]. Many of the joint research projects that China and Latin America are involved in reflect national interests.

Energy Needs

China consumes a tremendous amount of oil every day. 2011 Data from US Energy resource association reports China consumed 4.8 million barrel per day[21]. It is second largest oil consuming country in the world just little behind of US. As an oil poor country, China depended on importing 52.56% of its oil in 2008[20]. Of the 52.56%, Latin American oil accounted for 7.6%[20]. By 2020, China is expected to depend on importing 60% of its oil[20]. For these reasons, China is extremely interested in renewable energy. Between China and Brazil, "energy is perhaps the most important area of complementary interest" [22].

Petrobras

Petroleo Brasileiro SA Petrobras (Petrobras), the world's third largest energy company, is known internationally for their ultra-deepwater technology and research in renewable energy[23,24]. With the majority of, "Brazilian oil resources [located] in deep water, [intensive] R&D is necessary in order to transform these resources into reserves and [into] a commodity product" [25]. Thus, it's not surprising to find that Petrobras has been an active supporter of Brazilian higher education, especially in the areas of Petroleum Engineering and Geosciences. Over the past four years, Petrobras has spent "$268-million each year [for researchers] pursing advances in the production of oil and gas and biofuels, as well as in environmental preservation" [29]. Petrobras and the State University of Campinas (Unicamp) founded the Center for Petroleum Studies (CEPETRO), which provides funding to top undergraduates and postgraduates pursing degrees in Petroleum Engineering and Earth Sciences[25]. With Petrobras' continued support, CEPETRO is able to participate in 80 research projects annually relating to deepwater oil recovery technology[25].

Petrobras Connects with China

This past April, Petrobras signed an academic agreement with Sinopec, part of a major Chinese state-owned petroleum company of Sinopec Group[34]. Petrobras and Sinopec plan to cooperate "for the exchange of knowledge in the areas of geophysics, geology, and oil reservoir engineering" [24]. Along with China Development Bank, Sinopec contributed to a $10 billion loan "to help Petrobras develop newly discovered offshore oil reserves" [7]. Petrobras signed a similar agreement with Sinochem, another branch of Sinopec Group, "for the strategic cooperation with the aim of identifying and enabling business opportunities in the areas of exploration and production, oil trade, and brownfield recovery" [24].

China-Brazil Center for Climate Change

China and Brazil have also formed university partnerships "[concentrating] on climate change and technologies focused on energy innovations" [26]. In 2009, Brazil and China established the Brazil-China Center for Climate Change and Energy Innovative Technologies. The Brazil-China Center supports the partnerships between the Coppe-Federal University of Rio de Janiero (Coppe/UFRJ) and Tsinghua University for research relating to biofuels and carbon capture storage (CCS)[27]. According to the Brazil China Joint Action Plan, Coppe/URFJ and Tsinghua will have continued support for the development of "a new process that uses enzymes in biodiesel production" [28,18]. Another university partnership formed by the Brazil-China Center is between Coppe/UFRJ and China University of Petroleum (CUP). In conjunction with the major Chinese and Brazilian oil companies, Coppe/UFRJ and CUP will focus on research relating to deepwater oil production technology, including floating systems and subsea technology[27].

Competitive Collaboration

University-industry partnerships provide valuable knowledge transfer between academia and industry. As China and Latin America are at similar stages of development, university-industry partnerships promote innovation, collaboration and competition. Using Brazilian aeronautics company Embraer as a model, we will look at its collaboration with a variety of universities to see how they have promoted competitive collaboration.

Embraer and Brazilian Universities

Like many countries in Latin America, "Brazil is growing fast, but it struggles to find the researchers, engineers, and highly skilled workers to maintain that growth" [17]. As a way to tackle this problem, Embraer was one of the first companies to establish industry-academic partnerships in Brazil[29]**.** Currently, Embraer is the world's third largest producer of commercial airplanes, behind the Boeing Company and Airbus[10].

Embraer connects with Universities

In 2001, Embraer and the Aeronautic Institute of Technology (ITA) started the Engineering Specialization Program (ESP)[33]. Through ESP, Embraer funds and train students interested in pursuing graduate degrees in engineering. Since its establishment in 2001, "[ESP] has graduated more 15 classes with more than 1000 engineers" [30]**.** With 25 percent of its total workforce made up of engineers, ESP successfully helps fulfill Embraer's needs for "engineers specialized in the different aeronautical design disciplines" [30].

Besides the Aeronautic Institute of Technology, Embraer partners with a number of Brazilian universities including Unicamp, Pontificia Catholic University of Rio de Janeiro and the Federal University of Bahia[30]. Each university has a unique area of engineering expertise. For example, Unicamp's specializes in software engineering whereas Pontificia Catholic University of Rio de Janeiro specializes in e-learning technologies[30].

In addition to Brazilian universities, Embraer also has a partnership with the Civil Aviation University of China. Every year Embraer provides 20 scholarships, each worth 5000 RMB, for undergraduates pursuing degrees in Aeronautical Engineering. Embraer additionally signed an agreement with the Civil Aviation University of China to train pilots and share information and library resources[31].

Forming University Partnerships

Remembering that China in an authoritarian state, having good relations with the government is essential for companies and universities interested in establishing partnerships with Chinese universities. We surveyed the websites of top Chinese engineering universities in order to understand how their programs and research projects are funded. We found that the Chinese government is the main sponsor for engineering programs and research projects. Some universities mentioned corporate partnerships. However, Tsinghua was the only university who explicitly stated the names of company sponsors participating in joint research collaboration[16]. Knowing this information, Latin American universities and companies interested in establishing

partnerships with Chinese universities should work closely with the appropriate government entity.

Analysis

At the request of this paper's reviewers, this summary analysis is offered of the situation regarding deeper understanding of China's motivations behind improving its engineering education position in Latin American nations and cultures.

As stated above, China has been constrained as a world military power by a long history of internal focus on domestic affairs. Even the name of the country 'Zhongguo'—the Middle Kingdom—reflects this mindset. Because of this, China has actively sought methods of establishing secure ties with other nations other than through military intervention. The two chief directions that China has led with in recent times have been export of students and export of goods. As a result, the two things one is most likely to encounter from China in all parts of the world are both students and Chinese-made products.

The impact on engineering education in Latin American countries has only begun, as has been profiled by some of the projects listed above. However, Chinese government activities in Latin America through the 28 Confucius Institutes are strategic and far-sighted, and are indications that, similar to their policies in Africa, larger initiatives are in development. China realizes that in order to have a larger, more comprehensive relationship with Latin America, and this includes enterprises involving all the STEM disciplines, that a base of cultural understanding must occur before sending large numbers of scholars abroad. Equally important is to groom future Latin American leaders in China with educational opportunities, so that 10-20 years from now, instead of looking north for direction and collaboration, Latin American countries will look to China.

It is expected that there will be two areas where the Chinese will make their mark with regards to engineering education. One is in the contribution of money to engineering education infrastructure in Latin America, through the direct subsidy of scholars, as well as joint research agreements, such as those already implemented between Petrobras and Embraer in Brazil, and China. The second wave will likely be direct, strategic investment in engineering education in Latin America itself.

The reasons behind this are two-fold. First, China will need the creation of engineers in Latin America that can augment the demands of industry that China requires for balance-of-trade in the region. For example, if oil exports to China are to increase, there will be more need for petroleum engineers in the region, and a majority, or at least a significant minority of those engineers will likely need to sourced from the home country in order to successfully integrate with that nation's workforce and avoid the development of long-term conflict and disruption that is seen in the Middle East. China's primary aim in its development efforts is its own internal stability. As such, securing long-term suppliers of vital natural resources by development of Latin American educational resources is a peaceful, non-threatening way to assure China's longer-term political aims.

The second reason China will invest in the region, if past Chinese export of its students around the globe is any indication of a larger strategy for its future, is for development of institutions where Chinese students are welcome and potential long-term contributors. Even if the actual

number of Latin American students learning Mandarin is relatively small, cultural awareness brought by such programs as the Confucius Institutes mainstreams the idea of larger populations of Chinese scholars abroad. Language leads to relationships, which then will lead to development of educational classes that the Chinese need to achieve their other aims. And that means that technical and engineering education will be highlighted.

A comparison with the U.S. can help participants in international engineering education to anticipate and prepare for the coming impact. Since it was extremely difficult for the paper's authors to come up with exact totals of Chinese engineering students in Latin America, it is helpful to look at the U.S./China relationship to understand the extent, and the seriousness that China takes the involvement of its young people abroad. In 2009 [36], there were approximately 100,000 Chinese students, both undergraduate and graduates, seeking degrees from U.S. universities. Out of these, 50,000 were estimated to be seeking business and engineering degrees. If one assumes that half these students are engineering students, this means a sizable population of total engineering students in the U.S. are citizens of China. Though the students are funded through a variety of mechanisms, including U.S. based research assistantships, family funds, and government monies, the sheer quantity reflects a national will, based on the rational calculation that an engineering education abroad is worth the expense, social dislocation and effort, as well as the reality of learning and practicing in a language for a valuable trading partner.

Contrast this to U.S. efforts, such as the 100,000 Strong Initiative in the U.S. Announced by President Barack Obama in November 2009, President Obama set up a campaign directed through the U.S. Department of State to send 100,000 American students to study in China over the next four years. China stepped up to the plate, by offering 10,000 Bridge Scholarships to Americans wishing to study in China[37]. Yet Obama dictated that the effort, which is estimated to cost $68M, must only be funded by philanthropic donations. Outside the webpage for the 100,000 Strong Initiative, and its Facebook page[38], most of the resources for actually facilitating study in China rest with traditional programs, such as the Boren Scholarships, that were already available, and extremely competitive.

Consider this within the context of China's Confucius Institute program in the U.S. alone. More than 70 universities have a Confucius Institute program, which is staffed by at least one Chinese language instructor[39]. This instructor cohort is paid for solely by the government of the PRC, and offers a solid touchstone for the universities involved with setting up exchanges of students with partner universities in China. Chinese instructors associated with the Confucius Institutes are teaching Mandarin to whole classes of U.S. undergraduates. When it comes to actual individuals designed to facilitate exchange between the two countries, China is mounting a serious effort, while the U.S. provides only verbal encouragement. History is well-written on the value of only words.

Policy recommendations to fix this situation are straightforward. While there at least is some lip service to students traveling to, and understanding China, it is short-sighted to assume that this will change any of the dynamic until faculty members themselves learn more about programs in China, and the relevance of a strong global engineering program. With regards to fixing the U.S./China academic relationship, there needs to be direct programs encouraging faculty visitation of mainland China. These residencies could look very much like ASEE's 10 week programs for partnerships with national labs. Looking at ASEE as an example, there have been

only modest programs sponsored by outside agencies, or involved self-sponsorship, and most of these involved brief visits to Beijing or Shanghai, with a list of cultural touristic spots along with obligatory stop-overs at the largest universities. Additionally, there needs to be encouragement of faculty acquiring rudimentary language skills as part of their careers, as some ability to converse in Chinese is vital not so much for technical exchange, but for the building of appropriate academic friendships that can result in more pathways for technical exchange. Fluency in Mandarin has never been a key requirement for doing business in China, as the actual transactions will likely be done in English. However, academic friendships are built on the concept of mutual respect of both language and culture, and being able to hold simple conversations in Mandarin place our Chinese colleagues on a more equal, hierarchical level as well as communicating the seriousness that U.S. scholars place on the partnership.

Without any direct effort to fix this situation, one should expect the U.S. position with China, and its influence on the China/Latin America relationship to languish. Other countries do not have a built-in bias against learning languages that seems to exist in the U.S., and as China goes into countries in Latin America, especially the ones with developing economies, it should be expected that enterprising young people in those countries will sense the opportunity and take advantage of expanding Chinese influence to make both their careers and fortunes.

Conclusion

China is not on a quest for global domination. According to Wang Zaibang[15], a reporter for China Daily News, given China's fast development:

> It is natural to assume the foreign strategy of an emerging power will inevitably be pursuit of hegemony…and ill-[information] about China's historical and cultural traditions, most foreigners feel uncertain about how a stronger China will use its power. But as time goes on, the peaceful development road of China will become more and more evident. (p.16)

China views the shift, "toward multi-polarity [as] irreversible" and believes, "It is in the fundamental interest of people of all countries...to share development opportunities, jointly address challenges and promote the noble cause of peace and development of mankind" [3]. As we have seen with the developing relations with Latin America, "China is committed to the path of peaceful development and the win-win strategy of opening-up" [3]. Though China and Latin America's relationship is predominately motivated by economics at this point, their relationship will continue to grow in a multi-faceted way. Already, we are seeing an increase in academic partnerships, research collaboration and university-industry links. The establishment of joint ventures between major engineering related companies are allowing for an increase in opportunities for academic-industry collaboration. Through these types of collaborations and research projects, Chinese and Latin American engineers are learning valuable technical skills and are gaining experience collaborating at an international level. As a result, China and Latin America are becoming more innovative and competitive. By working together, China and Latin America are becoming more influential on a global scale. It is important to note that their relationship is only in the beginning stages and will continue to grow and strengthen in the future.

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