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GLOBAL TRENDS IN ENTREPRENEURSHIP & INNOVATION

APPLIED INNOVATION REVIEW

The Applied Innovation Review (AIR) is an on-line and in-print publication on special topics in Technology Business Innovation, New Venture Models and Education in Entrepreneurship and Innovation. Unlike traditional business reviews, papers in AIR identify more current research, best practices and trends that can affect the global economy.

Information in AIR is intended to be effective, modern in style, insightful and useful for industry, policy makers and educators interested in participating in entrepreneurship & innovation. AIR papers and opinions may preview work still in formation and that may be accepted by more formal journals at a later time.

Editors

Editorial Staff

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Letter from Dado Banatao for the Inaugural Issue of the Applied Innovation review

Dear Global Innovation Community,
It is my pleasure to welcome you to the first issue of the Applied Innovation Review (AIR). As an entrepreneur, venture capitalist and now Chairman and Founder of PhilDev (Philippine Development Foundation), I have always been interested in harnessing the power of entrepreneurship and innovation. In this inaugural issue of AIR, I would like to begin the conversation with global economic development.

In recent years, we have seen the emergence of interest in innovation and entrepreneurship in developing countries. Presidents and industry leaders use it as a call for action as if everyone knows how and why it works and why it matters.

Research has shown that, in any economy, sustained high growth happens due to a number of common attributes. These include a functioning market system, high levels of saving by the population, public and private sector investment, resource mobility, innovation in science and technology and political leadership and their ability to deploy the right infrastructure and business policies.

Additionally, the infrastructure for innovation in science and technology assumes an educational system in primary and secondary levels that promotes a science and mathematics culture. At the higher education levels, a globally competitive practice of research and development focuses on society's needs. Although strong leadership in government is necessary, government is not necessarily the cause of growth. That role falls to the private sector and their ability to innovate and invest, as well as entrepreneurs' responses to market needs.

In the case of global market demand, it is important to note that in a relatively poor developing economy, the size of the global economy is huge in comparison and, at the right conditions, the global market demand is, for practical purposes, unlimited. It is not only possible now but, more importantly, easier to enter the global market because the world economy is open and integrated. Generally, industries in which the country has a comparative advantage, growth in exports will not be constrained by demand, and growth in the economy can occur at a rate determined by savings and investments.

We need to be aware, however, that in a country with a higher percentage of population in poverty, savings alone does not promote inclusive development. This is because invested savings come from those that have the financial resources—that is, the rich—resulting in the rich getting richer and the poor remaining poor.

The only known solution to this is innovation and entrepreneurship where knowledge in innovation is valued—in most cases more than money—and there exists a practice of entrepreneurship through fair equity distribution between entrepreneurs, investors and employees. It is also well known that entrepreneurship is the fastest means of wealth absorption by the population.

The second resource for growth is innovation and entrepreneurship based on technology. It is very important and necessary that the value of technology innovation is translated to equity and fair ownership

in enterprise building. Local economies that cannot compete globally on technology innovation experience slow growth of development and remain at the developing status.

The third resource for high growth is foreign direct investments (FDI) or investments beyond the capacity of the local economy to save. It is especially important in that it brings in more technology, market knowledge and access to global markets. In short, FDIs are the conduit for growing economies to import ideas, technologies and market know-how. Additionally, foreign education is valuable in the sense that it often creates lasting international networks. Since learning is faster than inventing, fast learners can rapidly gain ground on leading economies.

These driving forces, which come from global markets, are there for all developed and developing countries to exploit. Those that can translate these benefits to fuel inclusive innovation and entrepreneurship will achieve a sustainable high rate of economic growth that will drastically reduce poverty.

As this is a central approach that PhilDev is using to change the economy and lives of the people in the Philippines, I am very happy to see that the Applied Innovation Review will also introduce the most recent trends of innovation and entrepreneurship in a global economy for the benefit of educators, industry and policy makers.

Sincerely,

Dado Banatao
Chairman, PhilDev, Philippine Development Foundation
Managing Partner, Founder, Tallwood Venture Capital in Silicon Valley

Self-Driving Cars: Disruptive or Incremental?

Tao Jiang, Srdjan Petrovic
Google

Uma Ayyer
Samsung

Anand Tolani
Yahoo

Sajid Husain
Altera

Are self-driving cars in our near future? In what ways do Google's self-driving car project disrupt the auto-industry? How are the auto manufacturers addressing this challenge? What suppliers will benefit from this technological revolution? Will the standards and regulations industries be ready? This paper aims to answer some of these questions and describe an overall state of the market for self-driving vehicles.

I. THE FUTURE OF SELF-DRIVING CARS AND ITS DISRUPTION TO THE AUTOMOTIVE INDUSTRY

There has recently been a flurry of news about self-driving cars in the media. As of the end of 2014, most of the biggest car manufacturers have been building their own versions of self-driving cars. Google has moved its focus from highway-oriented autonomous driving to driving on local streets. Companies such as Baidu, a Chinese web services corporation, have announced their intention to enter the self-driving car market. Everyone seems to have realized that self-driving cars are the future of automotive industry. This new prospect, however, is elucidating the major split that is occurring in the self-driving industry. This separation originates in the approach that companies are taking to achieve the goal of fully autonomous driving. On one side, auto manufacturers are adopting the incremental approach; cars are becoming more and more autonomous over the years. On the other side, Google is aiming to release a fully autonomous vehicle straight to the market. This split is best articulated in the words of Carlos Ghosn, CEO of Nissan Motor Co., Ltd.: "Autonomous drive is about relieving motorists of everyday tasks, particularly in congested or long-distance situations. The driver remains in control, at the wheel, of a car that is capable of doing more things automatically. Self-driving cars, by comparison, don't require any human intervention – and remain a long-way from commercial reality. They are suitable only for tightly-controlled road environments, at slow speeds, and face a regulatory minefield[1]."

Mr. Ghosn speaks on behalf of all car manufacturers to lay out their vision of achieving fully autonomous vehicles. In his vision, drivers will remain behind the vehicle steering wheel, ready to take over control of the vehicle whenever the driving conditions are not conducive to autonomous driving. Initially, for example, cars may drive themselves only on highways and under good weather conditions. Over the years, however, cars will be self-sufficient under more and more conditions and will eventually relieve the driver entirely of the need to steer, thus achieving the fully autonomous status. Mr. Ghosn is implicitly comparing his approach to Google, which aims to release a fully autonomous car straight to the market. The difference in approach is best exemplified in the concept car Google recently unveiled: the car does not have a steering wheel or gas and break pedals. In Google's vision, there is no driver to take over the control of the vehicle; the vehicle has to drive itself regardless of the conditions. As Mr. Ghosn states, Google's approach is not only technically difficult, it also faces a number of regulatory issues.

In this paper, we focus on a number of these issues. In Section I, we present a detailed roadmap for self-driving cars from both the automakers' and Google's perspectives. In Section II, we present a global overview of the market for self-driving vehicles. In Section III, we focus on the technology adopted by the automakers and Google. In Section IV, we dive into the legal and regulatory issues

facing automakers and Google in their pursuit of fully autonomous cars. In Section V, we present the main expected winners and losers in the self-driving vehicle reality. In Section VI, we summarize the main ideas and talk about the most likely unfolding scenarios for all players.

II. ROADMAP FOR SELF-DRIVING CARS

Automaker Roadmap for Self-Driving Cars

The automaker will incrementally add autonomous features in existing cars, which allows them to monetize these features and as well as test them in real conditions. The following features are considered as incremental changes that may lead us to the development of self-driving cars.

*Image Courtesy of Nissan

Automated Park Assist Technology (Available Now)

Intelligent park assist technology was developed by Toyota. In the United States, this feature first appeared in the Toyota Prius, followed by the Lexus. This technology allows the car to automatically steer itself into tight parking spots[2]. The Ford automated park assist can be operated from outside of the car. It is available in all Ford models manufactured after 20113. European companies such as BMW and Volkswagen have also produced initial versions of automated park assist technology[3]. Most recently, Tesla announced that their Model D electric car will include park assist technology[4].

Adaptive Cruise Control Technology (2016)[5]

Radar and laser based adaptive cruise control (ACC) systems have been installed in cars for the last fifteen years. This technology allows cars to maintain a safe distance from the vehicle in front of them. Audi, Volkswagen, BMW, Toyota, and Subaru have deployed this technology in a variety of ways in their vehicles. Super Cruise is a GPS oriented intelligent navigation technology that predicts freeway entries and exits; it aids ACC in assessing freeway conditions and making intelligent decisions. It also integrates additional sensors in order to make autonomous decisions if a car cuts into the lane ahead[6].

Automated Highway Driving Assistant (2018)

Toyota's Automated Highway Driving Assistant is a two-part system that takes over acceleration, deceleration, and lane maintenance on highways. The AHDA system represents a more capable, next generation version of features that are available today. The Toyota cars with this feature will be available by 2016[7]. BMW recently unveiled one of the most advanced driverless technology pilot projects in early 2014. BMW's ActiveAssist is one of the most advanced autopilots unveiled to date. It is able to navigate its way at breathtaking speeds on a test track, avoiding all obstacles. While the commercial version of an autopilot is years away from availability to the public, the predicted time-line is 2018[8].

Autonomous Highway Driving (2020)

In autonomous highway driving, the driver can fully cede control of all safety-critical functions in certain conditions. The car senses when conditions require the driver to retake control and provides a "sufficiently comfortable transition time" for the driver to do so. This is identical to the Level 3 definition put forward by NHTSA. Currently, Mercedes-Benz, Nissan, Volvo, BMW, and Audi have test models, which are slated to go to production by 2020[9].

Current Announcement Of Autonomous Features[10]

Manufacturer	Product Name	Extent of Automation	Expected Introduction
BMW	Traffic Jam Assist	Assist in traffic jam situations up to 25mph	2014
Cadillac	Super Cruise	Full range hands-free	2018
Ford	Traffic Jam Assist	Stop and go highway traffic	2017
Mercedes-Benz	Stop-and-Go Pilot	Stop and go highway traffic	2014
Volvo	Traffic Jam Assist	Assist in traffic jam situations up to 25mph	2018
Tesla	Auto Pilot	Detect and avoid pedestrians	2014
Audi	Auto Pilot	Take control of steering in traffic jam	2016

Table 1: Announcement of Autonomous Features[10]

Google Roadmap For Self-Driving Vehicles

Google is building prototypes of fully autonomous vehicles that reject carmakers' plans to gradually enhance existing cars with self-driving features. The Google self-driving car does not even have a steering wheel. Google will ramp up the production version of their car by 2020[11]. The long-term vision of the self-driving car involves moving from an ownership model to a service model, in which large numbers of people simply call cars whenever they want them. The new business model from Google favors the Robo-Taxi model, where car rides will be provided on demand. Google also wants to dominate the market for providing maps and software for the self-driving car.

III. GLOBAL OVERVIEW FOR MARKET OF SELF-DRIVING CAR[12,13]

Market For Automaker Autonomous Cars

The automaker is already introducing various autonomous features in the car, which bring additional high margin revenues. It is projected to be the fastest growing market for carmakers for next ten years. Carmakers are charging anywhere from $3000 on mid-range to $7000 on luxury models for these features. Autonomous features will bring in $30B in additional revenue in 2014. Additionally,

autonomous features are expected to grow to $250B by 2030. The revenue from autonomous features will grow 15% in Compound Annual Growth Rate (CAGR) from 2014 to 2024. Finally, 50% of cars are projected to be autonomous by 2035.

Market For Self-Driving Cars

The Google self-driving car is in the prototype stage as of 2014. The vehicles are projected to bring in an additional $80B in revenue by 2030. Additionally, 25% of cars will be self-driving by 2030. The new entrant, Google, is expected to capture 8% of the total car market by 2035.

Global Market For Cars

The number of total cars sold globally will pass 90 million units in 2014. The number of autonomous cars will exceed 15 million units in 2014. Additionally, the total number cars in use globally will exceed 900 million in 2014. By 2030, however, the number of cars in use globally will exceed 2 billion. It is estimated that 50% of the cars sold by 2030 will be either autonomous or self-driving cars. The number of autonomous and self-driving cars will grow by 15-17% in CAGR over the next ten years.

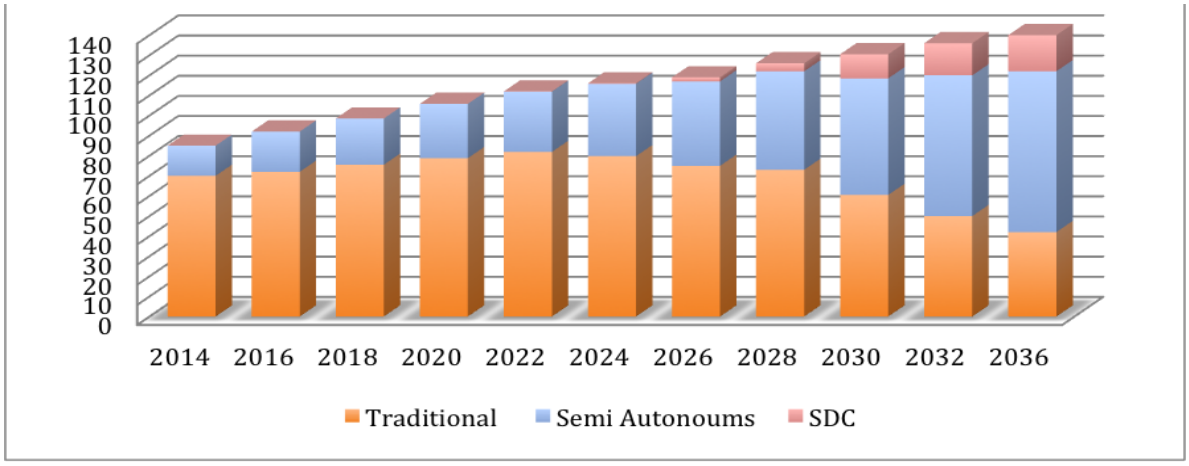

Figure 1: Global Market For Cars

Global Market For Cars By Region

The United States and Europe will lead in the early adoption of autonomous and self-driving cars. However, China is projected to take over Europe as the second biggest market for the vehicles by 2030.

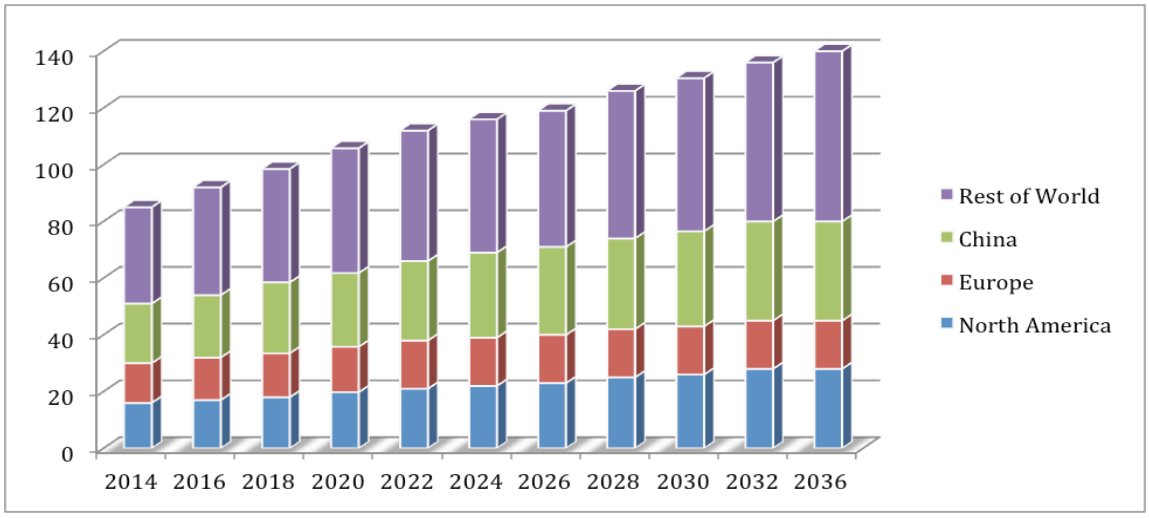

Figure 2: Global Market for Cars by Region

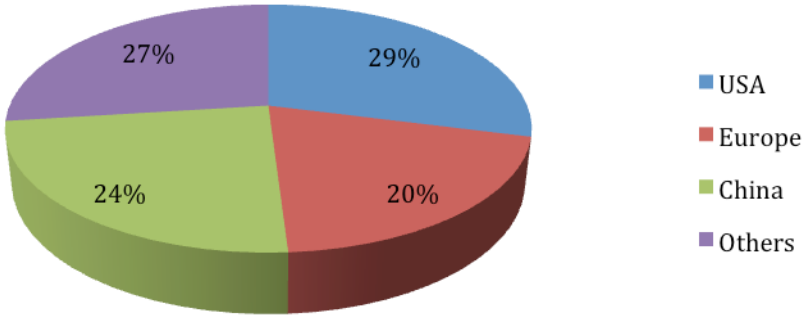

Figure 3: SDC Market Share Forecast by Region by IHS (2013)

Key Hurdles For SDC Penetration

One of the key hurdles for Google's self-driving car is cost. It cost $200,000 to build a self-driving car in 2014. By 2015, these costs are expected to decrease to $50,000. There will be a rapid decline in building self-driving cars as volume increases and technology matures. The adoption will rapidly rise once cost of self-driving car features will be less than $7000.

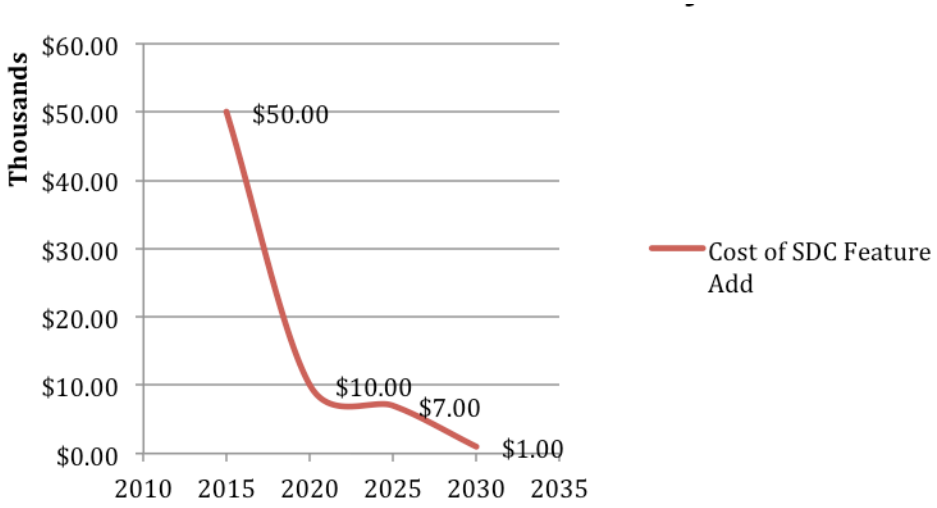

Figure 4: Cost of SDC Feature Addition by IHS

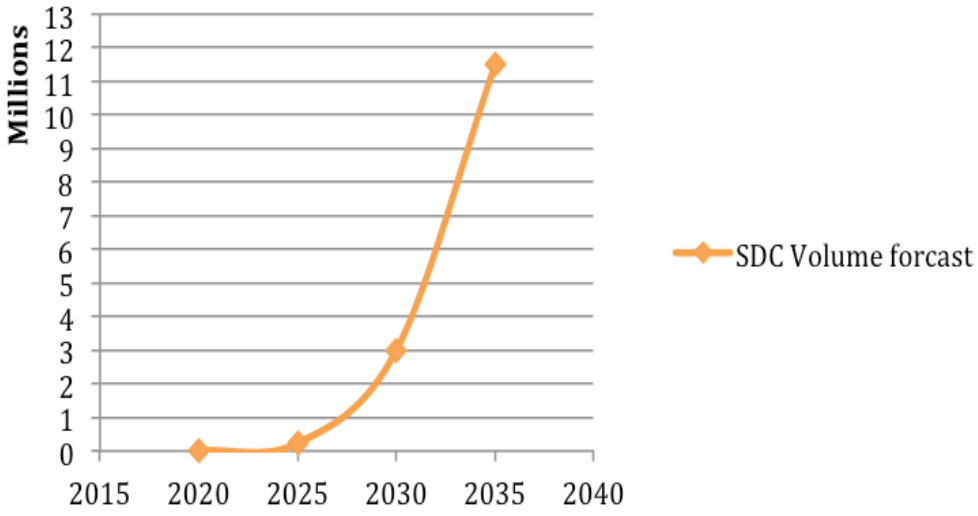

Figure 5: SDC Volume Forecast by IHS

Component Suppliers Share Of Self-Driving Cars[14]

According to Lux Research, self-driving technology will create a new opportunity for the automotive value chain. It will bring in outsiders to join incumbents looking to capitalize on a new market. Software will be the biggest autonomous vehicle value chain winner with $25 billion in revenues in 2030, a 28% CAGR. Optical cameras and radar sensors will amount to $8.7-billion and $5.9-billion opportunities in 2020. Computers will be the biggest hardware on board autonomous cars, amounting to a $13-billion opportunity. Prospective suppliers in the value chain should anticipate significant changes in both the inside and outside of the vehicle over time, inevitably creating opportunities for new entrants. The electronics and software will become 50% of car cost by 2030.

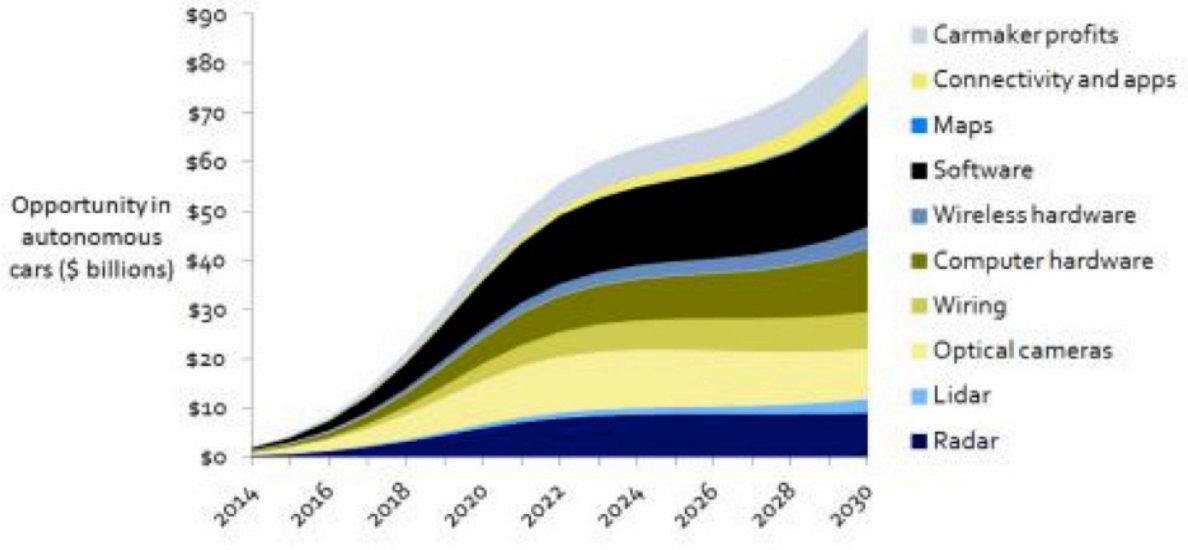

Figure 6: Behind-the-Scenes Software Will Capture the Largest Share of SDC Opportunity

The Impact On Adjacent Markets

The $200 billion auto insurance industry will be transformed as premiums decline due to fewer accidents. It is estimated that car accidents will decline by 90% as autonomous cars become widespread. Because self-driving cars cannot be manipulated, most of the crashes will result in product liability claims. The product manufacturer will sell master policies with SDC to cover these claims. Secondly, the rental car, taxi service and rideshare industries will merge and evolve into Robo-Taxi Model industries. Once SDCs become popular, people will move toward fractional ownership or “car sharing subscription service.” The service will provide flexibility to summon cars without drivers to your location and have them take you where you want to go. Finally, the auto service industry will be consolidated into a few big automated service companies.

IV. TECHNOLOGIES BEHIND SELF-DRIVING CARS

Google’s Self-Driving Car

Google’s driverless car uses a lot of very advanced hardware. It needs to be able to detect and avoid obstacles, as well as understand if an object is a curb, a pedestrian or cyclist. Google’s driverless car uses a host of detection technologies such as sonar devices, stereo cameras, lasers and radar[15].The Velodyne 64-beam laser (LIDAR – light detection and ranging) mounted on the roof of the Google car is at the heart of its object detection. It measures the distance between the vehicle and object surfaces facing the vehicle by spinning on its axis, changing its pitch and taking 1.3 million readings per second. The laser has a 360-degree horizontal field of view, a 30-degree vertical field of view and a maximum distance of 100 meters. The radar has a horizontal field of view of 60 degrees for the near beam and 30 degrees for the far beam, as well as a maximum distance of 200 meters. The radar mounted on the front and back bumper of the car is used to monitor the speed of other cars in

real-time. Based on this information, the Google car adjusts the throttle and brakes continuously to prevent an impact. It is essentially an adaptive cruise control. The sonar has a 60-degree horizontal field of view for a maximum distance of 6 meters. The stereo cameras have an overlapping region with a 50-degree horizontal field of view, a 10-degree vertical field of view, and a maximum distance of 30 meters.

Both the radar and sonar sensors have a narrow field of view; therefore, the car knows things are about to get messy if another vehicle crosses both beams. This signal is used to swerve the vehicle or apply the brakes. Google mounts regular cameras around the exterior of the car in spaced-out pairs. The overlapping fields of view create a parallax not unlike your own eyes that allow the system to track an object's distance in real time. As long as it has been spotted by more than one camera, the car knows where it is. These stereo cameras have a 50-degree field of view, but they are only accurate up to about 30 meters[15].

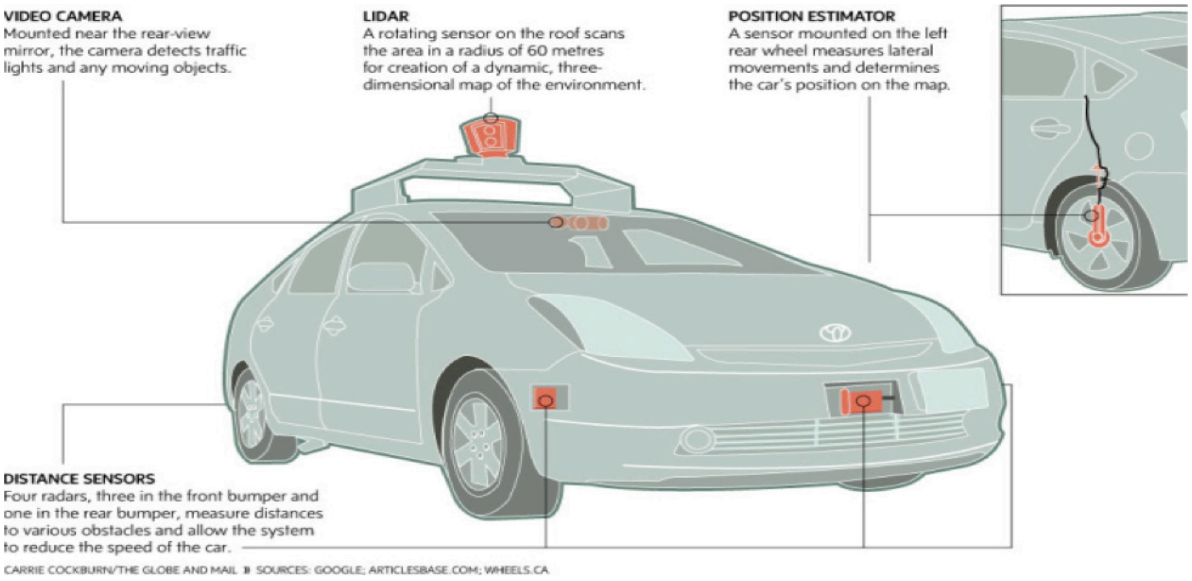

Figure 7: Google's Self-Driving Car (Source: Google)

Google has built the entirety of California's road system (about 172,000 miles) in software, along with accurate simulations of traffic, pedestrians and weather. Google has built the data the cars need to process by mapping each road that the cars will drive on by ultra-precise digitization of the terrain. Google's software integrates all the data from these remote sensing systems (~ 1GB per second) to build a map of the car's position. Its algorithms then process data based on observing deltas.

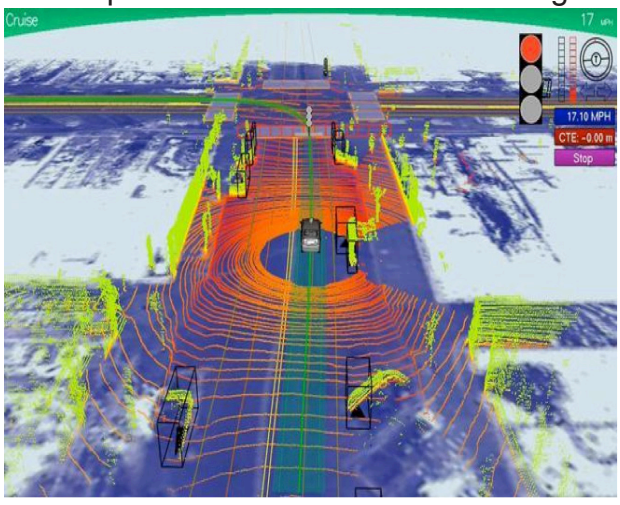

Figure 8: Google's Road Map Simulation (Source: Google)

To summarize, Google has no intention of challenging the automakers on their playing field. It will change the game and introduce a disruption in the auto industry by providing various technologies and services rather than selling cars. It plans to release the following four technologies within four years:

- Autonomous mobility services such as “robo-taxi” (this has the potential of reducing the car ownership by a factor of three)
- Producing and selling specialized maps and software
- Technology for monitoring systems to reduce congestion
- Technology for robotics (probabilistic inference, planning & search, localization, tracking and control)

Technologies Used By Automakers

Auto manufacturers are focused on driver assistance systems and expect to have someone in the driver seat to take charge in between “self-driving” modes. Their strategy is to enhance the driving experience in the automobile and remove the “stress” aspect of it. Mapping of the terrain in which the car drives is done in “real-time” as opposed to using the “delta” approach that Google is taking, starting with pre-mapped routes and terrain information. The following sections cover some interesting technologies available, illustrating the incremental approach to self-driving cars by auto manufacturers.

Lane Change Assist

This driver assistance system consists of two radar units. The devices are invisibly mounted in the corners of the rear bumper. One sensor operates as system master; the second unit is configured as slave. By using a private data link, the data of both radars are combined in a sensor data fusion-tracking algorithm. This technology is in volume production since Q1/2006 and is used for example by Audi, Volkswagen, BMW, Porsche and Mazda[16].

Figure 9: Lane Change Assist Simulation (Source: Audi)

Parking Assist

Fully Assisted Parking Aid is now available in Ford. It can now park cars in tight spaces and back into perpendicular and angled parking spaces. This is particularly much needed in Europe and Asia. This technology uses ultrasonic sensors to scan for an open parking space at speeds as high as 19mph. When the car finds a suitable spot, it alerts the driver, who can stay in the car or get out and use a remote to finish the parking job. The car then backs itself into the parking space. Other automakers such as Mercedes also have similar technology available in their cars[17].

Adaptive Cruise Control

Adaptive cruise control (ACC) is an intelligent form of cruise control that slows down and speeds up automatically to keep pace with the car in front of you. A small radar unit behind the front grille or under the bumper measures the distance. Some cars employ a laser while others use an optical system based on stereoscopic cameras. ACC is ideal for stop-and-go traffic and rush hour commuting that swings from 60 mph to a standstill. Regardless of the technology, ACC works day and night

but its abilities are hampered by heavy rain, fog or snow. In an autonomous driving car, ACC needs to track not only the car in front but also the cars in adjacent lanes in case a lane change becomes necessary[18].

Vehicle-Vehicle Communication

On Feb 6, 2014, Obama Administration announced that it plans to push the V2V communications technology forward. Cars will talk to other cars, exchanging data and alerting drivers to potential collisions. They will talk to sensors on signs on stoplights and bus stops and even sensors embedded in the roads to get traffic updates and rerouting alerts. They will communicate with your house, office and smart devices, acting as a digital assistant, gathering information you need to go about your day. Vehicle-to-vehicle (V2V) communications comprise a wireless network where automobiles send messages to each other with information about what they are doing. This data includes speed, location, direction of travel, braking and loss of stability. Vehicle-to-vehicle technology uses dedicated short-range communications (DSRC), a standard set forth by bodies like FCC and ISO. Sometimes it is described as a WiFi network because one of the possible frequencies is 5.9GHz; this frequency is used by WiFi, but it is more accurate to say that DSRC is “WiFi-like.” The range is up to 300 meters or 1000 feet for about ten seconds at highway speeds (not three seconds as some reports say). V2V would be a mesh network, meaning every node (car, smart traffic signal, etc.) could send, capture and retransmit signals. Five to ten hops on the network would gather traffic conditions a mile ahead. That’s enough time for even the most distracted driver to take his foot off the gas[19].

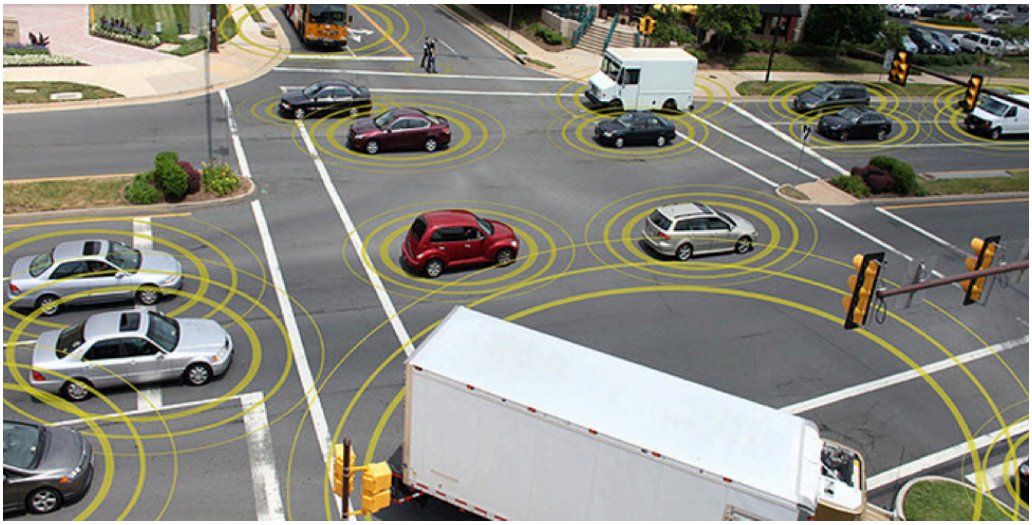

Figure 10: Vehicle-to-Vehicle Communication (Source: United States Department of Transportation)

Another technology used in this is Cloud-based computing. Automobiles today are already packed with an impressive amount of processing power, because some 100 million lines of software code help run the typical luxury vehicle. But as connected cars before were sophisticated rolling wired devices, the amount of information flowing back and forth from them will skyrocket. Therefore, they will be an increased demand for the cloud’s scalability and storage capabilities. In summary, auto-manufacturers predict that fully autonomous vehicles may not reach mainstream for at least another decade but incremental technologies are already in prototype phase and some have launched. They are betting and working on incremental automation technologies but not a driverless future.

Industries That Will Benefit From Self-Driving Cars

Technologies	Purpose	Key Players
LIDAR	Obstacle detection and avoidance	Velodyne Quanergy Leddar Tech ASCar Inc
Imaging Sensors	Viewing objects Reading traffic signs Reading speed limits	Omnivision ON Semiconductor SONY
Compute Power	Si with greater compute power Low Power Consumption	Intel Qualcomm
Big Data & Security	Data Security Systems Traffic Monitoring Systems Communication Systems (V2V)	Google IBM GM, BMW, Daimler, Honda, Audi, Volvo
Artificial Intelligence & Robotics	GPS, Localization Maps, Cognitive Learning, Augmented Reality	Google Trimble CSR Samsung Facebook

Table 2: Industries That Will Benefit From Self-Driving Cars

V. CHALLENGES FOR SELF-DRIVING VEHICLES

Regulatory Landscape

Previous to 2011, no existing state or federal legislation could be cited as explicitly prohibiting self-driving cars. Auto-manufacturers continued to innovate on and incrementally roll out driver assistance features in their premium class vehicles with no perceived need—publically, politically or within the greater auto industry ecosystem (e.g. including the insurance companies) itself—to craft regulations governing their legality. Features such as self-pumping brakes, adaptive cruise control, and lane departure warning systems happily co-existed with existing regulatory terminology like “driver” or “vehicle operator” that did not even explicitly identify (nor likely ever anticipate the need to state) that the operator in question should be a human being.

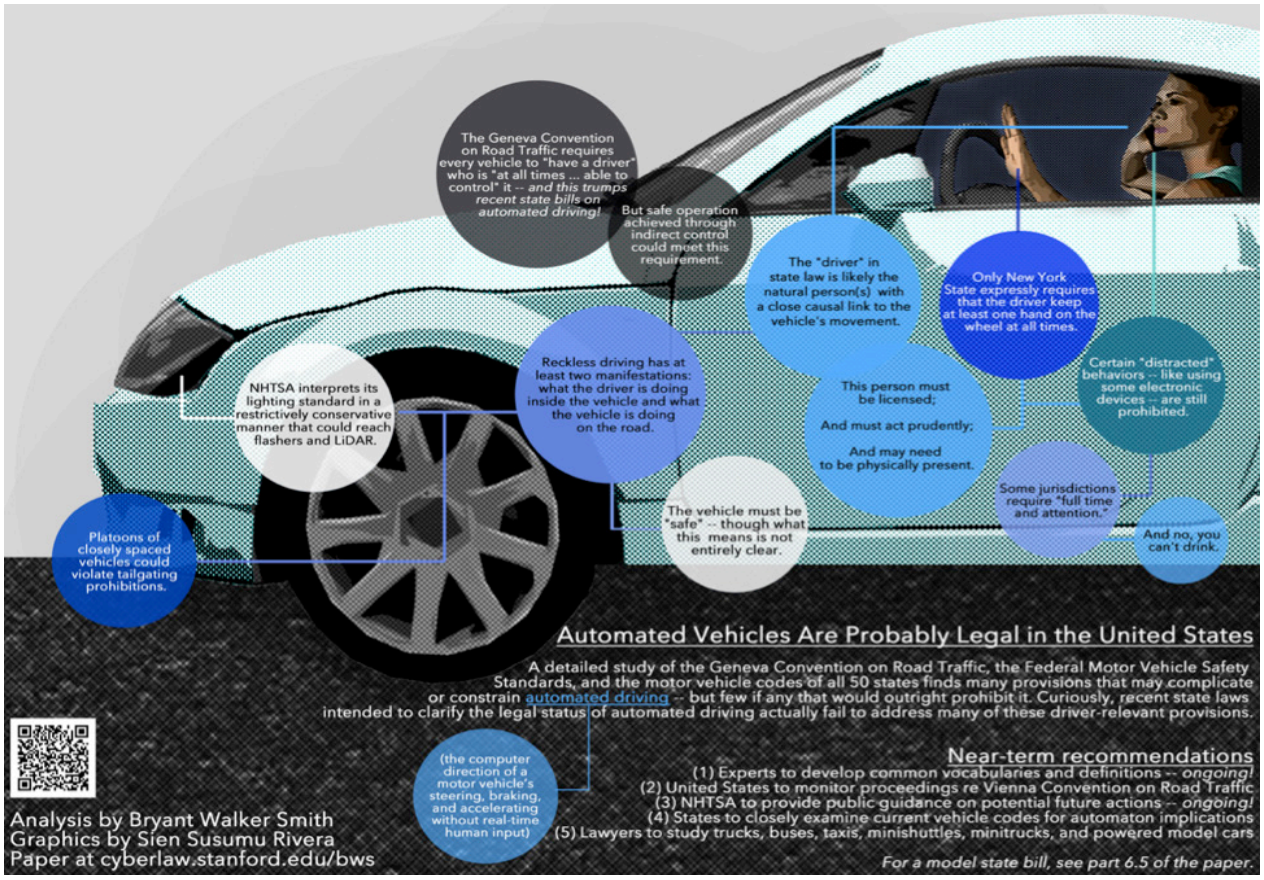

Figure 11: Automated Vehicles Are Probably Legal in the United States (Graphic by Sien Susumu Riviera)

In November 2012, Bryant Walker Smith, an affiliate scholar at the Center for Internet and Society at Stanford Law School (and an assistant professor at the University of South Carolina School of Law), painstakingly examined the statutes of The Geneva Convention on Road Traffic, the Motor Vehicle Codes of each U.S. state and the Federal Motor Vehicle Safety Standards for existing regulations that might impact the status of autonomous vehicles. He summarized and published his titular conclusion in the academic paper "Automated Vehicles are Probably Legal in the United States"[20] with the accompanying poster (included above) highlighting the numerous questions still open to interpretation.

State Legislative Action

However, in 2011 no attempt to even aggregate and codify the legislative gaps even existed. Companies with more ambitious and immediate agendas for autonomous vehicle testing had to be satisfied operating in this vacuum of robust inquiry. Google, ill-contented with millions in R&D investment already in play, took the issue into its own hands and lobbied the Nevada state legislature to pass bill SB-140, which, whether by design or not, opened the door to a flurry of state congressional activity summarized in the figure below.

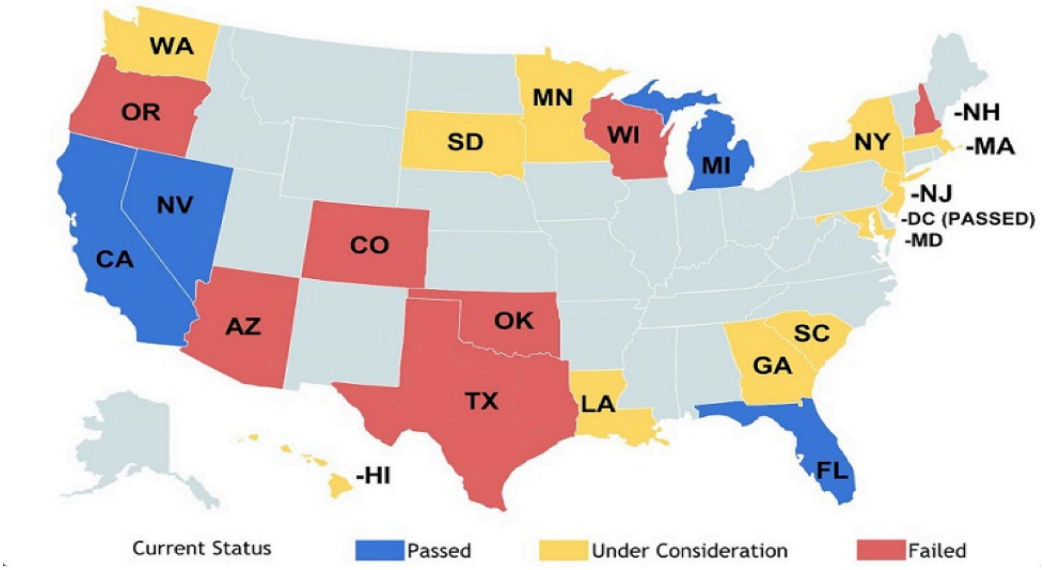

Figure 12: Status of Legislative Action by States (Source: Driverless Transportation)

	Bill		Year	License	Routes	Driver's Seat Occupant [1]	Distracted Driving Ban [2]	Vehicle OEM Liability	Safety & Operating Standards
NV	AB 511 SB 140	✓	2011	Testing for now	Designated state highways	Licensed driver & passenger required	Exempt when autonomous	Exempt	TBD by NV DOT
CA	SB 1298	✓	2012	Mandate for testing and public operation	Not explicitly restricted	Licensed driver required	Exempt when autonomous	Not exempt	**Due from CA DMV before Jan 2015** [3]
FL	HB 1207 SB 1768		2012	Testing only	Not explicitly restricted	Licensed driver required		Exempt	Drafter report was due Feb 2014
MI	SB 169	✗	2013	Testing only	Not explicitly restricted	Licensed driver required			MI DOT to submit report by Feb 2016
CO	SB 13-016	✗	2013	Testing only		Licensed driver required with kill switch	Exempt when autonomous		Bill indefinitely tabled by Sen. Brophy citing transportation committee opposition

(1) Driver's seat occupant must be a licensed driver with access to steering, throttle, and brake controls.
(2) Ban on use of cell phones and texting while driver is operating the vehicle.
(3) Intent for public operation by June 2015.

Table 3: Summary of State Legislative Activity

Nevada Sb-140 & Ab-511

Google began its Nevada campaign with the hiring of Las Vegas based lobbyist David Goldwater, tasked with shepherding two bills through the state legislature[21]:

- SB-140: allowing for the licensing of autonomous vehicles on designated Nevada highways for testing purposes.
- AB-511: granting the driver an exemption to the "distracted driving ban" against texting when the vehicle is not under manual operation.

Early socialization of the technology simplified the passage of the bills; state lawmakers, including the governor, were given rides in Google's "fleet" of modified Prius vehicles and came away as enthusiastic backers. The bills passed easily; opposition from automakers was unable to affect the

outcomes. As with other state bills to follow, the Nevada legislation set high level directives and stipulated desired outcomes without specifying actual procedures. Specifics of how to author regulations for issuing licenses were left to the state Department of Transportation to complete later, leaving many state employees scratching their heads on how to write regulations for a technology they knew basically nothing about. However, Google found an enthusiastic ally in David Breslow, the head of the Nevada DMV. Breslow directed his staff to work closely with Google employees in crafting the regulations. Within nine months, the first autonomous vehicle license was issued to a Google car, complete with an infinity branded symbol on its license plate.

California Sb-1298

In 2012, Google forged ahead again, this time in California, with a more ambitious agenda in mind. The playbook was essentially the same and the outcome equally predictable, now buoyed with a sense of urgency created by the quick passage of the Nevada bills. California lawmakers were primed to act and state senator Alex Padilla authored SB-1298. Opposition from the Alliance of Automobile Manufacturers was overcome and Governor Jerry Brown signed the bill into law in November 2012. Of specific note are the following points:

- SB-1298 contains a mandate not only for licensing for testing purposes, but also for public operation.
- SB-1298 contains language opening the door to the possibility of vehicles without a licensed human driver standing by. This is in opposition to the Nevada bill, which not only required a licensed human driver be available behind the wheel, but that a 2nd licensed driver be present as a passenger.
- SB-1298 directs the California DMV to complete detailed regulation by the end of 2014, with the intent of review and revisions leading to public licensing by June of 2015.

An important test in the gap between imprecise legislative intent and actual regulatory behavior occurred in May of 2014, when Google proposed a new version of its prototype vehicle without a steering wheel for testing in California. This eventuality had been foreseen by Howard Posner, who in 2012 as a member of the California assembly's transportation committee had unsuccessfully suggested the bill be altered to explicitly require a human driver present in the car[22]. The California DMV, however, insisted on a steering wheel and the presence of a human driver. In September 2014, Google relented and installed a "temporary" steering wheel[23]. Although legislative action had been very successfully steered by Google in both Nevada and California, state regulatory departments tasked with the actual implementation of the laws maintain degrees of autonomy—if perhaps only in delaying certain aspects of the technological momentum until fully satisfied.

Michigan Sb-169 & Colorado Sb-13-016

Also worthy of brief discussion are the 2013 legislative actions proposed in Michigan and Colorado. Unlike the bills in Nevada and California, these bills did not receive support from Google and it seems relatively clear why; neither advances the precedent already established in California. In fact, both bills—while perhaps more permissive that Nevada's SB-140, which permitted testing only on designated state highways—pulled back on important advancements in California: the mandate for public operation and language permissive for a future of autonomous operation without a licensed driver present. Google, which had initially participated in the Michigan's SB-169, publically pulled away its support citing the testing-only limitations. Regardless, SB-169 passed, with the full weight and backing of its champion Governor Rick Snyder and the approval of Detroit's "big three" and Toyota[24]. On the other hand, in Colorado, SB-13-016 was "indefinitely withdrawn" by its sponsor, Republican state senator Greg Brophy. Brophy cited Google's influence on Democratic opponents on the state senate's transportation committee as the reason for his decision[25].

Federal Regulation By Nhtsa

On May 13, 2013, NHTSA (National Highway Transportation and Safety Administration) released a "Preliminary Statement of Policy" regarding self-driving cars, primarily to act as a set of guidelines for states to follow. Perhaps the potential for contradictory legislation by individual states, and the resulting chaos this could introduce (into a national vehicular code system previously harmonized by decades of cross state agreements honoring each other's licenses), was a call to action.NHTSA's policy statement establishes a definition of autonomous vehicles around four levels, shown below.

Level	Definition	Example / Explanation
Level 0	No Automation	Driver always in complete control
Level 1	Function-specific Automation	E.g. stability control or brake assist
Level 2	Combined Function Automation	Two or more automated functions
Level 3	Limited Self-Driving Automation	Google car circa 2013, BMW X5 w/traffic jam assist
Level 4	Full Self-Driving Automation	Driver not available at any time

Table 4: NHTSA Policy Statement

Of note is the classification of Google's test vehicle at the time, as only Level 3. NHTSA essentially did not recognize any existing technology of being capable of (or approved for) Level 4 operation, a finding in line with other recommendations issued in their statement. These included the following:

- A statement encouraging states to allow testing of self-driving cars.
- Suggestions that states should not include provisions for public operation at this time.
- However, in the event of a state not heeding the recommendation against public operation, that specific provisions for a licensed driver in the driver's seat be included.
- That special training and licensing requirements be met for human operators of self-driving vehicles.

The NHTSA statement also indicates the agency's commitment to running their own technology study, scheduled to conclude in 2017. They explicitly mention the inclusion of V2V ("vehicle to vehicle") and V2I ("vehicle to infrastructure") technology in the study, a clear indication of their intent to evaluate the technological directions of both Google as well as the traditional automakers. It seems possible that the response of the California DMV to Google's steering wheel free prototype was made with one eye focused on staying within some level of current compliance with NHTSA's policy statement.

The Insurance Industry

Questions of liability in an accident involving at least one party operated by a self-driving vehicle are also unclear and open to interpretation. Nevada's regulations indicate the operator who pushes the start button remains liable[26], a resolution only possible in conjunction with regulations requiring a licensed driver to be present in the vehicle. Michigan's SB-169 states nothing to otherwise contradict the state's existing "Owner Liability Law" placing liability with the vehicle owner. But SB-169 does go on to absolve auto manufacturers of product liability for conversions of standard automobiles to autonomous driving vehicles by a third party[27]. The Alliance of Automobile Manufacturers unsuccessfully petitioned Governor Brown of California not to sign into law SB-1298 over similar concerns of not being absolved from product liability if one of their vehicles, modified for self-driving by another party (i.e. Google), were to be involved in an accident, and publically voiced their displeasure with the bill[28].

Ultimately, however, it should not be forgotten that basic auto insurance liability practice dictates that

insurance policies "follow the vehicle" and not the driver. In this sense at least, the unit of issuance of automotive insurance policies line up well with self-driving cars. But when a car meets the standards of NHTSA's Level 4 autonomous vehicle, what is actually being insured, the vehicle or the manufacturer of the self-driving tech? In the eyes of many, the logical conclusion is the latter. In essence, this predicts a future model of liability coverage that moves from a per vehicle policy to a manufacturer product liability policy[29]—a cost which would be passed on to the consumer by being built into the sticker price of the vehicle itself. Even in a scenario where market forces conspire to keep individual vehicle policies in place, the automobile insurance industry could still face a complete disruption of its current business model. Predictions of a 90% reduction in vehicle accidents in a world fully populated with Level 4 autonomous vehicles would have enormous revenue implications.

Total Crashes per year in U.S.[11]	5.5 million
% human cause as primary factor[12]	93%
Economic Costs of U.S. Crashes[13]	$300 billion
% of U.S. GDP[14]	2%
Total Fatal & Inurious Crashes per Year in U.S.	2.22 million
Fatal Crashes per Year in U.S.[15]	32,367
% of fatal crashes involving alcohol	31%
% involving speeding	30%
% involving distracted driver	21%
% involving failure to keep in proper lane	14%
% involving failure to yield right-of-way	11%
% involving wet road surface	11%
% involving erratic vehicle operation	9%
% involving inexperience or overcorrecting	8%
% involving drugs	7%
% involving ice, snow, debris, or other slippery surface	3.7%
% involving fatigued or sleeping driver	2.5%
% involving other prohibited driver errors (e.g. improper following, driving on shoulder, wrong side of road, improper turn, improper passing, etc.)	21%

Figure 13: Human Cause as Primary Factor in Accidents

According to the NAIC (National Association of Insurance Commissioners), the US auto insurance industry collected roughly $200B in insurance premiums[30]—87% in private policies and 13% in commercial. Of this windfall, 68% of premium cost was applied to paying accident claims, including actual cost of repairs, determination of fault and rental replacements. The cost breakdown of collected premiums is illustrated in the figure below.

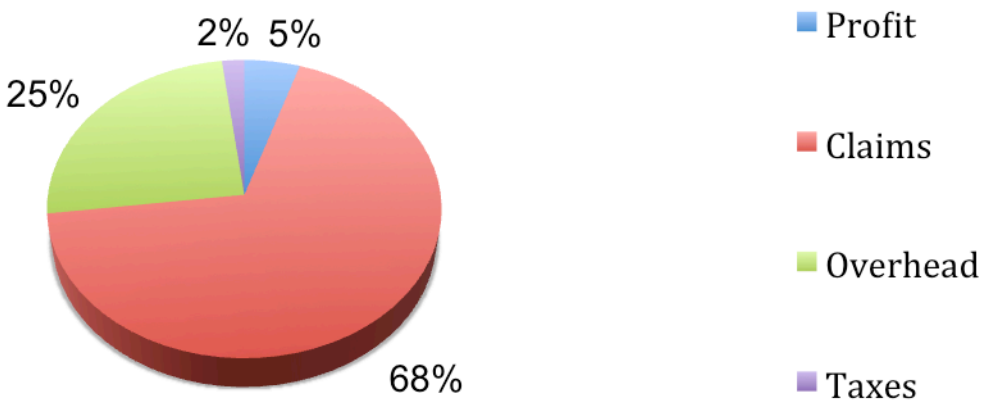

Figure 14: Breakdown of Auto Insurance Premiums[31]

Assuming these ratios hold true, a 90% reduction in accidents and the resulting 90% costs in claims could theoretically reduce the auto insurance industry to a $20B industry, leaving little room for today's larger insurance firms. This is very coarse math, but regardless of the specifics, a world full of Level 4 autonomous vehicles can only be perceived as a massive threat and disruption to the health of the existing industry.

Privacy Concerns

In March 2014, the Consumer Watchdog society voiced its concerns over SB-1298 to the CA DMV. John Simpson, the director of the Privacy Project, made the following statement in his published report[32]: "The DMV's autonomous vehicle regulations must provide that driverless cars gather only the data necessary to operate the vehicle and retain the data only as long as necessary for the vehicle's operation." He then went on to single out concerns over Google.

"Failure to act will mean substantial privacy risks from the manufacturers' driverless car technology if there are not protections from what Google is best known for: the collection and use of voluminous personal information about us and our movements." Though based on different motives, his concerns were somewhat reinforced by an earlier event in August 2013. The acting head of the NTSB at the time, Deborah Hersman, the top ranking safety official in the United Sates government, spoke directly about requiring EDRs (electronic data recorders, i.e. "black boxes") in driverless cars[33], a comment targeted squarely at Google's test vehicles. Hersman's comments were based on safety concerns and the need for analyzable data should a traffic incident occur, especially one resulting in no survivors. Google had in fact already acknowledged that their test vehicles were logging telemetry information for analysis and operational improvement. Perhaps lost in this Google focused discussion was the fact that 96% of 2013 model vehicles already had EDRs on-board due to a NHTSA proposal to create a mandatory requirement for EDRs on new cars[34].

VI. WINNERS VS. LOSERS

Winner: Semi And Fully Autonomous Car Adopters

In the short term, we expect auto manufacturers who produce premium semi-autonomous features to enjoy increased sales and brand recognition. Software makers, such as IBM, that process large volumes of sensor data and wirelessly connect cars will be a significant part of the value chain as well. Many technical, regulatory and governmental support uncertainties remain for fully autonomous cars. We expect Google to be an important player in licensing maps/traffic data and software to automakers. It is likely that, over the long term, fully autonomous cars will become reality and Google will be

a leader of the new robo-taxi ecosystem.

Winner: Component Suppliers And Sensor Manufacturers

The number of sensors and electronic devices in cars is increasing quickly, resulting in more revenue for sensor and component suppliers. As an example, both Google and IBM are working with supplier Continental to develop parts for autonomous cars.

Winner: Rental & Ride Sharing Companies

Rental, taxi and ride sharing businesses will converge with the robo-taxi model. The market size will grow substantially as more people move from car-owners to ride-sharers. The younger generation and older adults will be early adopters of the new model.

Loser: Traditional Auto Manufacturers

Auto manufactures that do not embrace autonomous driving technologies will see their brand connected to inferior cars. They will suffer from lower margins and reduced sales. The robo-taxi model will further squeeze their market size, making them irrelevant over the long term.

Loser: Taxi Services And Professional Drivers

The lower cost robo-taxi model will disrupt traditional taxi services. This will significantly reduce the need for professional drivers. The role of professional driver could be replaced with crisis control personnel, who may patrol around or remain in a service center to perform remote diagnostics and manual intervention of autonomous cars. The way passengers interact with the car will also be significantly different. Instead of relying on steering wheels and brake pedals, passengers will be able to use natural user interface such as spoken commands or gestures to control their cars.

Loser: Auto Insurance Companies

The number of accidents will drop sharply, leading to reduced insurance premiums. There will be new models for liability and collision coverage due to the driving responsibility shift from the driver to the car.

Loser: Auto Service Industry

There will be fewer accidents and potentially fewer cars with the robo-taxi model. The auto service industry will be consolidated with few survivors.

VII. SUMMARY AND PREDICTION OF OPPORTUNITY

In the previous sections, we discussed the main differences in approach taken by automakers and Google toward delivering self-driving cars to the market. We can best describe these approaches as incremental and disruptive, respectively. We have also seen the effects that autonomous vehicles will have on the market. In Section 3, we described the technologies used by automakers and Google. Next, in Section 4, we presented a study on the legal hurdles and challenges faced by automakers and more so by Google. Finally, in Section 5, we predicted the winners and losers in the overall market. In this section, we will attempt to predict the overall release trajectory for self-driving cars and estimate areas of future opportunity.

As previous sections state, automakers plan to release their self-driving technology piecemeal. At first, newer features will be released in the luxurious car segment only, slowly trickling down to mass-market vehicles. This trajectory follows their existing mode of operation in releasing features such as adaptive cruise control and lane departure warning/correction. The self-driving reality will therefore be reached gradually.

Google, on the other hand, plans to design a fully autonomous car from the get-go. There has been a lot of speculation about how exactly Google plans to release its vehicles to the market. A previous course research paper states that Google may lease its technology to or enter into a partnership with an automaker. We, however, believe that a more likely scenario is that Google will enter a taxi-service market. This approach has numerous benefits for Google. It allows Google to release its vehicles in markets where regulatory requirements are most lenient. It also allows Google to build a standalone and quirky set of cars without having to worry whether the consumers will want to buy them. Google can likely avoid going through an established car manufacturer in building these cars. Finally, it fits best with Google's model of being driven, as opposed to driving.

In terms of areas of opportunity, we will only focus on a few. Generally, manufacturers of laser/sonar/camera components will likely see a large growth in demand. Some of the components, such as lidar technology used by Google cars, are still extremely expensive; therefore, a new entrant into the market has a better chance to be profitable. On the taxi service front, we expect a number of interesting services to mushroom up, be it driving seniors to the doctors or driving kids to soccer practices. Ride sharing will become more common and instrumental in reducing congestion in urban areas. Startups focusing on any of these technologies are likely to benefit greatly. Finally, the goods transportation industry will see a phenomenal benefit from self-driving vehicles. We expect service focused on maintenance, resupplying and management to benefit greatly from the development of self-driving vehicles.

Clearly, the future is bright for self-driving vehicles. The question that remains is how fast we can expect to see a fully autonomous vehicle on our roads. Our guess is: sooner than everybody thinks!

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Technology & Banking

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I. Introduction

The banking industry has been around for millennia. Some institutions in existence now were originally chartered in the middle ages[1] and the word "bank" itself has biblical origins. Banks keep our deposits, provide us credit, facilitate payments and are an integral part of our social, economic and political systems.

Yet, banks are now facing disruption in all areas, mainly driven by innovation in information technology (IT). Peer-to-peer lenders provide efficient alternative markets for lending and saving. There is a frenzy of new competition in the payments industry, driven as IT corporations, both large and small, act to transform the industry. Neobanks offer highly accessible yet purely online services that compete directly with retail banks. In the developing world, nearly 3 billion people look to mobile telecom operators, rather than chartered banks, to manage their money. Beyond all of this, new distributed currencies like Bitcoin compete with governmentally-issued fiat money.

Traditional banks have developed their operations over decades or centuries and find it difficult to respond to these new, highly agile competitors. Chartered banks also have a regulatory burden that the new competitors are skirting; political processes have not yet stepped in to level the playing field.

In this paper, we focus on the disruption facing retail banks in particular. Many other banks, including commercial, investment and central banks, also face disruption. However, the challenges to retail banks are particularly vivid and have a broad impact. Generally, when we use the term "bank," we refer to traditional chartered retail banking institutions such as Wells Fargo and Bank of America. New competitors may eventually find it in their interest to form chartered banks, despite the regulatory burden; this is still a disruption between the new IT-oriented players and the traditional businesses.

There are tremendous opportunities in this disruption. It has already begun and the outcome will impact our lives, economies and political systems. We discuss it in several parts, including lending, payments, neobanks, money management, mobile banking and Bitcoin. We begin with lending.

II. Lending

Lending is a core bank service with a history going back several thousands of years. Banks receive deposits from investors and lend some portion of those deposits to borrowers, charging interest to the borrowers and returning interest to the investors. Credit has become easily accessible, cheap and ubiquitous. In fact, US household debt as a share of income increased to nearly 130% during the housing crisis, although it has decreased somewhat since then.

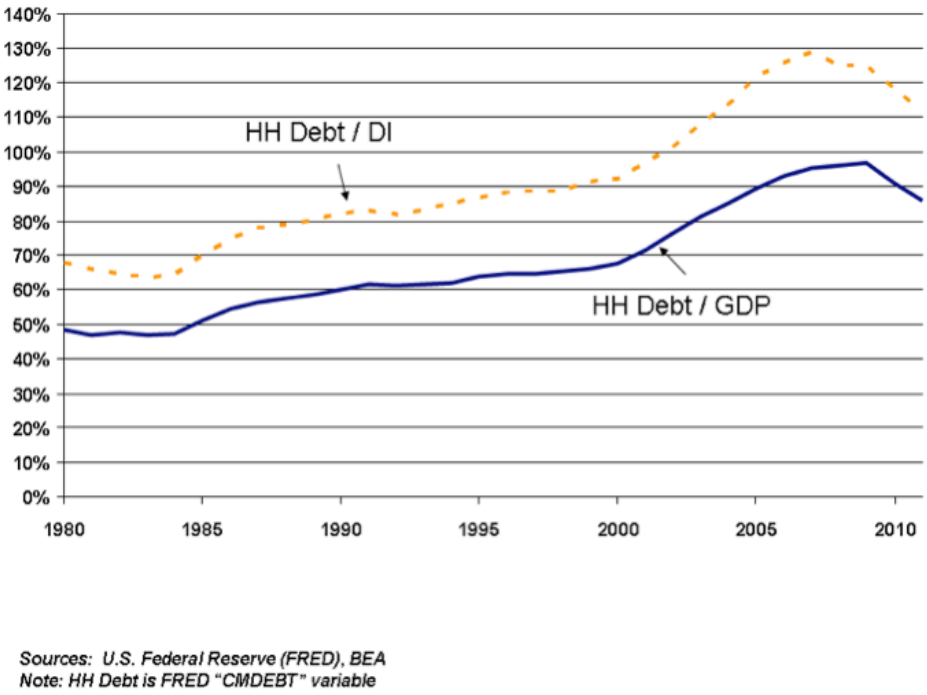

Figure 1: US Household Debt vs. Disposable Income (DI) and GDP

This is big business. In absolute numbers, total household debt in the United States is now about $12 trillion[2]. This includes about $9 trillion in mortgages and other housing-related loans. The remainder includes revolving credit accounts, auto loans, student loans and other sources. Current (Q4 2014) interest rates for borrowers range from 4% for mortgages to 16-22% for credit cards. Rates for investors are much lower at 1% or lower for CDs, money market and savings accounts[3].

Peer-to-peer (P2P) lending

Banks are facing scrutiny since the financial crisis in 2009, which was brought on by poor risk management practices. As a result, banks have taken a conservative position and it has become difficult for consumers to find loans. In addition, traditional banks operate using well established but inefficient practices that place many layers between borrowers and investors. Borrowers go through an extensive application process and then once loans are granted, they are packaged, securitized and sold to investors through a variety of investment vehicles. Each of these layers adds some overhead, consuming part of the margin between the borrower and lender.

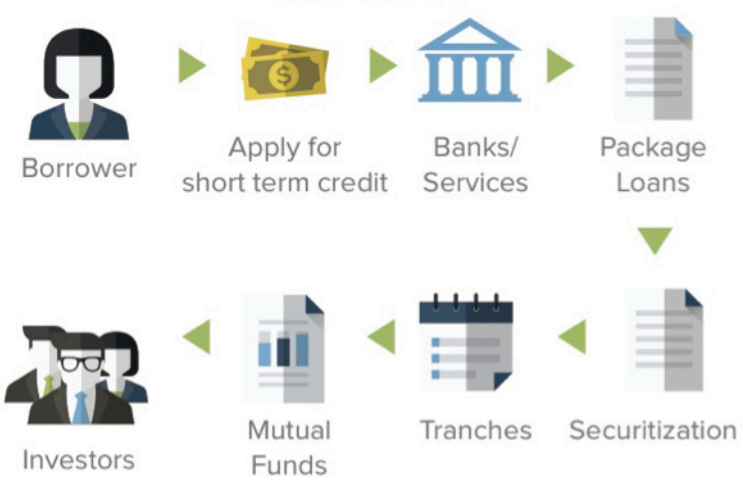

Figure 2: Retail Lending Layers (Source: Lending Club)

Peer-to-peer (P2P) lenders, also called “marketplace” lenders, compete directly with banks by offering better rates and a streamlined experience using a shared marketplace.

Figure 3: Marketplace Lending Layers (Source: Lending Club)

In this case, borrowers and investors pay fees to the market, but otherwise interact directly, eliminating much of the overhead. Zopa, a peer-to-peer lender in the UK, was operating in 2012 with a spread of 3%, in comparison with 10% for traditional banks[4]. The largest P2P lender in the US is LendingClub, with $4B in loans issued in 2014. A snapshot of rates in Q4 2014 includes the following rates, where the letters A through G are used to denote risk categories, with progressively higher expected default rates. Investors have full control over which loans they choose to fund. The minimum investment per loan is $25, allowing investors to spread their risk over a large number of loans.

Risk	A	B	C	D	E	F	G
Interest	7.32%	10.82%	13.63%	16.25%	19.20%	22.99%	24.42%
Expected default rate	1.74%	3.54%	5.04%	6.60%	8.24%	10.36%	11.41%
Return	4.80%	6.48%	7.81%	8.92%	10.21%	11.84%	12.28%

Table 1: LendingClub Risk Categories

LendingClub charges an origination fee when loans fund, but does not charge interest; borrowers pay interest directly to the investors. A large majority of the loans issued are for “debt consolidation.” Borrowers are attracted by rates that are lower than their credit cards and investors are attracted by rates that are much higher than they can achieve from banks.

Risk Assessment

Risk and P2P lenders differ substantially in how they assess and manage risk. In the case of banks, the bank assumes the risk; if the borrower defaults on a loan that the bank holds, the bank loses the money, not the depositors. For example, average credit card interest rates are currently 14% and defaults are currently around 4%, so the effective yield for credit card lending is 10%. 10% is a reasonable rate of return. However, should the economy experience a downturn that causes the default rate to rise, the banks assume the losses. In fact, the 2009 financial crisis was caused by unexpectedly high default rates (due to poor risk assessment) causing cascading losses through the industry. Since then, banks have become more conservative, perhaps excessively so, in giving access to credit.

P2P lenders generally operate on a different model where the investor assumes the risk. Investors fund

individual loans directly and, if a loan defaults, the investor's money is lost. If default rates rise, investors will suffer, but the P2P marketplace itself is not directly affected. As a consequence, investors will choose marketplaces where risk can be effectively assessed and managed. In fact, one of the attractions of P2P lending is that investors can hand-pick the loans that they fund, bringing the knowledge of the crowd to bear on risk assessment.

Traditionally, risk is assessed through the FICO credit rating system, which is based on a history of behavior, including debt load, delinquent payments and other factors. The predictive power of FICO scores is questionable; increasing reliance on credit scores has led to deterioration in loan performance even as FICO scores have increased over time[5].

As a result, P2P lenders are using new technologies to help assess risk.

- Neo Lending assesses applicants' LinkedIn networks, both for quality of the contacts and employment stability.
- Lenddo calculates its own credit score of 1 to 1,000 after looking through 100 databases and social networks for such things as an applicant's location and number of connections. In addition, Lenddo notifies the customers' Facebook friends if they haven't paid and friends' Lenddo scores could suffer if the customer fails to repay the loan[6].

Regulation

Regulation is another way in which P2P lenders and banks do not operate the same. In the US, banks are required by law to maintain 20% cash reserves. This was originally motivated to reduce the risk of bank runs, but it also dampens monetary expansion. For example, when $100 is deposited in a bank, the bank can lend only $80. If these are subsequently resulting in $80 of deposits, another $64 can be lent. This progression leads to a money multiplier of 5; that is, each $100 of deposits results in a maximum of $500 of money being created. P2P lenders do not have reserve requirements. All the money being deposited can be lent, leading to a possibly unbounded creation of money and possibly catastrophic consequences as the result of defaults.

At present, P2P lenders make up a small (but quickly increasing) part of the lending industry, so the economic risk is small. In addition, P2P lenders are targeting only unsecured loans, not mortgages. Should the industry grow to include mortgages, however, regulation would unavoidably be applied. This regulation would be driven by both national monetary policy and banks, which would want to level the playing field. This is not to say that P2P lending is not a threat to traditional banks. Should a bank charter become a requirement, it is well within the power of the marketplace to partner with a banking institution or for the marketplace to form a bank of its own.

Threats and Opportunities

Banks are threatened by new lenders in several ways. First, highly efficient online marketplaces for unsecured loans offer far better rates to both borrowers and investors. Second, more effective risk assessment and management practices increase the quality of a lending portfolio. Third, non-bank lenders are not subject to the full set of banking regulations. Finally, banks are risk-averse and limit access to credit, which urges consumers to turn to other markets. These pose significant threats in the area of unsecured loans. Figure 4 demonstrates the growth rate for LendingClub loans. However, P2P lenders are not currently targeting mortgages, which form the majority of lending (about 75% of total debt is housing related).

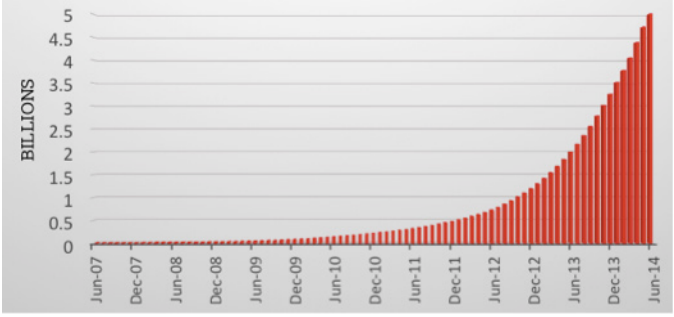

Figure 4: Total Issued Loans in USD for LendingClub since 2007 (Source: Lending Club)

III. Payments

Payments are an important part of the banking system revenue. In 2012, account-related and transaction-banking revenue comprised one-quarter of global banking revenue. In 2012 Banks handled $337 trillion in non-cash transactions, which is estimated to grow to $712 trillion, generating $1.1 trillion in revenue by 2022. Payment revenues are generated by transaction cost associated with every non-cash transaction. In order to understand the payment disruptions it is important to understand the business models for various types of payments. Credit cards are the most apparent form of non-cash transactions. We will explore the VISA business model to show the transaction cost breakup, the players and steps involved in completing the transaction.

Credit Card (VISA) Payment Model

VISA is a Technology company providing global payment solutions to the banks. Its payment product platforms are used by the banks to develop credit and debit card programs for their customers. VISA does not issue credit cards nor does it extend credit to the consumers. Instead, it operates an "open-loop payments network" to manage the exchange of information between different financial institutions.

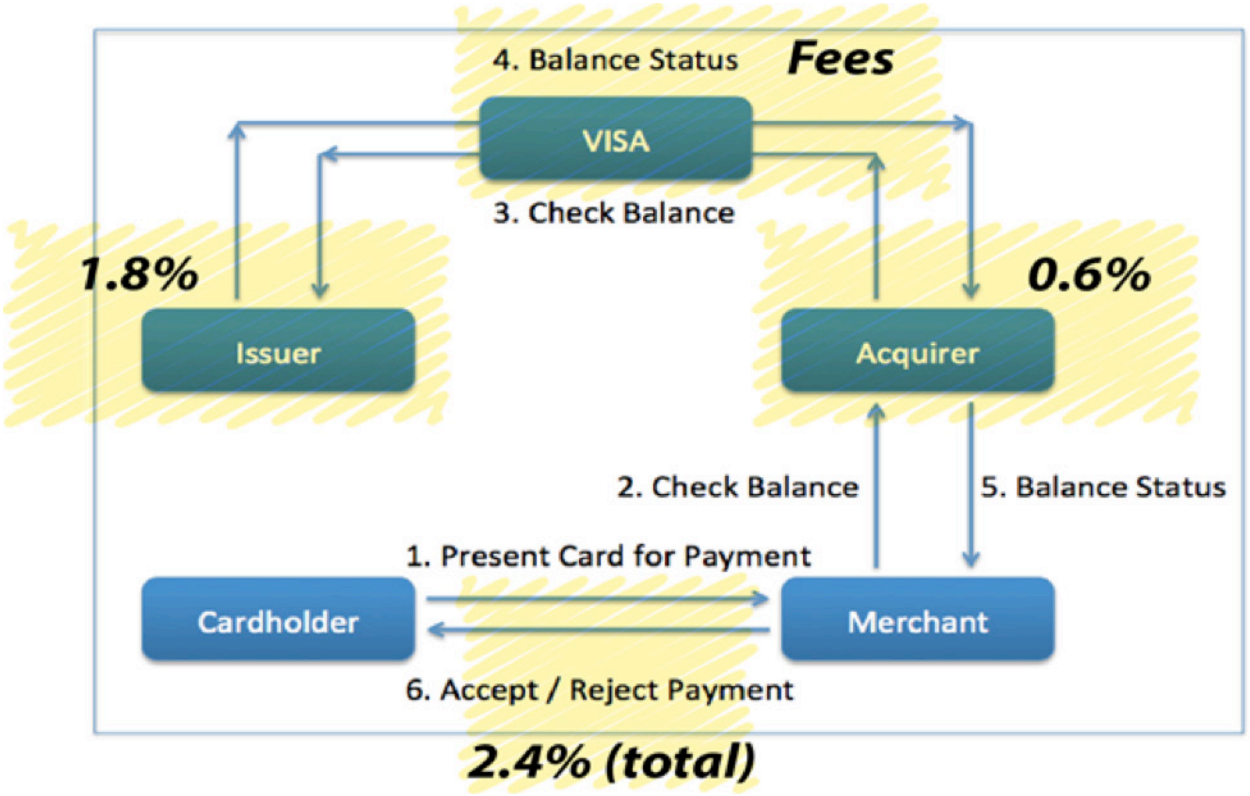

Figure 5: VISA Open-Loop Payments Network (Source: BMI Matters)

The diagram in Figure 5 explains what happens when a cardholder presents a card for payment to a merchant. The payment request is forwarded to the acquirer (the merchant's bank). The acquirer contacts the issuer (the client's bank) through the VISA network. The issuer shares the information on whether sufficient balance is available to carry out the transaction. The information is then routed to the merchant. If sufficient balance is available, the payment is accepted. Otherwise, it is rejected. The issuer bills the cardholder on a monthly basis. The cardholder pays those bills then.

The diagram also tells us how VISA and banks make money in the process. They make money from the transaction fees charged to merchants. A typical merchant fee is 2.4%, which would get unevenly split between the issuer at 1.8% and the acquirer at 0.6%. The issuer gets to keep more of the merchant fee because of a higher risk of payment default from the cardholder. VISA makes money on payment volumes, transaction processing and value-added service.

Threat: New Payment Enablers

New payment providers are emerging to enable customers to make easy to use, fast and secure anywhere-to-anyone payments. These IT competitors threaten to take an increasing part of the issuer/acquirer fees and negotiate to come up with different business models. This results in lower costs and decreased fees for the banks.

A more revolutionary threat is from IT companies such as Amazon or Apple becoming retail banks and replacing issuer/acquirer banks completely. The diagram in Figure 6 shows new players like Apple Pay, Google Wallet and Paypal Beacon emerging in this space.

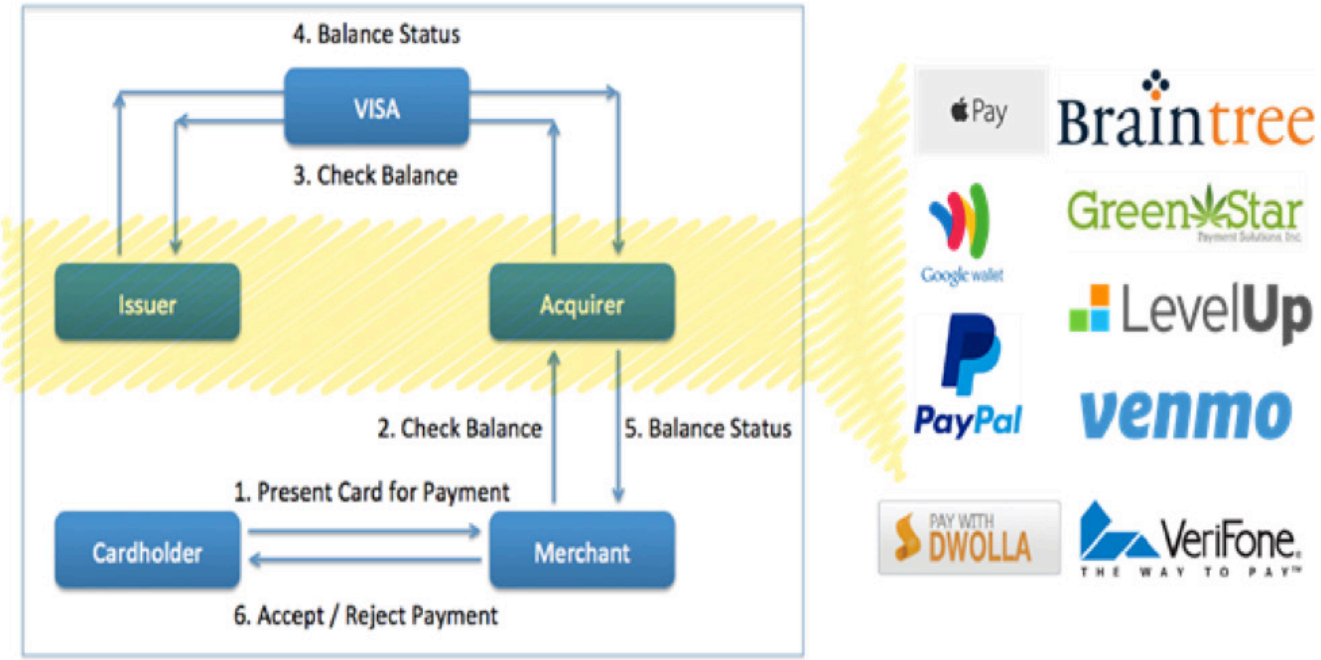

Figure 6: New Players Emerging in the Issuer/Acquirer Bank Space (Source: BMI Matters)

Threat: Payment Model is Replaced

Credit card payment network infrastructure powers everything from bank transfers to cutting-edge payment companies like Square. As shown in the diagram below, there are many steps and hefty interchange fees are levied in the traditional payment networks.

Startups such as Dwolla may radically alter the fabric of digital payments by building their own alternative to the credit card networks. Creating their own network from scratch helps avoid the hefty interchange fees levied by the credit card companies and can also offer instantaneous transfers.

The diagram in Figure 7 shows how the Dwolla network helps bring direct customer-to-merchant payments by bypassing conventional networks with multiple layers and bringing fundamentally lower transaction cost structure, such as “No Charge” for less than $10 transactions and $0.25/transaction otherwise.

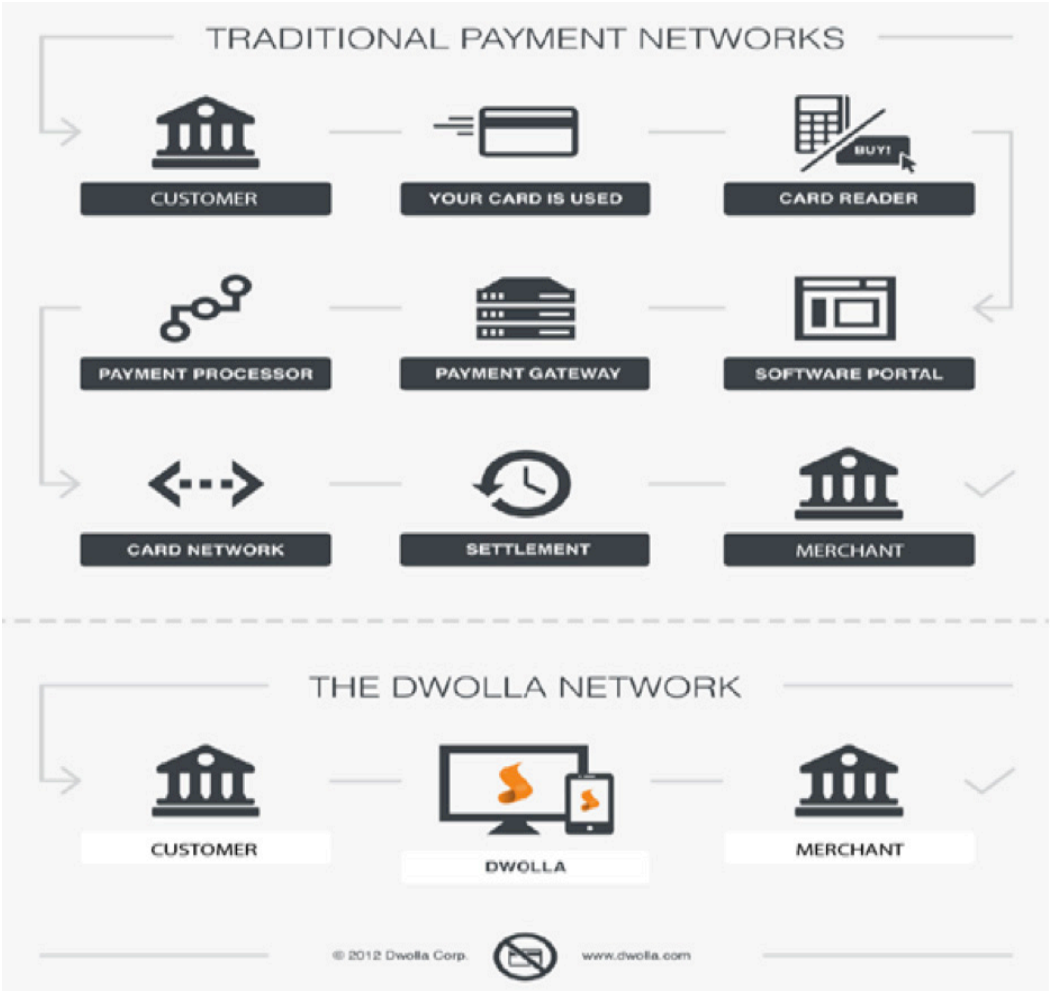

Figure 7: Traditional Payment Networks vs. the Dwolla Network (Source: Dwolla)

IV. Customer Engagement

Customer engagement is critical to the growth and survivability of the banking business model. It includes:

- Acquisition of customer
- Sales of product and services
- Relationship management including conflict resolutions
- Brand and loyalty management

Traditionally, banks have used their branch networks for strong and profitable customer engagement. Banks leveraged the mainframe-to-client server technology-driven transformation to strengthen the engagement model, driving improved convenience for the customers while improving their top and bottom lines. Branch networks remained central to that transformation.

The early days of Internet-led transformation augmented this trend. It never really disrupted the engagement model and core value propositions of the customer engagement model. Investment in branch networks (e.g. $50B/yr to operate branch networks by 25 top banks in US) continued to provide attractive ROI. However, as shown in Figure 8, more recent mobile broadband-based Internet, along with chang-

ing demographics from baby boomers and millennials and their behaviors, are disrupting the customer engagement model.

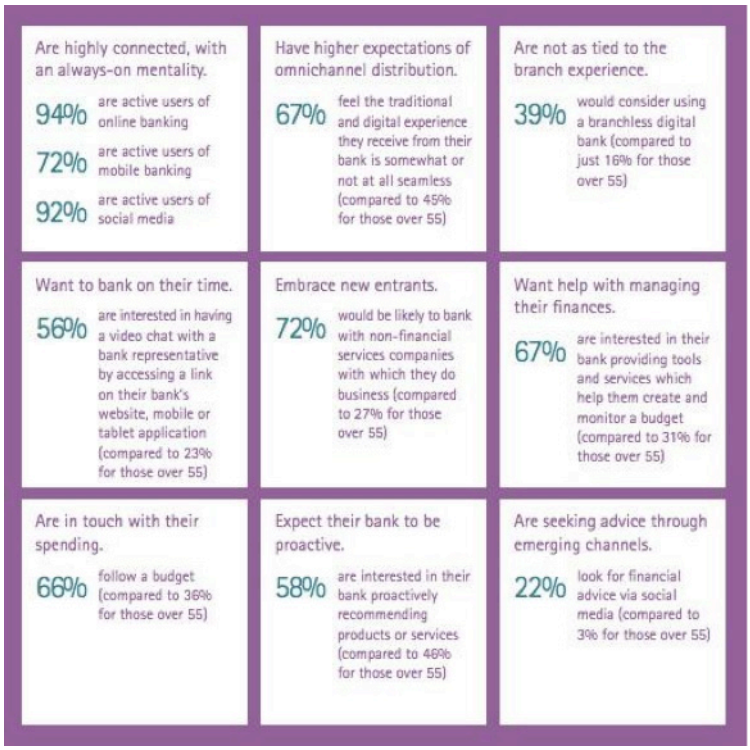

Figure 8: Millennals and Money

Customers are expecting financial services to be available at any place, at any time and in any way they want it. They are also expecting banks to be proactive in anticipating their needs and providing them personalized services. The engagement model is transforming from “how do I find/acquire and most profitably serve my customers” to “how do customers find me and use my services in real-time where, when and how they want them?”

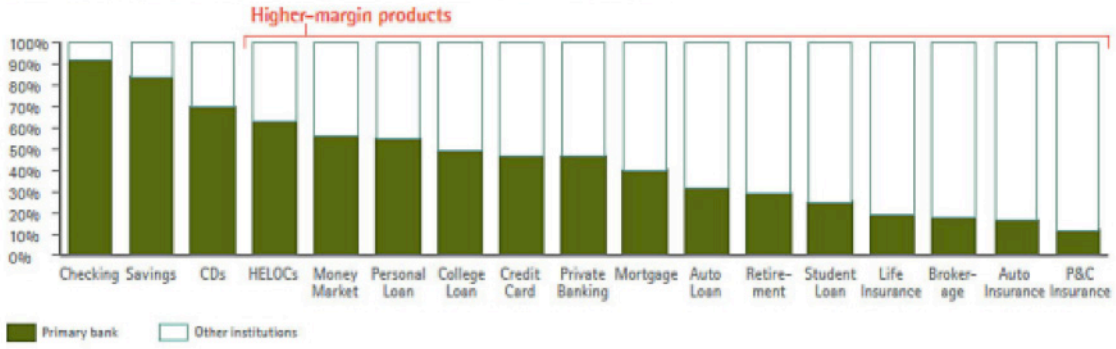

Figure 9: Who Did You Buy Financial Services Products From in the Last Year? (Source: Accenture Retail Banking Survey)

As shown in Figure 9, customers continue to use branch bank networks for basic banking services such as checking, savings, CDs and high touch issue resolutions. Branches continue to help build brand and trust. However, many other providers started to offer high-margin products on the Internet decoupled from the banks and its branch networks. Customers’ comfort with Internet and changing behaviors has started to disrupt sales of the higher-margin products impacting banks’ top and bottom line.

Many disruptors are emerging in all aspects of financial transactions in customers’ lives, offering digital channel alternatives in developed and emerging markets. They are disrupting the branch network-based

bundled customer engagement model with the online digital channel-based unbundled engagement model. This is disintermediating banks from their customers, revenue growth and profits. To counteract this, banks will need to rethink their customer engagement model and innovate and transform themselves at a higher velocity than what they have been used to in the prior technology-driven transitions.

V. Customer Money Management: Mobile Money

Mobile money refers to an emerging alternative banking service offered by mobile operators. It can be viewed as a natural extension of their billing system already in place. Without delving into technical details, it is easy to understand the key aspects of mobile money. Firstly, account-billing services are generalized to handle banking transactions such as payments and deposits. Secondly, the communication infrastructure is already in place to transport those transactions, including security features, such as encryption and authentication. Finally, worldwide network interoperability enables international transactions, such as remittances. With some over-simplification, if you have a mobile account, you have a mobile money account; you just don't know it yet.

Mobile money takes on a special importance in emerging markets, due to a confluence of factors[7]. First, government infrastructure, from transportation to police, is barely functional, especially in remote (rural, rugged) areas. Second, banks have low penetration, focusing on the rich and urban. Most people are "unbanked," operate in a cash economy and have practically no interaction with banks. Again, this issue becomes more acute in remote areas. Finally, mobile operators have very high penetration and coverage well into remote areas. They are often the only reliable infrastructure around. There is already mutual financial trust between operators and customers due to mobile billing transactions, which extends easily to mobile money.

The numbers are staggering: in emerging markets, there are four times more mobile accounts than bank accounts. Some 2.5 billion adults are unbanked and 1.7 billion of these have mobile accounts. Figure 10 illustrates the geographical disparity in banking penetration worldwide.

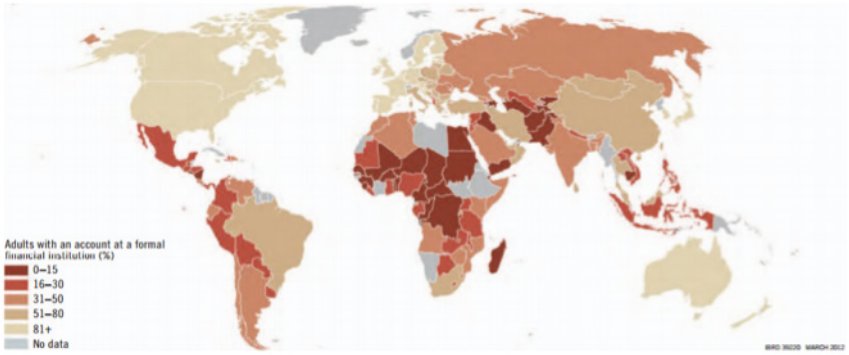

Figure 10: Global distribution of Unbanked[8]

The unbanked issue is not just one of convenience. Operating in a cash economy under an absentee government has many pitfalls: people are discouraged from saving and investing in their future, which affects their resilience to financial setbacks. They are also in plain danger, as they become easy prey to extortion and theft.

The Gates Foundation has identified access to financial services as critical to lifting people out of poverty. This includes them in the financial system and empowers them to weather crises and grasp opportunities[9]. In particular, it highlights digital payment platforms as the tools to deliver financial services to the poor—profitably and at scale. Mobile money clearly fits this description.

Opportunity and Threat

There is a big opportunity for mobile money to address the unbanked segment in emerging markets. In the short term, the mobile industry is cooperating with banks by reaching into an underserved population and easing its access to banking services. In Peru for example, Ericsson is working with the banking association to deploy mobile money services[10]. This cooperation provides an opportunity for banking to increase its penetration in the short term. Thus, the two systems could coexist and thrive in parallel. In the longer term, however, mobile money easily becomes a threat, by quickly filling the unbanked vacuum and choking off the growth prospects of banks.

In contrast, developed markets do not have a large unbanked segment and one would be tempted to discount the threat of mobile money. But we should consider another scenario, where mobile money gets deployed in emerging markets and has a few years to evolve into a highly efficient attractive service with huge scale. Then it comes into developed markets and competes head on with banks. Keep in mind that mobile networks are essentially the same throughout the world. So introducing mobile money would be "just a software upgrade."

VI. Customer Money Management: NeoBanks

Neo-banks are an extension of the prepaid card business. They provide synthetic bank-like services with internet-only operations, skipping branches completely[11]. A key aspect is the absence of credit, which removes risk, keeps regulation at bay and simplifies operations, enabling scaling.

The prepaid card business is very attractive; in the simplest form, the customer pays first and the balance is kept on the card itself, requiring very basic back-end support by the issuer. Financially, it is a great deal for the issuer. In addition to paying various fees, the customer provides an interest-free loan and often forgives some or all of the principal as cards get lost. It is no wonder that the prepaid segment is growing quickly, quadrupling between 2007 and 2014. Also, by 2017, the US government will issue $120 billion in benefits with pre-paid cards.

Neo-banks are an interesting study in contrast. On the customer side, they synthesize the look and feel of a traditional bank account, with checking and savings, bankcards and physical checks. They aim to have a low and clear fee structure, so customers know what they are getting. All transactions are immediately accounted for and there is no credit or overdraft protection. Neo-banks claim to empower their customers in that way, by allowing them to track their finances exactly. Although neo-banks do not have branches, they emphasize customer support, online or by phone.

On the operations side, neo-banks appear to be very different from banks. Clearly the absence of branches removes a whole layer of cost and complexity. Expanding from simple prepaid cards to bank accounts does require a sophisticated infrastructure, but we can guess that it is no worse than that of a traditional bank for the same function. Most importantly, the absence of credit removes risk and we speculate that this has two crucial impacts. First, neo-banks can maintain low cost. By keeping regulators at bay, they avoid the requirements banks must satisfy, which include keeping cash reserves to maintaining bureaucratic overhead. Second, neo-banks can scale. By skirting complicated risk management, which is likely to involve significant human oversight, they can grow quickly by expanding their infrastructure capacity.

Indeed, today neo-banks are not legally considered to be banks. Of the four current neo-banks in the US—Moven, Simple, BlueBird and GoBank—only the latter has a bank charter. Moven and Simple are partners with banks and BlueBird is backed by American Express. The combination of low cost operation and traditional bank-like customer experience seems to be working. Overall, neo-banks are already

a reality, with a 9% market share of banking in the US.

Threat to Banking

The emergence of neo-banks is happening at a time when banks are struggling with their branch deployments. Focusing on the US, the density of branches is excessive in comparison to similar economies and their number is on a slow decline. Also, many branches are being reduced in size as services are moved to the Internet. Figure 11 below highlights the declining role of branches over time, with only 15% of transactions taking place at a branch in 2013. In this light, the lack of branches is not much of a handicap to neo-banks in terms of customer interaction; however, the cost savings are significant. With their efficient operations and familiar bank-like services, neo-banks appear to be a deadly threat to banks. We speculate that the wild card will be regulation; neo-banks will try to avoid it by steering clear of credit, while banks should push government for consistent regulation and an even playing field.

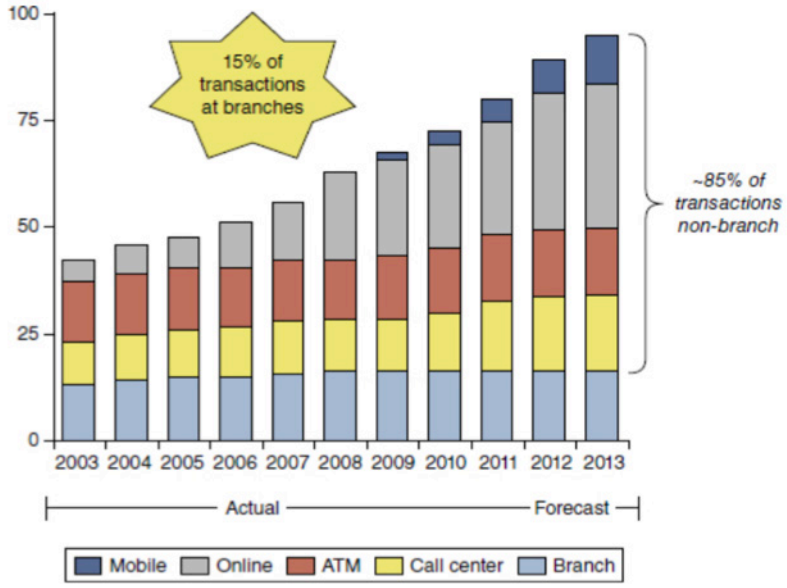

Figure 11: The Time Progression of Bank Transactions

VII. Future Trends: Bitcoin

Bitcoin is a form of digital currency and its main advantage is to eliminate the third-party intermediary and thus significantly lower the cost of the e-commerce transactions, especially across international borders. However, Bitcoin faces many challenges to serve as a stable payment platform for the mainstream use.

What is Bitcoin?

Like the U.S. dollar, the Bitcoin is a fiat currency in that it is not redeemable for some amount of another commodity, such as an ounce of gold. Unlike the dollar, a Bitcoin is not legal tender. It is not backed by any government or legal entity, nor is its supply determined by a central bank. The Bitcoin system is private, with no traditional financial institutions involved in transactions. Unlike earlier digital currencies that had some central controlling person or entity, the Bitcoin network is completely decentralized, with all parts of transactions performed by the users of the system.

Bitcoin is sometimes referred to as a crypto currency because it relies on the principles of cryptography (communication that is secure from the view of third parties) to validate transactions and govern the

production of the currency itself. Each Bitcoin and each user is encrypted with a unique identity and each transaction is recorded on a decentralized public ledger (also called a block chain) that is visible to all computers on the network, but does not reveal any personal information about the involved parties. The public ledger verifies that the buyer has the amount of Bitcoin being spent and has transferred that amount to the account of the seller. The public ledger is a unique attribute of Bitcoin and other crypto currencies because it solves the so called double spending problem (i.e. spending money you do not own by use of forgery or counterfeiting) and the need for a trusted third party (such as a bank or credit card company) to verify the integrity of electronic transactions between a buyer and a seller. Figure 12 below shows a detailed transaction flow for Bitcoin[12].

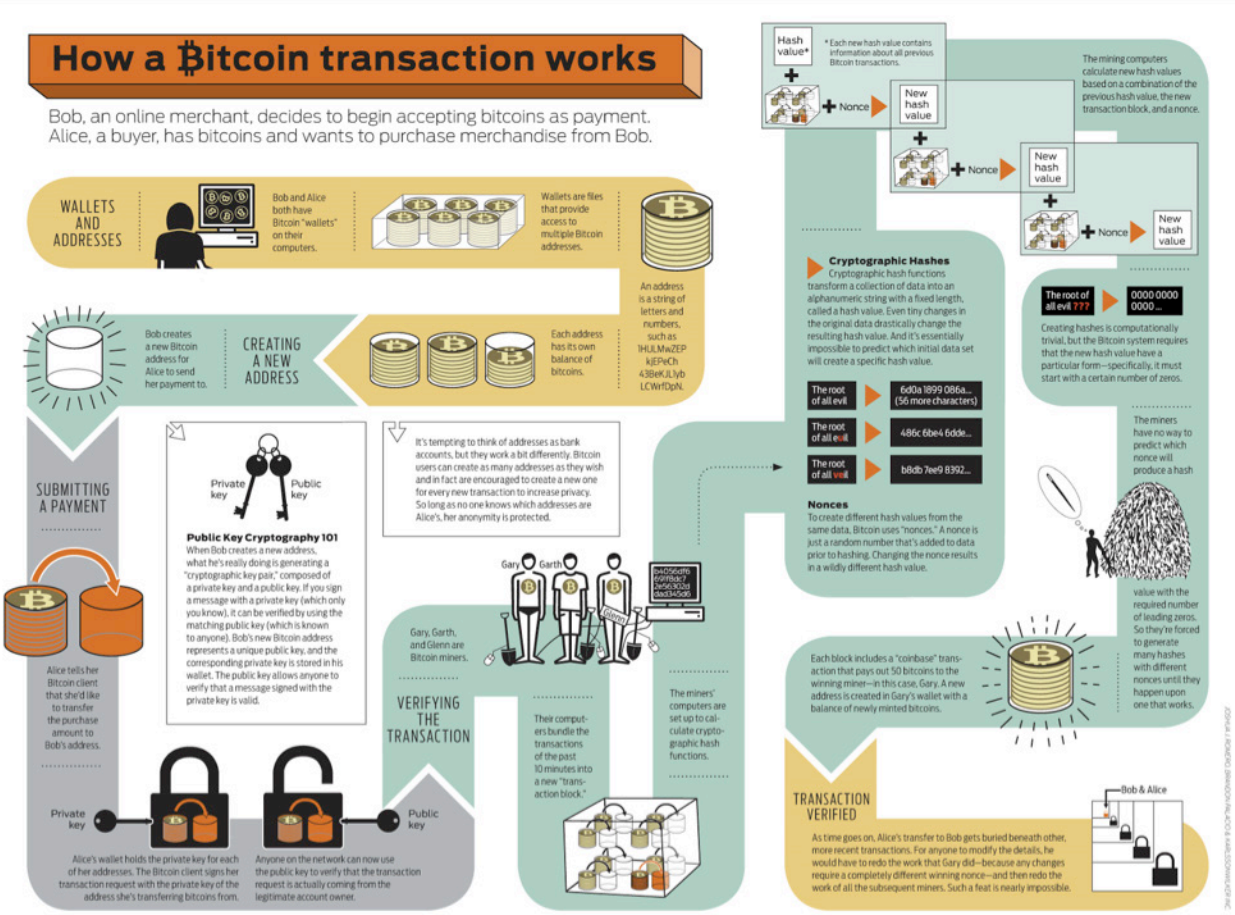

Figure 12: How a Bitcoin Transaction Works (Source: Bitcoin)

Benefits of Using Bitcoin

Cheaper and Broader Payment System

At the moment, many Bitcoin transactions are typically processed in a way where no fee is expected at all. However, for transactions that draw coins from many Bitcoin addresses and therefore have a large data size, a small transaction fee is usually expected. This is very significant to electronic vendors whose total margin is below 5%, where a normal credit card transaction costs somewhere between 2% and 3%. In addition, transactions across the border are very difficult. Amazon does not sell merchandise to other countries, mainly because credit card transactions rely on the underlying banking systems and each country has its own laws and regulations governing their banks. By using Bitcoin, a merchant can reach customers in other countries and significantly increase its market reach.

Increased Privacy

Bitcoin is often referred to as pseudo-anonymous. Bitcoin transactions are largely not traceable. You

do not have to be afraid of any organization being able to trace the source of your funds. This is a clear benefit in many areas of the world because governments that are supposed to guard against fraud are actually defrauding people by taking their savings partially or fully.

Enable Smaller Content Publishing via Micro Payment

Bitcoin can be split into smaller payments without additional cost. This will make a big impact to the content industry. For example, a magazine can be broken into individual stories and each individual article can be sold online.

No Erosion of Purchasing Power Due to Inflation

One of the biggest problems with our current dollars and other currencies used around the world is inflation. Over time all currencies lose purchasing power at a rate of few percent per year, mainly because governments keep printing more money. This process is basically a small tax on your accumulated wealth. With Bitcoin, this problem does not exist because the system is designed to make Bitcoins finite. Only about 21 million Bitcoins will ever be released (mined). The release of new Bitcoins is slowing down and it will stop completely within a few decades. We have a slowing population growth, which is projected to stop at around 10 billion by approximately 2050, which roughly coincides with the last Bitcoin to be mined. There will be roughly 1 Bitcoin for every 500 people.

Challenges Associated With Bitcoin

Cannot Revert or Track a Transaction.

This is not completely true. Using public ledger and sophisticated computer analysis, transactions involving large quantities of Bitcoin can be tracked. Paired with current law enforcement tools, it would be possible to gain a lot of information on the persons moving the Bitcoins. But because of this perception, Bitcoin is often associated with illegitimate activities, such as money laundering across the borders. Some governments such as Russia's ban its use.

Could Affect the Fed's Conduct of Monetary Policy

Bitcoin could have an impact on the conduct of monetary policy to the extent that it would (1) substantially affect the quantity of money or (2) influence the velocity (rate of circulation) of money through the economy by reducing the demand for dollars. This possible outcome highlights the likely importance of the economy's principal currency being elastic—its supply increases and decreases to meet the changing needs of the economy—and of the important role of the central bank in implementing such a monetary policy.

Slow Speed

A Bitcoin transaction can take between ten minutes to one hour. This could be an issue with many of the internet transactions.

Easy to Lose

If your credit card is stolen or somebody hacks into your bank account there is a good chance you will not lose any money, as banks will fix your balance. Even cash can be potentially recovered if the police act fast. But lost Bitcoins are los for good. There is no mechanism to recover stolen or lost Bitcoins. If somebody hacks into the wallet where the Bitcoins are stored, they are irretrievable. The best way to store your Bitcoins is on a disk that is disconnected from the Internet.

Too Speculative

Currently, Bitcoin prices fluctuate significantly. It is likely that the price will stabilize at around US $10 from the current US $400. Currently, the price is going up so quickly a web shop would have to adjust their prices almost daily if they wanted to accept Bitcoin. It is not very convenient.

In conclusion, Bitcoin or any digital currency has a huge potential to disrupt the banks as it completely bypasses the banking system and reduces the cost of sending money to almost zero. Therefore, Bitcoin takes the payment infrastructure of banks and turns it on its head. However, it still requires a few more years to grow into a mature payment system.

VIII. Future Trends: Explosion in Company Valuation

So far, we have identified threats from several industries to banking. Most of these threats constitute a "clear and present danger," with Bitcoin perhaps being more of a future threat. Here we look further towards the future and argue that there are clear signs of a trend towards increasing disruption to banking.

We conjecture that venture capital investment is a good predictor of future success, in the sense that VCs will bet on a winning trend. One can argue that much of Silicon Valley is proof of VC prescience. Having adopted this conjecture, we look at companies in the transaction segment and see an explosion in valuation.

There are many companies in varying stages of maturity in the transaction segment. We focus on three related companies to illustrate our point. First we establish the basic facts: Venmo was founded in 2007, raised $1.3 million in funding and was acquired for $26 million in 2012[13]. Braintree was founded in 2007, raised $69 million in funding and was acquired by for $800 million in 2013[14]. Paypal, probably the most prominent name in payment, was founded in 1998, raised $197 million in funding and was acquired for $1.5 billion in 2002[15].

The common thread among the companies is that Paypal acquired Braintree, which had acquired Venmo. The big news recently is that Paypal will be spun off as a separate company from Ebay in 2015. As a standalone company, Paypal's value is estimated as high as $47 billion, compared to the current market capitalization of $65 billion for Ebay[16]. We illustrate the explosion in valuation for the three companies in Figure 13 below, where the y-axis is on a log-scale to cover the huge value range.

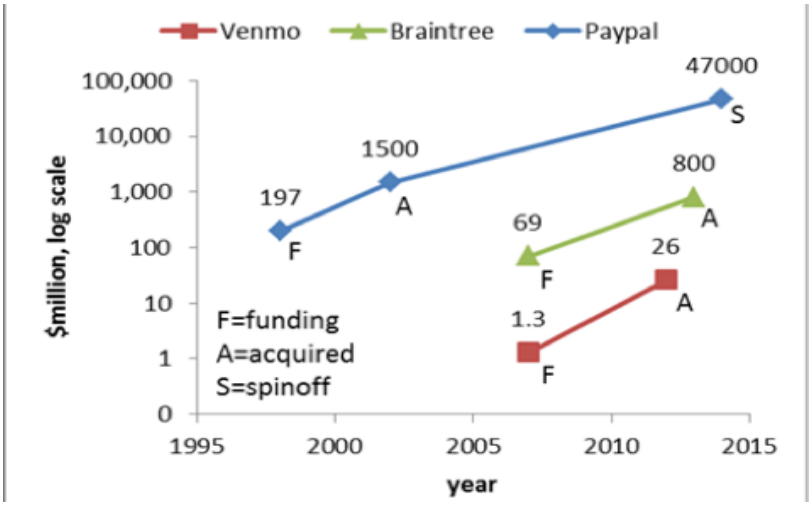

Figure 13: Valuation Explosion of Venmo, Braintree and Paypal

A new wave of funding is starting up. Stripe, founded in 2010, has developed a payment platform with links to Twitter and Facebook. Recently, VC firm General Catalyst has raised a $10 million fund specifically for seed stage startups that build applications on the Stripe platform[17]. The first company to be funded is Baremetrics, with $0.5 million in September 2014. Even in the fast paced startup world, it is puzzling that a four year old company is considered to be a stable platform for future innovation!

Threat to Banking

The high valuation of the companies in the transaction area is justified by their growth potential, rather than their current profitability. These companies can leverage this high valuation as a "license to print money" (pun intended). This money can be used to launch innovative services and applications without having to worry about immediate profitability. Such an approach would be too toxic to the banking culture for banks to even try. This creates a self-fulfilling prophecy with these companies diverting the growth from new services away from banks and further justifying their valuation.

IX. Conclusion

In short, banks have the money and other industries want it. Our study identified a number of key external threats from various industries, each leveraging its core strengths to carve out some of banking territory. For instance, new lenders exploit social networks to assess credit worthiness and crowdfunding to raise money. Neo-banks rely on internet infrastructure to provide a familiar bank-like customer experience. Mobile money uses the reach and the billing systems of mobile networks to serve the huge unbanked segment. Bitcoin relies on Internet security technology to bypass normal currency altogether and handle transactions in an alternative currency. Next we will summarize our findings about various external threats to banks, then briefly discuss how banks may react to those threats.

Threat Summary

- Lending
- Neo-lenders will significantly erode, but not replace, bank lending
- Mortgages are not (currently) under threat
- Disintermediated Customer Engagement
- Neo-banks take market shares from banks with reduced costs and good enough services
- Customer engagement is unbundled; customer open to financial services from many channels when, how and where she wants it; significantly impacting revenue and margins sustainability and growth
- Customer Money Management
- Mobile money already took off, especially in emerging markets
- Payments
- Nimble, secure money transfer networks to enable instant transfers
- Technology innovators own the digital experience/interface for payments
- Currency
- Digital currency (Bitcoin) further removes friction in the payment system, especially in the international transactions
- New Company Valuation
- High valued new companies, unencumbered by current profitability, divert growth away from banks.

Note that taken together, many of these threats also result in customers becoming further and further removed from banks. Eventually, the customer relationship is not the bank's anymore, making it very difficult to for banks to cultivate and exploit it.

Banking Response

Finally, we take a brief look at how banks can respond to external threats. First, they can ignore the threats and lose revenue streams. The banking sector has endured many crises, including devastating damage during the last recession, yet it comes back more or less the same. It may view the external threats as passing fads that will fizzle out, or find them so different from its business model that they cannot be emulated anyway. For instance, crowd-funded lending may be too foreign to banking to be

considered for inclusion. Second, they can adapt to the threats and find new growth opportunities. Banks are eminently placed to recognize which threats are worth co-opting and how to go about incorporating them into the business. If banks see an attractive revenue stream, they may be willing to make painful structural and cultural changes to take it over. For instance, mobile money may be a growth opportunity for banks by reaching out to the unbanked segment. Finally, banks can fight back against the threats and keep the status quo. Banks understand regulation and they have the political clout and government lobbying capability to use regulation to blunt the threats. Many of the banking alternatives are too new and regulators have not caught up yet. For example, neo-banks are not chartered as banks and are being subjected to very little oversight thus far. But banks can demand an even playing field; should they succeed, it would put a bureaucratic burden on neo-banks and reduce their cost advantage.

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Intersections of Applied Innovation and "Global Inclusive Scalable Ventures" for Inclusive Economic Development

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This paper establishes the linkages and methodology of a unique process towards inclusive economic development by appropriately intersecting the available applied innovation and its concomitant culmination into a "Global Inclusive Scalable Venture" facilitated by an academic network. The resulting ventures lead to necessary scalability through creation of capacity and capability of the local community enabled enterprises, which can eventually solve complex problems of providing healthcare, energy, education, sanitation and environmentally sustainable lifestyles by initiating and utilizing applied innovation. Global collaboration through networking of businesses and government, catalyzed within a knowledge-sharing framework in an inspired university system that transgresses its usual role as a giver of education to an enabler of knowledge systems to provide an inclusive society as an outcome of economic development. This paper will elaborate on the structural and functional linkages of such an ecosystem created around university systems like that of IIT systems in India, with three base elements: Entrepreneurial Ecosystem, Academic Platform and Global Applied Innovation. It discusses the outcome of such unique experimentation in developmental entrepreneurship through ecosystem creation that addresses balanced economic development lead by investments and consumption, while providing deserved human rights to its citizens possessing respectable human development index in a sustainable mechanism.

I. Introduction and Background

The dynamic socio-economic scenario facing the nations post 2008 financial crisis, necessitates the need of novel tools and methods for empowering new age economic development. Developmental economists primarily espouse two theories of regional development, one led by Amartya Sen[1] (Harvard University) stressing on the need to invest more in social infrastructure to boost the productivity of its people and thereby raise growth, while Jagdish Bhagwati[2] (Columbia University) argues that only a focus on growth can yield enough resources for investing in social sector schemes. Considerable research has been conducted linking poverty alleviation to improvement of accessibility to healthcare, education, food, sanitation, housing, water, internet and sustainable lifestyle. It has also been linked to human rights and has formed the basis of an inclusive society[3]. Evidences and researches have already established the fact that entrepreneurship is the only realistic solution to empower people for fast forwarding economic development in either of the two scenarios, but are constrained by traditional market driven solutions that had faltered in pre 2008 conditions. Creation of new enterprises that are globally born and scalable while based in inclusivity and sustainability, inherently empowering people with the ability to solve problems through applied innovation, creating every day solutions that are beyond conventional deliverables of faster, better and cheaper, is the unifying developmental entrepreneurship methodology between the two developmental economic approaches.

However, it requires a paradigm shift of economic development driven by utilization of applied innovation for creation of new type of enterprises, GISV to create holistic economic development that meets maximum requirements of inclusive economic development. It is “Global” as a result of its genesis of problem solutions and sustainability through global collaboration to pull in the best of technology and practices. It is ‘Inclusive” as its desired business output is to mitigate the local problems of the local community to attain a respectable levels of human rights and dignified living as its for-profit motives, yet technology and business enabled for sustainable solutions. It is “Scalable” because otherwise such solutions will not be implementable and available for the entire local community, with technology innovation driven business models creating paradigm shifts in socio-economic outputs as developmental entrepreneurship with global collaborations. The basic tenets of increasing economic efficiency and optimal allocation of resources are better served through the creation and assimilation of GISV. Such new GISV enterprises will increase a nation’s both capacities and capabilities towards development and sustainability with transformational implications for the society powered by uniquely positioned applied innovations.

The platform creation is pivoted around structural and functional linkages of such an ecosystem created around university systems like that of Indian Institute of Technology (IIT) systems in India, with three base elements i.e. entrepreneurial ecosystem, Academic Platform and Global Applied Innovation. A cohesive and comprehensive knowledge driven resource creation platform has developed on these three pillars. This resource creation platform with the capacity and capability to support GISV enterprises in various domains for market ready solutions for the basic societal needs i.e., drinking water, Low cost housing, affordable and accessible healthcare, inclusive education system, easily available energy, accessible sanitation and water resources etc. will be discussed. Various companies and educational institutes are directly or indirectly part of this resource creation platform in the IIT system, without which inequality will widen and the growth process itself will falter. Growth may raise inequality initially but sustained growth through unique GISVs will eventually raise enough resources for the state to redistribute and mitigate the effects of the initial inequality. In this experimental doctrine of applied innovation, sprouts the creation of global ventures by local people for solving unique local problems one at a time. This realistic and effective equalizer can be both cost effective and economically bringing together the two apparent conflicting methodologies of economic development through the powerful disruptive forces of applied innovation out of university systems cradled in the hot bed of GISV driven entrepreneurship.

The entrepreneurs with the vision of changing the society have been introducing GISV so as to cater the solutions for the basic social needs. It is the only cost effective way to solve the existing social problems by providing innovative solutions and add values to the welfare of the community. Powerful academic networks by business and technology practitioners through global collaborations with the primary focus of creation of GISV unique enterprises in this study is geared towards providing solutions for all, which is irrespective of socio-economic status of the people. Inclusiveness is the most important factor for the ventures through which they can provide available, accessible, affordable and quality solutions for the basic needs of the maximum number of people in the community. Needless to say that scalability of the proposed ventures has been found to be an important aspect for future sustainability. Identification of innovative ideas to provide low-cost solutions while maintaining the service quality has raised the question of sustainability of the ventures. This entire process of providing solution for local community problems through inclusive scalable ventures is associated with high risk of failure, but its unique mitigation by scalable inclusiveness has become an important subject of study among the entrepreneurship communities.

II. The Framework Creation and Utilization

The appropriate economic growth model relevant to the socio economic conditions is a non-trivial situation and both Sen and Bhagwati as well their associates have well debated on this. Since independence and sovereignty of most emerging nations[4] around end of Second World War, there has been intense soul searching on the best practises necessary to uplift the standard of living in the developing nations through creation of either free enterprises or state enterprises. Our search for a framework for GISV are based on the scintillating debate of appropriate economic growth models[5,6,7] for an emerging economy like India, is equally applicable to low growth western economies. It is needless to mention that the emerging and developing economies needs to provide millions of jobs to its growing and aspiring youth population every year, where in India alone this is over 10 million every year. In spite of this stupendous challenges it is necessary to celebrate the poverty reduction from 45% in 1994 to 37% 2007 and eventually 22% in 2014, with a current goal of eradicating it by 2022[8]. Improvement in basic services is necessary with only fractional governmental spending than at current levels if global inclusive scalable venture creation process can be unleashed that will break the productivity barriers, delivery impediments and reduce inefficient distribution into a thriving delivery model powered by innovative collaborative solutions of local problems. Added emphasis is needed to create non-farm jobs and rapid increases in farm productivity so that jobless growth is replaced by inclusive sustainable manufacturing/ services job creation lead high economic growth for true poverty eradication in line with both Sen and Bhagwati models. Basic necessities may be classified in Fig 1 as follows:-

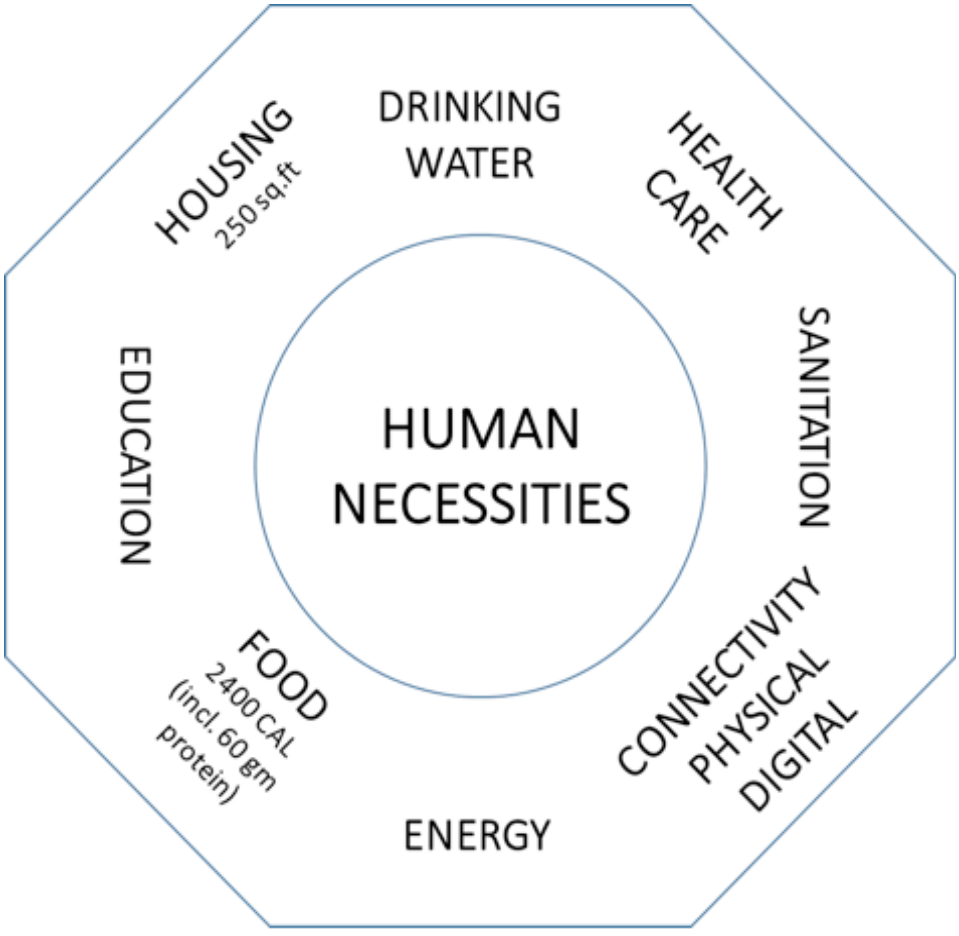

Figure 1: Mitigation of different aspects of human necessities for a GISV

Even the western economies facing stagflation and low economic growth rates has the risk of being

unable to support the standard of living of its future progeny. There have been age old interactive distractions of market and socialist economic doctrines by Schumpeter[9], which lingered in the society for almost seven decades. Such dilemmas have been rekindled with debates on entrepreneurship, innovation and growth in North America[10] and Scandinivia[11]. Recently, Accenture[12] has been propounding a circular advantage of innovative business models to address the growing gap of resources and constraints faced by conventional business in today's changes in socio-economic scenarios. This is depicted in Figure 2.

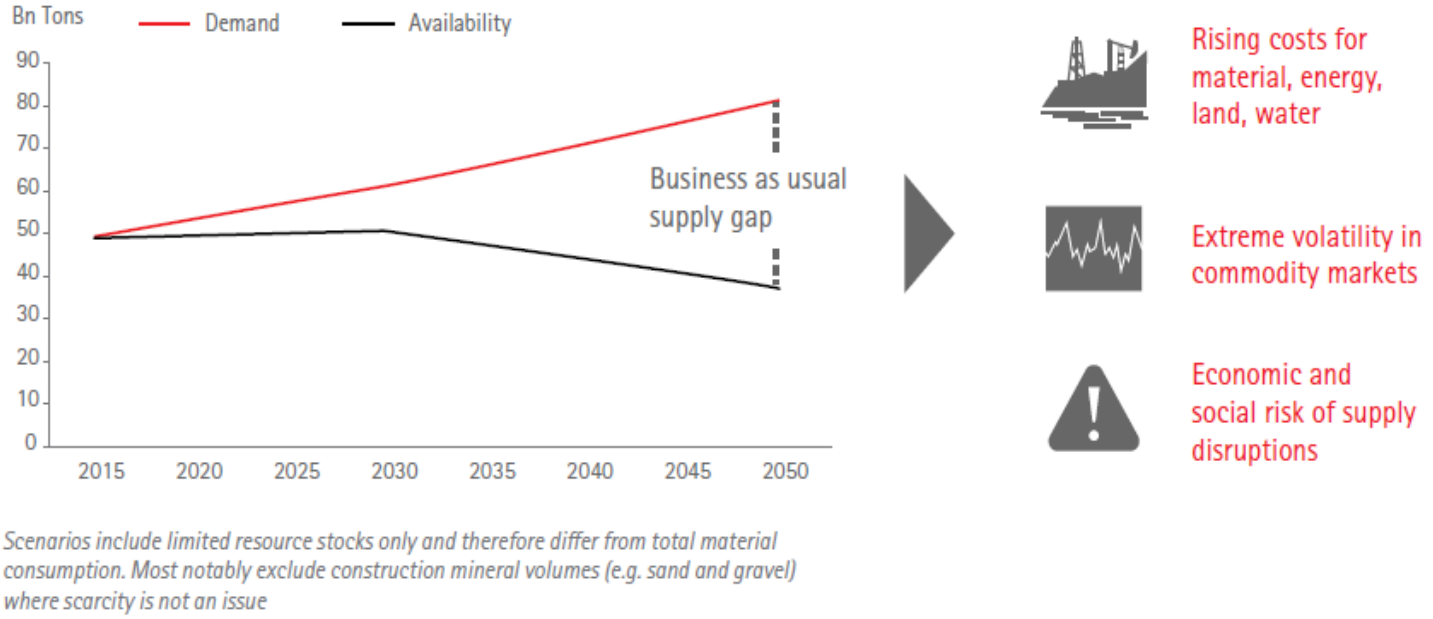

Figure 2: Resource Supply Demand Imbalance 2015-2050. Source Accenture[12]

Local resource constraints, lack of adequate manufacturing and service jobs, flight of manufacturing hubs to Asia, and higher cost of labor worsened by the demands of higher living costs have brought in the urgency for new models of venture creations, where such crippling bottlenecks will not stifle economic growth that is urgently required for a balanced world economic development through innovation-led economic models. Added to such uncertainty are the financial inconsistencies driven by pre-2008 Wall Street-dominated money and power relationships[13] leading to financial crisis and the post-2008 period of lower growth. This necessitates a new innovation-led entrepreneurial model not akin to earlier existing practices of venture economics.

It is obvious that an inclusive growth approach takes a longer term perspective because of its emphasis on improving the productive capacity of individuals and creating conducive environments for employment, rather than its focus on income redistribution as a means of increasing incomes for excluded groups. There is an explicit focus on structural transformation and internal migration in the inclusive growth analytics framework as a result of this longer term perspective. It may be noted that, in developing countries, a significant part of growth is generated through reallocation of labor from low-productivity to high-productivity sectors. This necessitates a goal to identify a bundle of binding constraints rather than a specific binding constraint, and then sequence these constraints to maximize inclusive growth in a country. This should not be misconstrued that we go back to the "laundry list" approach, but rather to a limited set of constraints. However, sequencing of these constraints may require further in-depth studies of the feasibility and costs of specific policy implications. The typical "one solution for all problems" is no longer applicable even though such a business model has been the staple of big multinationals for last half a century. A product or a service solution developed for one geographical area is most likely not suitable for another area of the world due to differences in local underpinnings. Drinking water sup-

ply is one such problem whereby a solution is not geography independent in terms of water sources, aggregation and storage, distribution, waste treatment and natural harvesting. Therefore, involvement of local community in the role of entrepreneur, subsequent creation of a localised home grown solution supplemented by external technologies through global collaboration, and sustainment with appropriate scalability is the most viable solution instead of a copy/paste solution.

However, current embedded venture models based on conventional businesses are inadequate in providing entrepreneurial solutions towards the creation of necessary enterprises. A combination of new technologies, new collaborators, new stakeholders and ownership and newer end use based business cycles are necessary, which provided the genesis of GISV. It is nothing new to bring together the industry, government and academia in a grand alliance to create entrepreneurial ecosystems and has been well elaborated by Etzkowitz and Leydesdorff[14,15] in Triple Helix Model. However, even in such collaborative efforts, the frameworks and missions are inadequate in addressing the teething problems of economic development in the post-2008 world, both in developed, emerging and developing economies as enumerated earlier. The author has observed the practical problems facing the urban/semi-urban/rural communities in the context of an Higher Education Institution (HEI) of international importance like that of Indian Institute of Technology, Kharagpur for over a decade, and then initiated, nurtured and fine-tuned the structural and functional linkages into a newer framework of Education-Enterprise model[16,17,18] (E-E). The role of government is diminished by choice so that uninterrupted free market mechanisms and knowledge support from academic institution will result in creation of new GISV with many benefits. This will lead to better capital allocation, risk mitigation, pragmatic innovations and optimum delivery of basic needs to the society in disruptive business models with full buy-in of the local community as an output of developmental entrepreneurship. Such E-E model-based entrepreneurship ecosystem has been developed to facilitate new GISV creation processes around IIT in Figure 3 below.

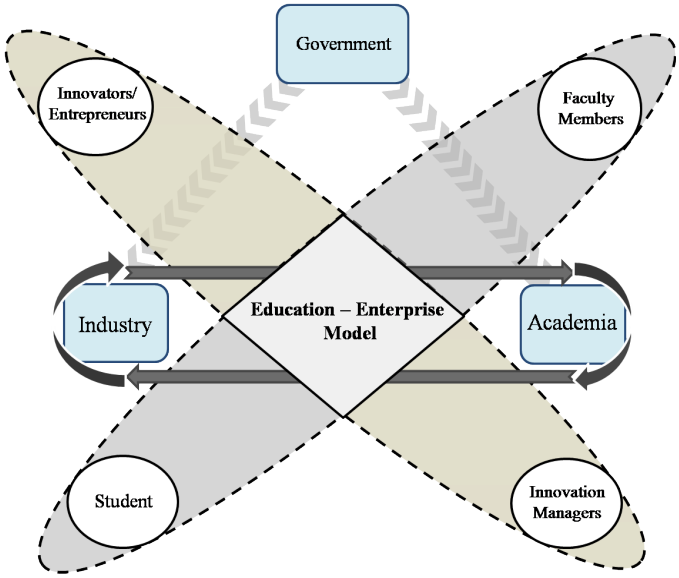

Figure 3: Collaborative Education-Enterprise Model of Business Creation

It may be noted that the academic platform of a renowned university plays the critical leadership role to bring together the disparate groups together consisting of entrepreneurs and customers in a dynamic relationship leading to formation of GISV ventures in our framework. This has been formalised by the author at IIT into a dedicated School of Engineering Entrepreneurship, where engineers, while pursuing their academic degree, are needed to put together a business plan for a venture, preferably for a GISV venture, get the necessary funding from the university under free competition among others and grow the venture into a reality before their graduation. Below is the functional diagram (Figure 4) for the novel entity.

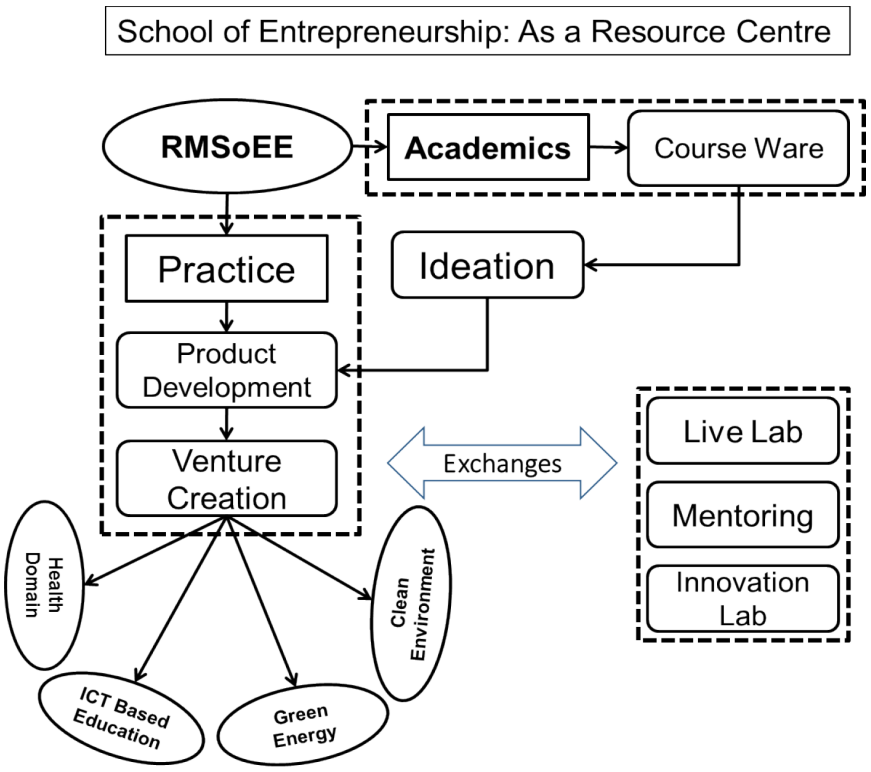

Figure 4: Role of the Entrepreneurial Academia

However, the university rules and regulations slow down enterprise formation process, more so in emerging economies with strong government—though our adopted Education-Enterprise model prerequisites little influence of government. But such controls are difficult to avoid in reality at this moment. Therefore, a university based foundation, here Society of Social Entrepreneurs' (SSE) since 2006, run by professors and students acts as an interface within this framework. It facilitates the resourcing of appropriate applied innovations for enabling the enterprise, which attempts to address a particular local problem in the community through a technology business solution. The local community is deeply engaged and the students are brought towards the local community, much like an intertwined lasso. This connects the students from all across the nation at IIT to focus on the engineering and business solution of a local problem, which must address the particulars of inclusivity, scalability and globally born credentials. Unique solutions are created for such problems to drive the efficiencies at a higher level, what we call "beyond better, beyond faster, beyond cheaper." Scalability will be cost effective in such a localised solution, customized yet low cost and output achieved through pulling in all the local resources through healthy collaboration with the developed world.

It is quite common that student teams mentored by faculty and industry patrons will create a rapid collaborative framework along the tenets of the University of California and IIT based early stage Global Venture Labs. The student teams then create a prototype, deploy and understand the feedback from the local community and mitigate product features with technology and business innovations to improve scalability of the solutions and adaptability for the local population. Routinely, impact analysis is carried out and further optimisation measures are undertaken. Figure 5 explains the relationships with SSE within the framework and positions the formative stages of GISV through solutions for wide ranging problems through the application of innovation and entrepreneurship, under market economics. Such a solution transforms and transgresses the role of the academic institution from merely imparting education to providing caring solutions by embedding the local community. The true strength of GISV is sustained through this unique ecosystem. Such noble relationships impart true inclusivity to the venture

foundations as a n elopment.

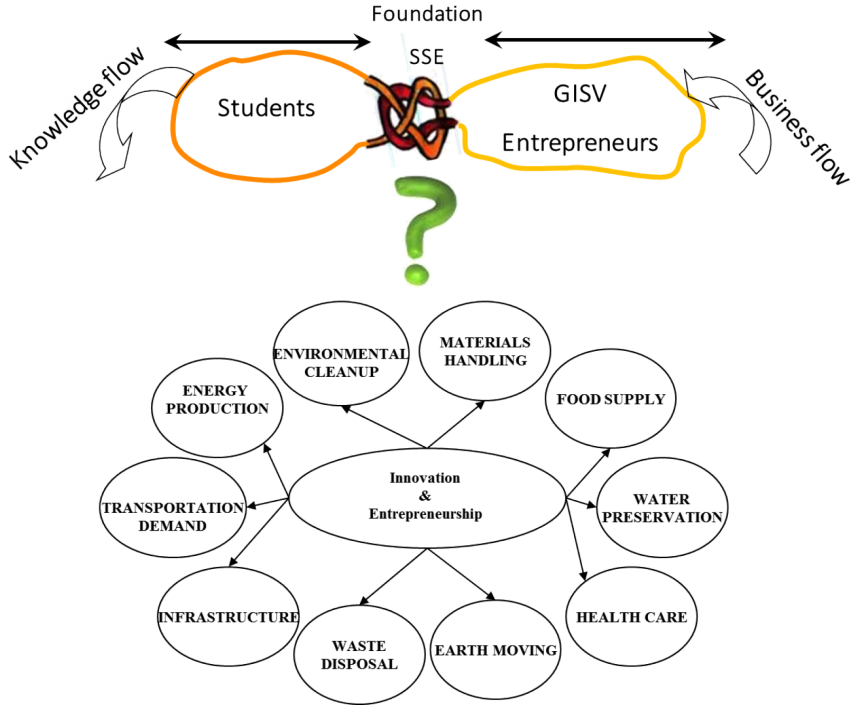

Figure 5: Role of the Interface Foundation: Society of Social Entrepreneurs

The entire system has evolved and been implemented around authors' research habitats around IIT Kharagpur and is driven by the visions of providing the solutions for the problems affecting the human development index in our country. All the promotion, incubation, training and academic programs are designed, developed and delivered to achieve this capability and capacity. This system has three base elements: entrepreneurial ecosystem, academic platform and one of the most successful incubation facilities in this country. A cohesive and comprehensive knowledge-driven resource creation platform has developed on these three pillars (Figure 6) as a key component of the framework to provide resources to GISV implementations. This resource creation platform has the capacity and capability to support new enterprise creations in various domains such as healthcare, ICT, product design and development, electrical, low cost housing and alternative energy in both traditional and social enterprise arenas. Various companies and educational institutes are directly or indirectly part of this resource creation platform.

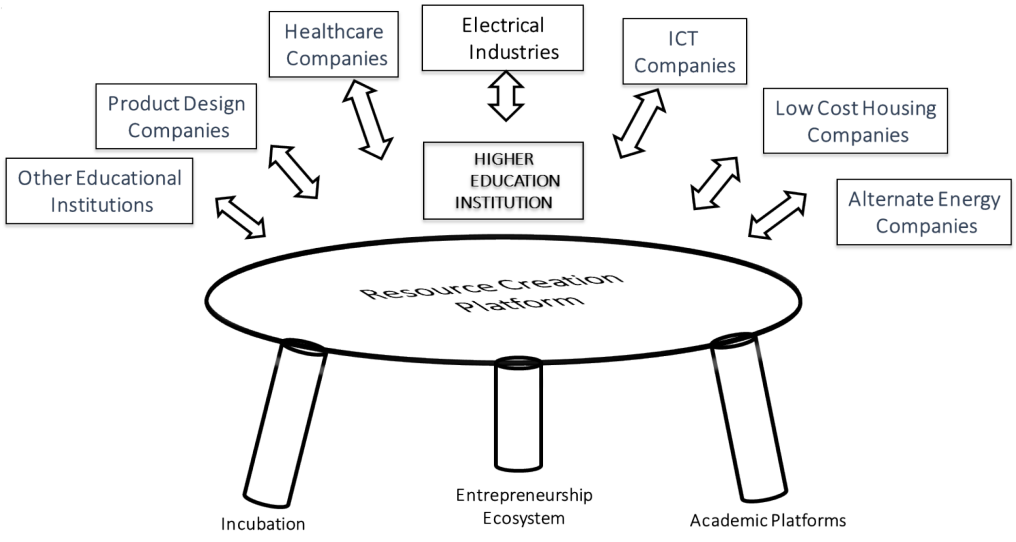

Figure 6: Concept of Resource Creation Platform in HEIs

Currently, this resource creation platform is leveraged for their inclusive and scalable healthcare and e-governance and e-education platforms in IIT Campus. Optimized juxtaposition of the efforts arising out of the resource platforms of the School with the Entrepreneurship Foundation SSE is further amalgamated by the local community-driven entrepreneurs, which is then integrated towards the creation of GISVs as shown in Figure 7. This process of venture creation by GISV is key to essential pathways of the new framework.

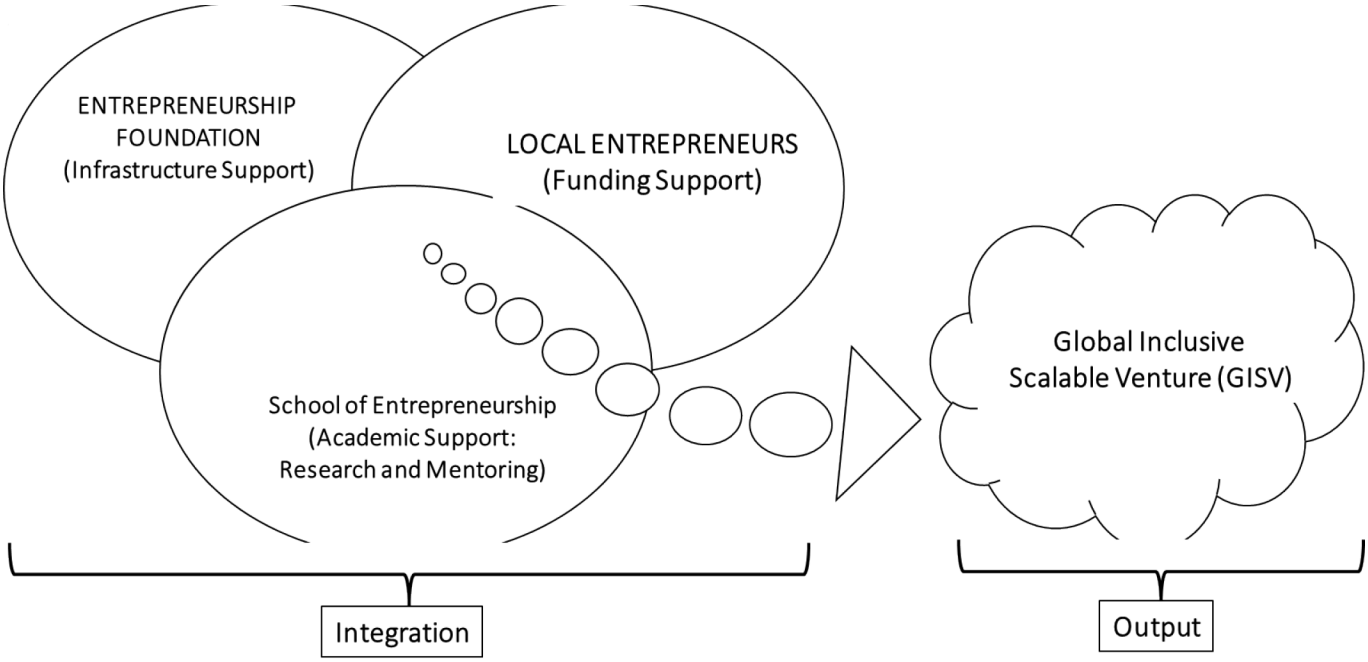

Figure 7: Process of venture creation by GISV roll outs

III. Demonstrations of GISV in this Research

In the early stages of this unique live experimentation at IIT Kharagpur, four focus areas of interest were education, energy, environment and health (EEEH paradigms) with the local area around the District of W. Midnapore, West Bengal, India. This semi-urban and mostly rural area is around 150 km south-west of the metropolis of Kolkata. This geographical area historically has been then political hot bed of Indian freedom wars, including the Maoist movements from the 70s and very recent farming land-owners protest movements. The population is poor, but seeks better education for their social upliftment and is in need of healthcare, better energy solutions, drinking water, sanitation and low cost homes towards improvements in their human development index. This makes the area ideally suited to the research experimentation toward a better economic growth model, which could be empowered by world class IIT as its epicentre. The foundation SSE played a key role as a facilitator of the stake holders within and outside the community. An education based GISV known as E-Turns was started in 2006 with local stakeholders from the adjoining rural area to educate the high school students in existing lagging schools to bring them at par with the best in digital content and trained local teachers, with IIT students taking a key part in content creation and teachers training[19]. This enterprise did very well until scalability became an issue as an early stage mortality to the GISV creation initiative. This was followed by incubation of several technology start-ups in IC design in an effort to create an IT cluster to attract high technology jobs in the local area for accelerated economic development[20].

With accumulation of experiences and global collaborations from University of California at Berkeley and Jyvaskyla University, Finland, unique scalable health delivery models were experimented (Fig. 8, 9) by SSE[21]. This time the geographical area was expanded into west north-central W. Bengal within the districts of Bardhaman and Birbhum (150 kms from IIT), including the home base of W. Midnapore.

This initiative by the author was awarded the Global Academic Cup from University Alliance Finland. The financial awards and collaborative linkages with Jyvaskyla University (Prof. Marco Seppa and Mari Suoranta) and the University of California at Berkeley (Prof. Ikhlaq Sidhu) quickly culminated into a dedicated separate foundation Aegles Angels Foundation under the mentorship of the author and overall guidance from SSE including infrastructural support and early stage funding.

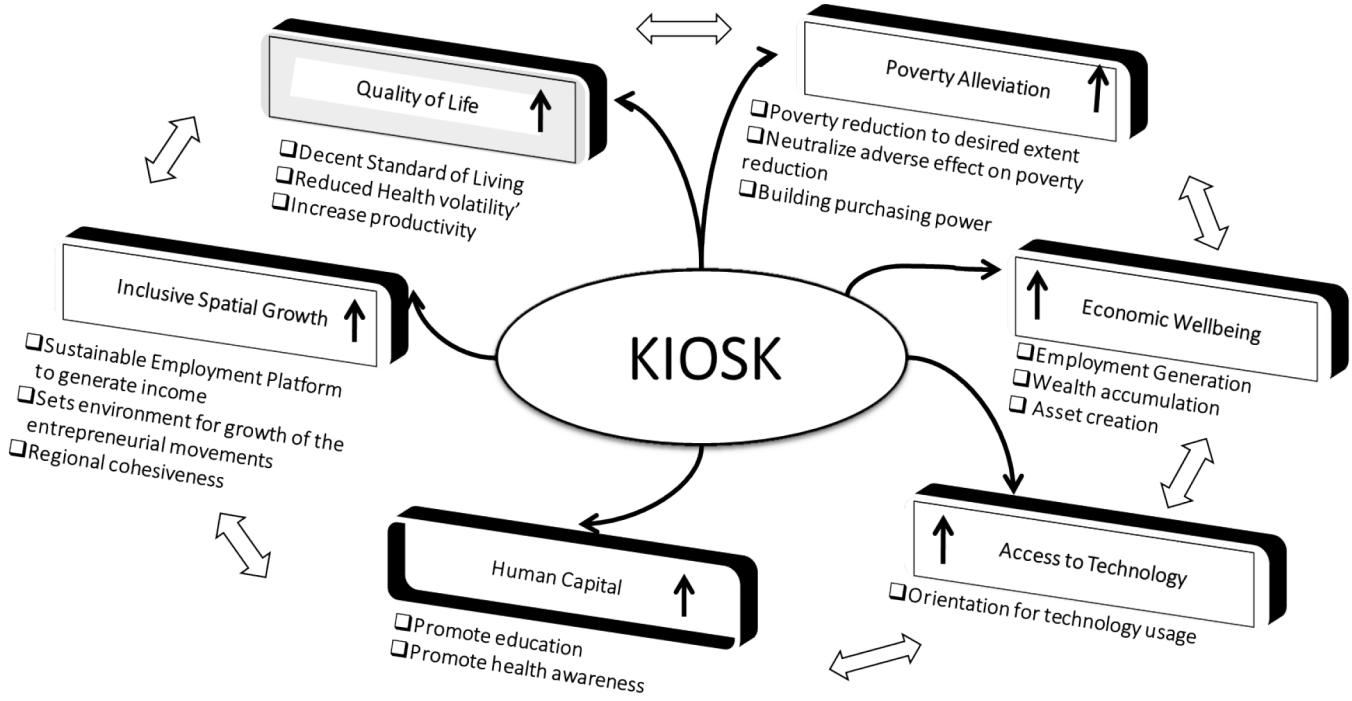

Figure 8: The unique health delivery scalable model based GISV

It expeditiously addressed the problems of availability, accessibility, affordability and quality of tertiary health care with emphasis on cardiac and diabetic patients, the two most prevalent diseases in India, due to its socioeconomic conditions. Appropriate Android-based interface tools were collaboratively innovated (hardware, software and service) and patients within the local community became the beneficiaries. The measured patient at the community kiosk was indexed dynamically using cloud services for data analysis and subsequent aggregation, and the patient was escalated to an appropriate hospital under a specific doctor according to the distance of the hospital from the patient, the severity of the disease and the financial situation of the patient within the business models of the service[22,23]. Local entrepreneurs were the angels committed to providing basic measurements of the health condition at the kiosk, as well as transportation of the patient to the hospital, maintenance and up gradation of the network. The network was scaled up to 15 kiosks, 590 entrepreneurs, 3 affiliate tertiary care hospitals and about 500 patients serviced on a daily basis, a large proportion who otherwise could have succumbed to the disease in view of the grim situation of tertiary health care in India beyond the metro cities. These efforts were eventually constrained with further scalability issues, non-viable business partners and inexperienced entrepreneurs, lack of awareness about socio-economic benefits of GISV and better differentiated business models.

Considerable success brought in foreign partners interested in utilizing a similar concept to provide low cost housing, maternity care and education, insurance and other financial services to the rural population. More roll outs are expected to substantially cover more services through creation of more GISVs. There are many other GISVs (over 40 in healthcare, education, energy and drinking water) that were independently created out of this initiative and are currently under various stages of growth in their respective business cycles.

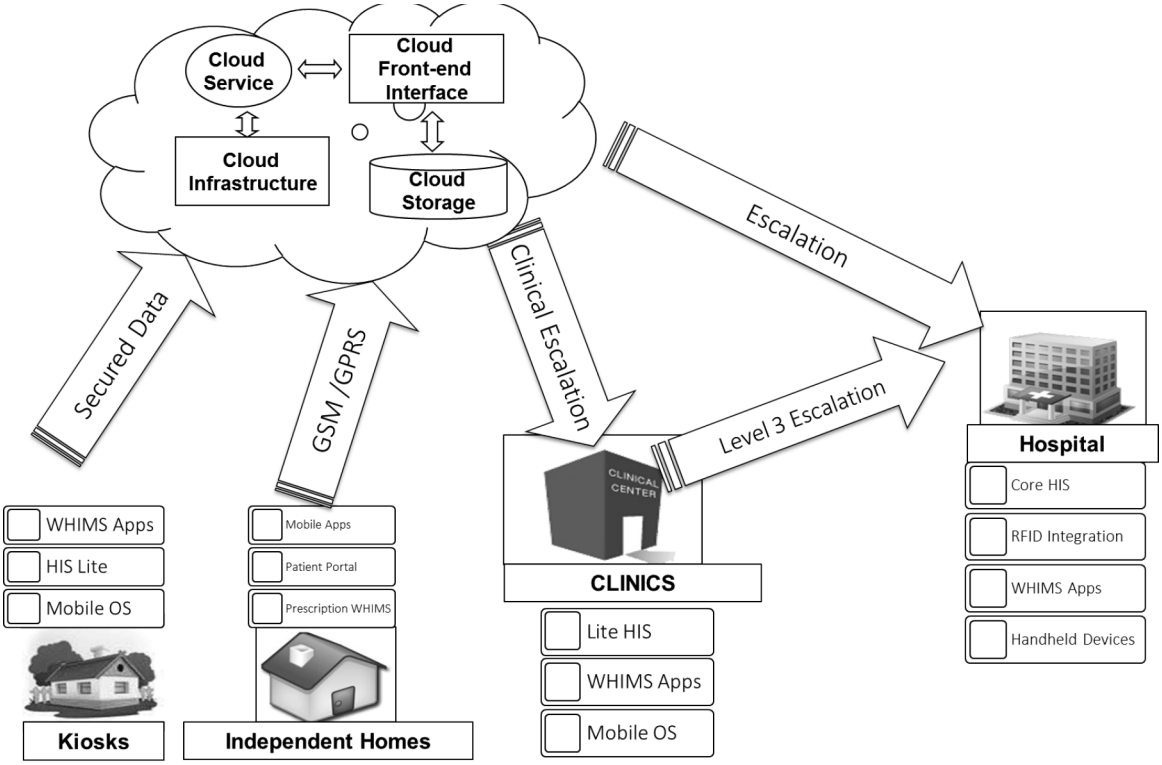

Figure 9: Architecture of the Health-based GISV in West Bengal, India

IV. Conclusion and Future Direction

As we are undertaking impact analysis of the major initiatives, a lot more needs to be understood to accelerate the GISV formation and realize holistic economic development both along the lines of Sen and Bhagwati. Despite of our enormous efforts towards creating an entrepreneurial environment, our initiatives are not getting its desired academic and enterprise values. Though the government is working with the HEIs for better result, still these initiatives are not well accepted in the academic communities in India in comparison to the western economies. Our strides in this regard are neither automatic nor inevitable, therefore vigorous concerted efforts must be made to achieve the perfect intersection of GISV and applied innovation for inclusive economic development. We have successfully developed the framework that lead to creation of new GISVs, facilitated and mobilized by HEI through active interaction with private enterprises of the HEI and adjoining physical communities.

While investment driven growth is favoured by the current government in India instead of relying on current consumption driven processes, neighbouring China is doing a rebalancing by focusing on more consumption driven models while taking a backseat from the much dependable investment driven process that was pursued by the Chinese government for last 30 years. In either case, both the countries and other emerging nations as well as previously explained developed economies need to focus on GISV lead venture creation process which will lead to an inclusive world free of poverty and economic growth that provides a balanced world for our progeny with respectable human development index for all. We need to prioritize a restructured entrepreneurial society through setting up of localised distributed GISV as the backbone architecture of economic enterprise that will solve the local problems through local people by application of innovative global solutions to create an economically vibrant, globally collaborated and integrated inclusive society.

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A Game-Based Method for Teaching Entrepreneurship

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Entrepreneurship is often thought of as the act of commercializing an innovation. In modern open economies, entrepreneurship is one of the key aspects for economic growth. The teaching and learning entrepreneurship is therefore of importance. Schools, colleges and universities can play an important role by including entrepreneurship and innovation in their curricula. The Berkeley Method of Entrepreneurship is a holistic and student-centered teaching and learning approach that is hypothesized to enable engineers to be more entrepreneurial. It encompasses three main elements: networks, mindset and frameworks. Networks and frameworks are covered in most entrepreneurial curricula, whereas only a few curricula explicitly include the mindset perspective. The Berkeley Method of Entrepreneurship is based on the hypothesis that the mindset of an entrepreneur can be characterized by a distinct set of behavioral patterns, and that an inductive game-based teaching approach is a successful vehicle for introducing and re-enforcing these. The game-based teaching approach allows the students to explore their current mindset and compare it with that of entrepreneurs. The paper presents two of the hypotheses behind the Berkeley Method of Entrepreneurship: the set of behavioral patterns and the game based teaching approach. This paper outlines the concepts behind this novel teaching approach as well as future research.

I. INTRODUCTION

Entrepreneurship matters. In modern open economies it is more important for economic growth than it has ever been. The reason behind this is that globalization and the revolution in information technology imply a need for structural change, requiring a substantial reallocation of resources. This induces an intense demand for entrepreneurship[1]. In understanding entrepreneurship, schools, colleges and universities play an important role and should therefore implement programs and courses that improve the education and training in the area of technology management and entrepreneurship[2]. Governments and universities worldwide are pushing for education programs that produce more “entrepreneurial engineers” who are “bilingual” in the sense that they possess dual managerial and technical competencies[3].

As pointed out by Phan, Siegel and Wright[4], more research concerning good ways to train students in entrepreneurship is needed, and Verzat et al.[5] states that research investigating suitable pedagogical methods to attain requisite skills among engineering students is lacking. Some of the most crucial elements of entrepreneurship at the level of individuals are attitudes, skills and actions[6]; i.e. elements that

are partly not taught in traditional classes at schools, colleges and universities. Creating entrepreneurial mindsets in students also calls for the use of innovative models and content in teaching and may involve changing the content of courses as well as the process of learning itself[7]. Research investigating suitable pedagogical methods to attain requisite skills among engineering students is lacking. Equally, accounts of the use and potential of games as a pedagogical tool are largely absent from mainstream journals[8].

The Berkeley Method of Entrepreneurship is a holistic and student-centered teaching and learning approach that is hypothesized to enable engineers to be more entrepreneurial. It encompasses three main elements: networks, mindset and frameworks. Networks and frameworks are elements found in many entrepreneurial courses and provide the students with knowledge and facts associated to entrepreneurship whereas mindset is an element often missing in traditional courses. Generally, the mindset is a way of thinking that influences the way someone views and acts upon a situation; the mindset is reflected in the person's behavioral patterns[9].

The Berkeley Method of Entrepreneurship is based on a two-fold hypothesis:
1. The mindset of an entrepreneur can be described as a set of behavioral patterns, and
2. An inductive game based teaching approach is a successful vehicle to introduce and reinforce behavioral patterns in students.

In the game-based teaching approach, students explore their current mindsets and compare it with that of entrepreneurs. The Berkeley Method of Entrepreneurship further stresses the relationship between the student and the subject—that is, how the student perceives information, experiences and knowledge provided in the course.

This paper begins with a definition and description of entrepreneurship and why it is of importance for society (Section 2). It describes current trends in teaching and learning as well as the special aspects of teaching and learning entrepreneurship (Section 3). Furthermore, the paper contains a description of the Berkeley Method of Entrepreneurship (Section 4) and the hypotheses on which it is based. The paper presents a set of behavioral patterns that characterize an entrepreneur (Section 5) and discusses how these can be invoked by introducing games in the teaching and learning setting (Section 6). The paper presents some ideas for further research related to entrepreneurship and management education in general, and to the Berkeley Method of Entrepreneurship in particular (Section 7). At last, the conclusions are drawn (Section 8).

II. ENTREPRENEURSHIP

Entrepreneur, originally a French word, is commonly defined as an individual who organizes or operates a business or businesses. The first usage of the word "entrepreneurs" dates back to the Irish-French economist Richard Cantillon who, in 1734, defined them as "non-fixed income earners who pay known costs of production but earn uncertain incomes"[10]. The newer definition comes from Ronald May, who states that "An Entrepreneur is someone who commercializes his or her innovation," and Howard Stevenson[11] who states that "Entrepreneurship is the process by which individuals pursue opportunities without regard to the resources they currently control." Entrepreneurship is the art of being an entrepreneur.

Entrepreneurship is an essential ingredient for creative destruction, a phenomenon described by the Austrian economist Joseph Schumpeter[12]. According to Schumpeter, creative destruction is "the essential fact about capitalism" where new combinations of resources (e.g. human talent, physical resources and financial resources) give rise to new industries and wealth[13]. According to Schumpeter, creative de-

struction is the primary mechanism for economic development for societies and businesses. In his view, entrepreneurs are the dynamic figures who combine, or recombine, vital resources to serve emerging customer needs, thereby "creatively" destroying the pre-existing economic order[14].
Entrepreneurship in a society can exist at three distinct levels: individual, firm and macro. The three levels operate under different conditions and have their own crucial elements. Their respective success has different implications[15]. The success of entrepreneurship at the macro level implies economic growth. However, a success at the macro level cannot be achieved without successful entrepreneurship at the firm and individual levels since the macroclimate is grown out of these[16].

Entrepreneurs often find themselves in novel and unexplored territories. This calls for a certain type of mindset as studied by several researchers. Political economist Robert Reich considers leadership, management ability and team-building to be essential qualities of an entrepreneur[17]. Other researchers state that common skills and attitudes of entrepreneurs are the ability to bear risk[18,19] and cope with true uncertainty, and possession of an extrovert behavior—that is, an outgoing, talkative, energetic behavior[20].

III. TEACHING AND LEARNING ENTREPRENEURSHIP

As an answer to the need of increasing entrepreneurship in society, citizens should be trained to start companies. One opportunity to create new companies is in areas of innovation and new inventions. In most countries, universities generate lots of new innovations. Thus, the universities that not only innovate (through research) but also train entrepreneurs will be at the forefront of growing their countries' economies[21]. Today many universities have extended their traditional missions (education, research and outreach) to also include innovation and entrepreneurship. The newer goal is often expressed as education, research and outreach-and-innovations. Entrepreneurship and innovation are being included in curricula at adaptive universities. In addition, discussions about teaching and learning in general have received increased attention at universities lately.

Generally speaking, teaching is interpreted as the act of helping someone to learn. In recent years, discussions about teaching have shifted from "how to present and transfer knowledge from a teacher to someone else" to "how information and knowledge provided is perceived by the receiver"[22]. They have shifted from a teacher-student-transfer focus in which the subject is only the transported goods, to the student-subject-relation focus in which the teacher is only the medium used. The task for the teachers is to help the students learn. This shift is illustrated in the didactic triangle in Figure 1[23].

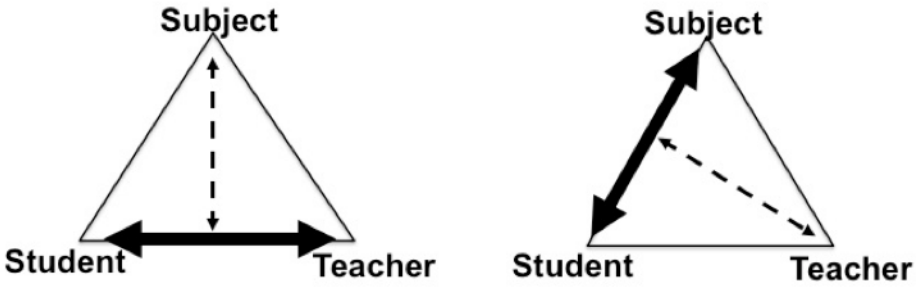

Figure 1: An interpretation of the Didactic Triangle showing a shift from the teacher-student-transfer focus (left) to the student-subject-relation focus (right).

The teacher-student-transfer focus (left in Figure 1) is also referred to as deductive teaching, whereas the student-subject-relation focus (right in Figure 1) is referred to as inductive learning[24]. In a deductive classroom, the teacher conducts lessons by introducing and explaining concepts to students. Then, students are expected to complete tasks to practice the concepts. The students should demonstrate

that they have understood the concepts by repeating what the teacher just said or did. In an inductive classroom, the teacher presents or exposes the students to examples that show how the concept is used. The intent is for students to "notice" how the concept works through reflection. The students should demonstrate that they have understood by re-inventing the concepts based on their own experience.

Deductive teaching methods are suitable to use in subjects where facts and raw knowledge is of most importance, whereas an inductive teaching approach is suitable to use when skills and attitudes are in focus. For entrepreneurs, skills and attitudes are equally or even more important than facts and raw knowledge, and an inductive learning approach is therefore most suitable. Since skills and attitudes are "owned" by the students, the relation between the student and the entrepreneurship-subject becomes essential, the school and teachers are only a means for the student to reflect upon his or her skills and attitudes (compare Figure 1, right side).

An example of an inductive learning approach is game-based learning, something that has received increased attention lately[25,26]. It has been driven by clear successes in military and industrial training, as well as by emerging research into the cognitive benefits of game plays. Developers and researchers are working in various areas of game-based learning, including games that are goal-oriented; social game environments; non-digital games that are easy to construct and play; games developed expressly for education; and commercial games that lend themselves to refining team and group skills. More complex approaches like role-playing, collaborative problem solving, and other forms of simulated experiences have broad applicability across a wide range of disciplines and are beginning to be explored in more classrooms[27].

IV. BERKELEY METHOD OF ENTREPRENEURSHIP

At the University of California at Berkeley, a new method for teaching and learning entrepreneurship is under development[28,29]. The pedagogy is focused around learning rather than teaching (compare Figure 1) and the students are pushed to proactively develop their own understanding rather than to wait for someone to teach them what they need to know. The students are trained to frame problems and find ways to solve them and then reflect on what they have learned from the process. The pedagogy of Berkeley Method of Entrepreneurship is based on the following five principles:

- Students learn by doing[30].
- Instructors host the environment for students to interact directly with the problem. Students make their own decisions and learn inductively[31].
- Behavior training for students is enforced through games and exercises[32].
- Learning outcomes prosper when focusing on goals and processes instead of grades.
- Learning leverages on mimicking real-world entrepreneurial situations[33].

The method has already been used in practice at different occasions: boot camps and courses for undergraduate and graduate students, Global Venture Lab Conferences for academia and industry, and research activities. The three-part model describing the Berkeley Method of Entrepreneurship is depicted in Figure 2.

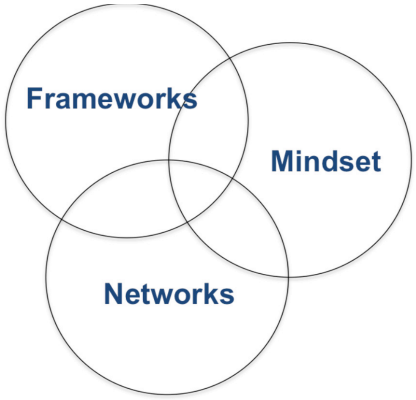

Figure 2: The three layers in Berkeley Method of Entrepreneurship

The three parts are defined as:

- Framework: Teaching effectiveness of strategy, tactics and execution—for example, opportunity recognition, pivots, minimum viable product, raising funds, tools, frameworks, etc.
- Mindset: Exposure to issues related to culture, social psychology and mindset. It covers the psychology of being an entrepreneur—for example, trusting, risk assessment, communication, overcoming social barriers, rejection therapy and fail training.
- Network: Network is a general term that covers both people-based connections for creating ventures as well as a safe environment to develop a venture. It assures infrastructure and a supportive, safe and effective environment such as diverse networks, ability to connect, facilities, services, clarity of rules of engagement and mentors.

Framework and networks are provided in most traditional and entrepreneurship courses, whereas mindset is often not explicitly included in courses today. In traditional courses, the students are given access to good infrastructure and a supporting environment (networks). The aim is to facilitate the students to study, search for information and share documents. The infrastructure and networks also contain clarity of rules; the students should know what is expected from them in the learning situation. In traditional courses, students are taught about the tactics associated with the subject (framework). In entrepreneurship courses, tactics and frameworks could encompass the following: knowledge about opportunity recognition, how to raise funds or how to use certain tools and frameworks.
What is often missing in traditional or entrepreneurship courses is an explicit work with mindset (mindset). The Berkeley Method of Entrepreneurship aims at training students to become entrepreneurs and therefore exposes the students to the entrepreneurial mindset. This is done with an inductive game-based teaching approach.

The Berkeley Method of Entrepreneurship is based on a two-fold hypothesis:

- The mindset of an entrepreneur can be described as a set of behavioral patterns, and
- An inductive game based teaching approach is a successful vehicle to introduce and reinforce students' behavioral patterns.

A list of ten behavioral patterns has been formulated and current research aims at confirming or rejecting each of the behavioral patterns. The inductive game-based teaching approach has started to be used at UC Berkeley in courses provided by the Sutardja Center for Entrepreneurship & Technology. Current research aims at tuning existing games and/or finding additional games to reinforce the behavioral patterns. Research concerning the measurement of the success of using a game-based teaching approach in entrepreneurial curricula is also in its initial stages. The following two chapters describe the ten behavioral patterns characterizing entrepreneurs and the game-based teaching approach.

V. THE GAME-BASED TEACHING APPROACH

The mindset of successful entrepreneurs has been studied and a proposal describing their most dominant characteristics is given through ten behavioral patterns. The proposal is based on extensive interaction with entrepreneurs in the Silicon Valley area and on literature review—e.g. Rainforest by Hwang and Horowitt[34]. A distinct set of behavioral patterns is identified and listed in Table 1. It is important to note that this is an ongoing research, which implies that the ten behavioral patterns should be interpreted as best current status. It cannot be excluded that more patterns will be added, or current patterns will be modified/removed. The ten behavioral patterns describe the typical mindset of successful entrepreneurs. If everyone in a community acts like this, there will be a vibrant entrepreneurial culture.

No.	Behaviour
1	Pay It Forward "Agree that you will get help from others, and pay it forward."
2	Story Telling "Realize something new by induction, and then learn to communicate the story with a new language."
3	Friend or Foe "If you can't tell: learn to trust others without expecting anything in return."
4	Seek Fairness "Make deals that seek fairness (in positive sum transactions), not advantage (in zero sum transactions)."
5	Plan to Fail "It is necessary to be wrong sometimes. Plan to experiment. Plan to fail. (Fail Fast) Analyze, adapt and repeat. The smarter you think you are, the harder this is going to be."
6	Diversify "Diversify your networks. Connect to people you would not normally, then go and listen. Open Up. And connect them to others."
7	Role Model "Be a role model for other entrepreneurs and innovators."
8	Believe "Believe that you can change the world."
9	Good Enough "Perfection is no good but good enough is perfect."
10	Collaboration Individual vs team and competitors vs partners

Table 1: Ten behavioral patterns characterizing an entrepreneur.

Pay It Forward

Pay-it-forward is a term used to describe the concept of "asking the beneficiary of a good deed to repay it to others instead of the original benefactor"[35]. The first known use of the term dates back to 1916 when it was used in the phrase "You don't pay love back; you pay it forward"[36]. In areas strong in entrepreneurship, such as Silicon Valley in California, a pay-it-forward culture has been identified[37]. Entrepreneurs in these areas build support networks outside of existing companies. These networks can be around any area of interest. The networks are mutually beneficial; that is, as a participant you both learn from others and contribute to help others. Over time, experienced executives "pay back" the help they received by mentoring others. A pay-it-forward culture makes an entrepreneurship ecosystem smarter[38].

The pay-it-forward concept is the motivation behind seasoned managers or entrepreneurs getting involved in coaching and/or mentoring[39]. Mentoring has been identified as an exchange relationship whereby both the mentor and the protégé gain several benefits from each other. For example, compared with non-mentored individuals, mentored employees demonstrate higher levels of objective and subjective positive outcomes such as career development, job satisfaction, socialization, organizational commitment and career advancements[40].

Story Telling

This behavioral pattern refers to Christensen's influential work on the innovator's dilemma[41] and Moore's work on crossing the chasm[42]. Especially in high-tech markets, an entrepreneur's product idea or business model can be radically new or disruptive. It can be a "new to the world" type of innovation. Often, even the terminology used to describe the concept might be missing. Exploring a new, possibly disruptive market requires major changes in patterns of behavior related to entrepreneurial communication. The entrepreneurs need to learn how to "cross the communication chasm" so that potential investors, and later on customers, understand the added value in the new offering. The entrepreneurs need to learn to communicate their story with a new language; they need to be storytellers and do story telling.

To be able to adopt new innovations, consumers need to be aware of an innovation and understand the additional value provided by the innovation[43]. Narrative, or story telling, is a central tool in addressing many of today's key leadership challenges such as the following: articulating the risks and opportunities identified by strategic management tools like strategic plans, scenario analysis, and dilemma resolution[44]. Story telling can be one way to overcome the communication chasm. It can be used effectively for several purposes of communication: sparking action, transmitting values, exploring alternative future scenarios or sharing knowledge.

Friend Or Foe

Trust, generalized trust and particularized trust are important concepts strongly related to a person's judgment of friend or foe. Trust means to believe in someone's word; it is often towards a known person. Research has validated the importance of social cohesion based on trust, support and altruism in driving behavioral outcomes. It has been shown that trust is mainly created through real-life collaborating, working together and/or sharing information[45]. In social networks, trust can be multiplied.

Generalized trust is trust towards strangers that arises when "a community shares a set of moral values in such a way as to create regular expectations of regular and honest behavior"[46]. Generalized trust differs fundamentally from particularized trust through extension to people on whom the trusting part has no direct information[47].

Seek Fairness

Covey[48] coined the idea of abundance mentality or abundance mindset, a concept in which a person

believes there are enough resources and successes to share with others. It can be contrasted with the scarcity mindset (i.e., destructive and unnecessary competition), which is founded on the idea that, if someone else wins or is successful in a situation, that means you lose—not considering the possibility of all parties winning (in some way or another) in a given situation. Individuals with an abundance mentality reject the notion of zero sum transactions and instead believe in positive sum transactions. They are able to celebrate the success of others rather than feel threatened by them. Genuine strive for mutually beneficial solutions or agreements, as supported by a positive sum transactions attitude, is the key in (entrepreneurial) relationships. A "win" for all is ultimately a better long-term solution than if only one person in the situation had gotten his way.

Plan To Fail

Important concepts related to this rule are effectual logic, failure acceptance and pivoting. Research on successful entrepreneurs revealed that they use non-predictive or effectual logic. This means that you begin with who you are, what you know and whom you know, and begin doing the doable with as few resources invested as possible[49]. Research also concludes that an entrepreneur should "repeat, continue after failure and pivot until the chain of stakeholders and commitments converge to a viable new venture"[50]. In particular, they begin by interacting with a wide variety of potential stakeholders and negotiating actual commitments. Let the actual commitments reshape the specific goals of the venture. An entrepreneur has to accept that the reshaping is an important part in aiming to improve; it is not to be thought of as a defeat.

Diversify

According to Dubini and Aldrich[51], the diversity of entrepreneurs' networks is crucial to the scope of opportunities available to them. Information about new business locations, potential markets for goods and services, sources of capital, potential investors and innovations is likely to be spread widely among individuals. This implies that someone with a small set of overlapping relationships is at a disadvantage when competing for information with someone with a large set of divergent ties. However, it is not easy to diversify; there are social barriers to stifle human connections. Although the geographical distances are shrinking due to technology, the social distances caused by culture, language and distrust are still there[52].

Role Model

It has been demonstrated that a first step in approaching a new role or a new behavior is to be able to associate oneself with a role model possessing this behavior. Culture can be learned by imitating people similar to us or imitating people that are admired as socially dominant[53,54]. Role models are therefore powerful tools for learning new behaviors. One of the most powerful ways to change someone's behavior is to have them spend time and listen to someone whom they want to emulate[55].

In a good mentoring relationship, the mentor can be a role model through both words and actions—assuming the mentor is an entrepreneur with experience and the mentee is a newer entrepreneur. Entrepreneurs are constantly breaking rules and making mistakes in an effort to drive their businesses forward. As a new entrepreneur, this is challenging; having a mentor in this process can be invaluable. Entrepreneurs are a role model for how other entrepreneurs should see and deal with ethics in entrepreneurship.

Believe

An important concept related to belief is self-efficacy. The construct of self-efficacy was introduced by Bandura[56] and represents one core aspect of his social-cognitive theory[57]. Perceived self-efficacy is concerned with people's beliefs in their ability to influence events that affect their lives. This core belief is the foundation of human motivation, performance accomplishments and emotional well-being. A me-

ta-analysis concerning the relationship between self-efficacy and work-related performance indicates that there is a significant weighted average correlation[58]; i.e. persons with a high belief in their ability to influence events demonstrate higher work-performance than those with a low belief.

It has also been found that a strong sense of personal efficacy is related to better health, higher achievement and more social integration. If people believe that they can take action to solve a problem instrumentally they become more inclined to do so and feel more committed to this decision[59].

Perfection Vs Good Enough

It is important for entrepreneurs to understand that perfection can be harmful, not because of the perfect result but because perfection usually requires time, and timing can be more important than a perfect result. An idea can always be changed or altered to make improvements. In the book The Art of the Start, author Kawasaki[60] explains that entrepreneurs should "fix, ship, fix, ship," rather than "fix, fix, fix, ship." The idea will constantly be improved. Bird Dunn states, "Perfection is the enemy of completion." Reid Hoffman, founder of LinkedIn, says, "One of the metaphors that I use for startups is you throw yourself off a cliff and assemble an airplane on the way down." This implies that you cannot wait for the plane to be perfect; it has to be assembled quick and with an aim to be good enough for flying.

Collaboration

Collaboration can be performed in different flavors; there can be collaborations between individuals who build the teams in businesses. Financial and human resources often seem to be the most critical for a successful launch of the venture and these resources tend to be closely interrelated. When new ventures apply for early stage venture capital funds, potential investors always evaluate the project by searching for a well-balanced team with sufficient business experience[61].

There can also be collaborations between competing companies, called co-opetition, which is defined as a strategy embodying simultaneous cooperation and competition between firms[62]. Collaboration in business today is more of a survival trait than a buzzword. Because competing firms possess relevant resources and face similar pressures, collaboration with competitors enables firms to acquire and create new technological knowledge and use the knowledge in pursuit of innovations[63]. Increased popularity of co-opetition is evident by the fact that over 50% of collaborative relations (strategic alliances) are between firms within the same industry—that is, among competitors[64]. Recently, scholars have suggested that especially small businesses in an industry need to collaborate with competitors so that they can create economies of scale, mitigate risk and leverage resources together[65].

VI. THE GAME-BASED TEACHING APPROACH

The Berkeley Method of Entrepreneurship includes behavioral training as well as reflections on mindset. For this, an inductive game-based teaching approach is used. Various games, referred to as the Berkeley Method of Entrepreneurship games, have been developed. A game can be defined as a structured playing, usually undertaken for enjoyment and sometimes used as an educational tool[66]. Or a game may be described as an "artificial situation" in which players engage in an artificial conflict against one another or all together against other forces. Games are regulated by rules, which may take the form of procedures, controls, obstacles or penalties[67]. Furthermore, four key components of games are goals, rules, challenges, and interactions. For the Berkeley Method of Entrepreneurship games this implies:

- Goals: A preset objective, aligned with the teaching objective
- Rules: Limitations on how to achieve the goals
- Challenge: Competition and use of skills to reinforce behavior
- Interaction: A setting for players to interact, communicate and enjoy the process

The idea is to let the games invoke a certain behavior or mindset in the student—for example, Story Telling (behavior-2) or Good Enough (behavior-9). After the game, the students should reflect about their own behavior and compare it with that of successful entrepreneurs. The result of the reflection can be either an ignition for the student (confirming that he/she wants to become an entrepreneur), an extinguisher (confirming that the student does not want to be an entrepreneur) or a wake-up call (ok, I need to learn more about this mindset).

Examples of games that can be used to invoke a specific behavior and games that invoke a set of behaviors are given below. Behavior-10 "Collaboration" involves group-dynamics. Win-win games emphasize the importance of cooperation, fun, sharing, caring and over-all group success in contrast to domination, egoistic behavior and personal gain. A game invoking this behavior was used in a marketing course in the Technology Business program at University of XX, Finland[68]. Students were given a problem to solve related to marketing communications of a local technology SME. The student teams competed against each other and, ultimately, the best solution would win. A faculty member initiated the collaboration between students and the firm; after the first introduction, students were on their own to build a relationship with the firm representatives. The students' first task was to negotiate the team building, or how to select members for a team. Ideally, teams should have been truly multidisciplinary, so that the members bring a wide variety of experiences and expertise to the team. The next step was to further identify the exact problem with the firm's marketing communication. Altogether, five teams, each with four to five students, continued to work for three weeks and presented their solutions in a final seminar to the panel of judges, consisting of faculty members and the founder/CEO and marketing manager of the firm. The first prize was actually given to two teams, which had also collaborated with co-opetition; that is, they had shared their memos from initial meetings with the CEO, which allowed them to identify the problem faster and proceed to analyze alternative courses of action, formulate strategy and implement strategy.

Behavior-1 "Pay-It-Forward" is the behavior of "asking the beneficiary of a good deed to repay it to others instead of the original benefactor." It has been used in an educational activity at Lund University, Sweden. In the Technology Management program[69], the students were asked to "assemble as much money as possible within 6 hours, and donate everything to charity." The students were free to come up with whatever (non-violent, fair, honest) idea of how this should be accomplished, but they only had six hours. The students were split into two competing teams of 20 students each where the team that assembled the most money won. When the activity was over, the students were asked to reflect about how they felt before, during and after the activity. This forced them to think about their attitude to the pay-it-forward behavior and their attitude of doing something that does not immediately give them any rewards or pay offs.

A multi-behavior "Scavenger game" has been used in educational activities initiated by UC Berkeley[70]. In this game, each team had five members, two of which were placed in a control room and three of which were part of the field-group. The field-group and group in the control room could only communicate via voice using a simple phone (no sms, texts, emails, videos etc). The group in the control room had no access to the Internet. A five-liner instruction was given to the group in the control room. These instructions had to be communicated to the field team, whose task was to find a location and take a picture of it. The field group that provided the correct picture first was the winning team. The task seems easy, except that the five lines of instructions were given in a different language (e.g. Chinese, Russian, illustrations, Korean or Finnish). In this game, an important behavior for the group in the control room was to be a Story Teller (able to communicate the shapes of the letters in the instructions), and for the field group to be able to demonstrate Collaboration skills, e.g. each student working on the translation of one instruction. Furthermore, the teams had to appreciate Diversity in the people they encounter in order to have someone to help them with translation. As soon as they thought they knew a location that

fulfills the instructions, they went there and took a picture of it. After completing the game, the students were asked to reflect about their own contributions, what behavior they felt comfortable with, and what behavior they needed to practice more. The students also reflected about the strategies used by the different teams and their respective advantages and disadvantages.

VII. FUTURE RESEARCH

The teaching and learning approach used in the Berkeley Method of Entrepreneurship is already in use in engineering entrepreneurship education at UC Berkeley and the first feedback from students and instructors is positive. However, the method is still under development and further research is required. A current study is being performed with the aim of confirming or rejecting each of the ten behavioral patterns that characterize a successful entrepreneur. An empirical study among a group of international students participating in a global entrepreneurial boot camp is planned to take place in the fall of 2015. As encouraged by Verzat et. al.[71], research is also being conducted in the area of games. The research concerns tuning existing games, designing additional games and assessing the suitability of games for reinforcing behavioral patterns. The research project is being performed in the Global Venture Lab Network at UC Berkeley, which includes approximately 25 universities from all continents[72].

VIII. CONCLUSIONS

The Berkeley Method of Entrepreneurship is a holistic and student-centered teaching and learning approach that is hypothesized to enable engineers to be more entrepreneurial. It is currently under development. It encompasses three main elements: networks, mindset and frameworks. Entrepreneurship is an essential ingredient for economic development for any country. Schools, colleges and universities can help foster and accelerate the formation of successful entrepreneurs by including entrepreneurship in their curricula, as is done by many schools, colleges and universities today. Most entrepreneurial curricula include the two traditional elements of networks and frameworks; however, very few curricula explicitly include the mindset perspective.

The Berkeley Method of Entrepreneurship is based on the hypothesis that the mindset of successful entrepreneurs can be characterized by a distinct set of behavioral patterns and that an inductive game-based teaching approach is the best vehicle to introduce and reinforce these patterns in students. A list of ten behavioral patterns that captures the mindset of successful entrepreneurs is presented and a game-based teaching approach is used to let the students explore their current mindset and compare it with that of entrepreneurs. The result can be an ignition for the student (yes, I want to be an entrepreneur), an extinguisher for the student (no, entrepreneurship is not for me) or a wake-up call (ok, I need to learn more about this mindset).

The pedagogy of the Berkeley Method of Entrepreneurship is inductive in its nature and thereby focused around learning rather than teaching. The students are pushed to proactively develop their own understanding rather than to wait for someone to teach them what they need to know. The students are trained to frame problems and find ways to solve them and then reflect on what they have learned from the process, or the outcome of a game.

The Berkeley Method of Entrepreneurship has already been used in engineering entrepreneurship education at UC Berkeley. The first feedback received from students, instructors and visiting scholars is positive. Nevertheless, the underlying hypotheses have to be further investigated and validated. Current research therefore aims at the following: confirming or rejecting each of the set of behavioral patterns, tuning existing games and/or finding additional games that reinforce the behavioral patterns

and finding ways to measure the success of the game-based teaching approach in entrepreneurial curricula.

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Mixing Engineering, Business and Design Students in an International Cross-Disciplinary Course on Innovation

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International Market Driven Engineering (iMDE) is an international course on innovation where Swedish and Chinese engineering students are mixed with business and design students. The course is run on a yearly basis, is six weeks long and takes place in China. Both the development and the execution of the course are created as a joint project between the Swedish and Chinese instructors. The course contains lectures, coaching sessions, company visits and an innovation-project performed in teams. The course aim is to expose students to the innovation process and international collaborations, and to open their eyes to entrepreneurship. Pertex analysis reveals that the students highly value the international collaboration in the innovation-project. The number of startup companies formed by the students has also increased with the introduction of the iMDE-course.

Keywords: cross-disciplinary, international, innovation, market-driven engineering

I. INTRODUCTION

The world is becoming more international. Cutting edge marketing knowledge and engineering are becoming valuable assets on the job market in this global world. There is a lack of people with skills in both fields with the ability to connect market needs and innovations with product development, especially in an international context. International Market Driving Engineering (iMDE) is aimed at providing this knowledge and these skills. This text is taken from the course homepage[1] and is the first presentation of the course that the students are exposed to. In essence, the course aim is to expose students to innovation processes and international collaborations, and to open their eyes to entrepreneurship[2].

Figure 1: The logo used for the iMDE course, a cross-disciplinary (Technology and Management) course on innovation.

The course International Market-Driven Engineering is a joint course collaboration between Technology Management at Lund University Sweden (LU) and three schools at Zhejiang University China (ZJU). The course is developed within the framework of LU-ZJU JCIE (Joint Centre for Innovation and Entrepreneurship) and co-funding was received from STINT (the Swedish Foundation for International Cooperation in Research and Higher Education). The course aims at making it possible to intertwine the disciplines of Technology and Management in Sweden and in China in four ways: Students, Teachers, Subjects and Cultures. Design is also included in the course and is considered part of the Technology discipline.

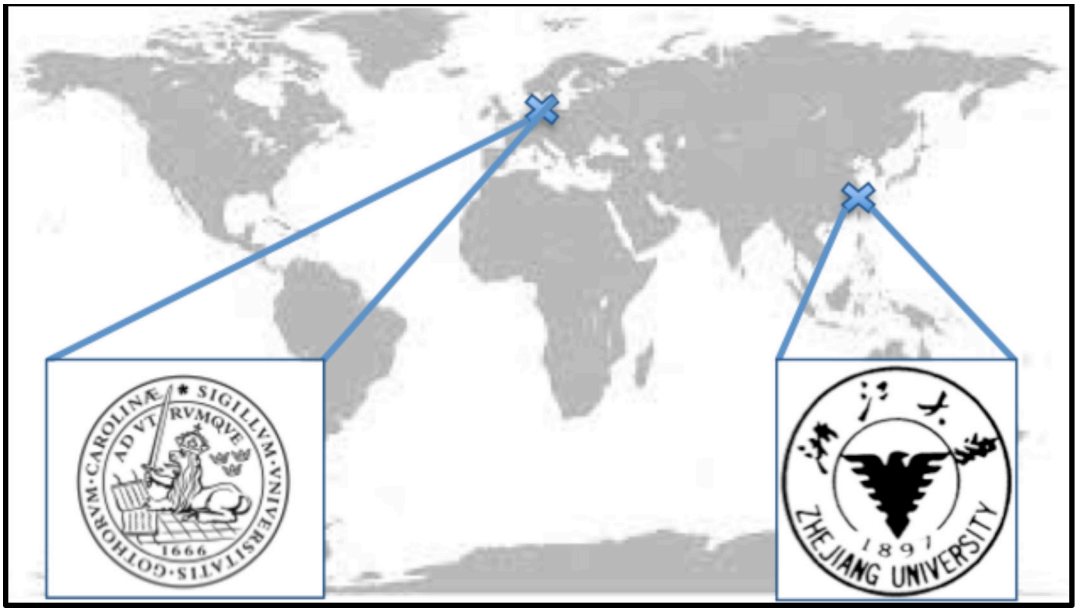

Figure 2: The course is a joint venture between Lund University, Lund, Sweden (upper-center marking in the figure) and Zhejiang University, Hangzhou, China (middle-right marking in the figure).

Swedish and Chinese instructors jointly developed the course in 2011/2012. They designed the course to be six weeks long, take place in China and use English as the course language. It was held for the first time in fall 2012 and attracts about 80 students (40 Swedish and 40 Chinese). The course has also been held in fall of 2013 and 2014.

During the course, the students work in eight teams. They work in mixed teams of about eight to ten students fully mixed between faculty, country and gender. The task of each group is to invent, design and prototype a product associated with a specific theme. The themes were 'helping every day life' in 2012; inclusion in 2013; and Cars and Clean Air in 2014. Each group develops a business plan, a marketing movie and a group-development movie.

After the first run of the course, a Pertex analysis[3] was performed in addition to the standard course evaluation. For the Pertex analysis, the students were asked to produce a text about the course in accordance with the Pertex methodology. The texts were run through the Pertex analysis and analyzed according to three dimensions: Swedes-Chinese, Engineering-Business and Male-Female. The Pertex analysis reveals that the students perceive the course partly alike and partly different.

This paper presents the iMDE course and its outcome (the yearly eight inventions); the paper also presents the evaluation results from the Pertex analysis. Reflections about how the course can be further improved are provided, thereby increasing the chances for the students to continue working as entrepreneurs. The last part of the paper presents the conclusions.

II. THE IMDE COURSE

Development Phase

The idea of developing an international course with focus on innovation was born in 2011. After initial discussions at the respective universities—Lund University in Lund, Sweden and Zhejiang University in Hangzhou, China—the course development began. The instructors that displayed interest in the course agreed that the design, development and execution of the course should be a collaboration project; they became role models for the students that later collaborated in project teams.

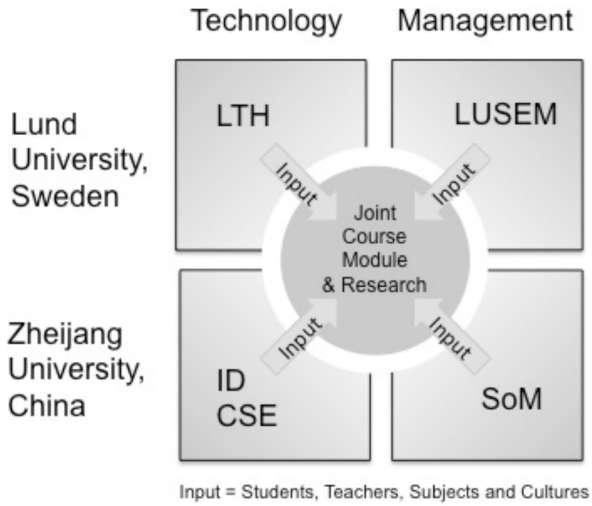

Figure 3: The parties involved in the iMDE course (iMDE-parties, 2013). From Sweden, LTH and LUSEM are involved. From China, ID, CSE and SoM are involved (ID = Industrial Design, CSE = Control Science and Engineering, SoM = School of Management).

The course intertwines the disciplines of Technology and Management in Sweden and China in four different ways: Students, Instructors, Subjects and Cultures.

For Subjects, the focus is on Innovation and Product Development, a subject that is of great relevance from the technical, economic and management aspects. The course contains both lectures and a project. For the Swedish students, the course also contains a few lectures on Chinese culture. At the end of the course, the students present their project through a written project report, a film and an oral presentation. The course is given to the 40 students from the Technology Management Program at Lund University (20 from LUSEM and 20 from LTH)[4,5] together with a minimum of 20 Chinese students (10 from SoM and 10 from the technical departments (ID and CSE)). Instructors from both Sweden and China in Engineering (LTH, ID and CSE) and Management (LUSEM and SoM) will be involved in the lectures. A minimum of two teachers with different aspects of the subject matter will be present at each lecture. The cultural aspects of project management and business behavior will be treated in the course and practiced in real life through the course project.

The design of the course took place during the academic year 2011/2012 and consisted of two face-to-face meetings lasting two days each and 16 Skype teleconference calls lasting one to two hours each. Between the teleconference calls, the instructors had time to develop their own teaching material and confirm setup with administrative personnel. Both of the face-to face meetings took place at Zhejiang University, China, allowing the Swedish instructors to also examine housing possibilities for the Swedish students.

Execution Phase

The course has been run on a yearly basis since 2012. It is held over six weeks, starting in early September and ending in late October. The students taking part in the course are split into eight mixed groups, each consisting of a mix of Swedish and Chinese students; Technology (including Design) and Business students; and Men and Women.

2012
37 Swedish students
- 18 from LTH
- 19 from LUSEM

33 Chinese students
- 12 from ID
- 12 from CSE
- 9 from SoM

2013
39 Swedish students
- 20 from LTH
- 19 from LUSEM

42 Chinese students
- 12 from ID
- 15 from CSE
- 15 from SoM

2014
40 Swedish students
- 20 from LTH
- 20 from LUSEM

25 Chinese students
- 6 from ID
- 8 from CSE
- 11 from SoM

Figure 4: Cohorts from the years 2012, 2013 and 2014 respectively.

The students that participate in the course have a set of ten lectures, providing them with materials and knowledge related to the innovation process. These include market analysis and inspiration; ideation, implementation and prototype development; and marketing and sales. The students also have access to coaching sessions where they can discuss their projects with the instructors. The course also includes two company visits.

In addition to the lectures, the students practice the innovation process in real life though the execution

of a project. The students work in eight international and cross-disciplinary teams of eight to ten students per group. The teamwork gives the students valuable insights into and experience with working in an international context. The groups are responsible for running a project of their own within a common theme. The theme is relatively open to allow ample room for the students to define a specific topic for their group. The deliverables from the student groups are:

- A market and business plan for their product
- A physical prototype of their product
- A marketing film for their product
- Documentation of the group process by filming their work along the way
- An oral presentation of their market and business plan
- A written report containing a market and business plan

III. OUTCOME

At the final presentation of the course, each student group makes an oral presentation of about 15 minutes. At the presentation they should argue their innovation from the three perspectives of Feasibility, Viability and Desirability. These three perspectives mirror the three central characteristics of a successful innovation and highlight the importance of collaboration between design, business and engineering students.

While engineering students know if and how a technical innovation can be brought into reality (feasibility), management students can determine the market and financial aspects of bringing an innovation to the market (viability) and design students can make sure the innovation is experienced and presented in an attractive way (desirability).

2012: Helping every day life

Naptop – sleep comfortably in public places on top of your laptop.
Beddy Teddy – a teddybear for children connected to the parents' cellphone.
iLock – maintain control of your computer while taking small breaks.
SoLED Lights – a safety product for e-scooters.
EAchair – elderly accessible (EA) chairs for public places.
Onewake – waking the user up in a quiet way.
EasySpace – everyday life recycling made easy.
PoPo – a photo-receiving phone making interaction with family members easy for elder people.

2013: Inclusion

UniteMe – a service for foreign students coming to a Chinese university.
BraceMe – baby monitoring making parents more involved in their baby's life.
BackApper – help backpackers meet and find activities.
MoveYouSeeMe – increasing road safety through the use of reflective earphones.
CharmExpress – instant beauty for everyone, anywhere and anytime.
EasyFeel - accurate measurement for visibly impaired.
ActiWe – making friends though activity.
iStick – adding technological features to the classic wooden stick.

2014: Cars and Clean Air

Aware – driving monitoring.
SlimShady – electro chromic shades that make you see.
VEM – improving the driver's ability regarding eco-driving.
The Modular Car – different sizes at different occasions.
Playground – educating all family members.
Eco Bonus Program – instant feedback regarding eco-driving performance.
EcoSense – develop the environmental friendly driving skills.
Portable AC system – ecofriendly air-conditioning system to use in the car as well as elsewhere.

Figure 5: The eight yearly inventions resulting from the iMDE-course. Each invention (left side) is also described in words (right side).

IV. PERTEX

The Pertex analysis[6] is best described as intuitive text-analysis. As opposed to traditional analysis methods, Pertex uses the text writer's frame of reference as found embedded in the text, rather than

translating to categories defined by the analyzer. Pertex uses three axiomatic human functions as the basis for analysis: objective, action and orientation. A writer writes based on his/her objectives, actions and orientations to the phenomena at hand thus producing a "fingerprint" of the text. Pertex deciphers this fingerprint thereby revealing the writer's frame of reference.

For the Pertex analysis the students were asked after the course to produce a text about the course in accordance with the Pertex methodology. The analysis setup consists of three dimensions each with two groups: Swedish-Chinese, engineering-business and male-female. The texts of the respondents have been run through a Pertex analysis for each of the eight analysis groups of (2^3 groups). The Pertex analysis reveals a nuanced picture of the meaning and utility of the course. The means of the course for seven of the groups is cooperation, teamwork, mixing of cultural backgrounds and educational background[7]. The single most wanted addition to the class involved social interaction between the working groups in the class.

The Pertex analysis further reveals that the students' take-away from the course differs most in the dimensions in the following order, arranged from most to least:
a) Attitude: (Positive – Negative). One group stood out with 2 distinct subgroups (Swedish Female Engineers). The subgroups differ in attitude toward the course: positive and negative hence affecting the whole analysis. Our view is that the explanation is found on an individual level and has nothing to do with Swedish Female Engineers as a category.
b) Home University: (Swedish –Chinese) Swedish students found more overlap with prior courses than did the Chinese students. Otherwise no major differences were found on this country/cultural dimension.
c) Major: (Engineering – Business) Business students reasoned more around goal and problem solving that did the engineers.
d) Gender: (Male – Female) Little differences were found relating to gender.

V. DISCUSSIONS

In short, the course aim is to expose students to the innovation process and international collaborations and to open their eyes to entrepreneurship. Did it succeed in its attempts?

Understanding The Innovation Process

The term innovation can be defined as "the application of better solutions that meet requirements or needs"[8]. Innovations could of course be sprung out of research; but they could also very well be based on new insights or market-discoveries. The latter type of innovations could be generated by undergraduate or graduate students as well as by senior researchers[9]. The iMDE-course includes aspects such as Inspiration-Ideation-and-Implementation from the innovation-process. Through the innovation project, the students gain hands-on experience on the three aspects.

Views On International Collaborations

Samples of the students' feedback on the aspect of international collaboration states:

- "The best with the course was to meet students from other country and different culture."
- "I think how to work in a group with different culture and in a free environment is the best thing. As a group, we should overcome the language, the culture, a lot of difference between two countries. But we worked well and understood each other very well."

- "In my opinion, the group work mixed with different professional background students from different countries is most attractive."
- "The cultural differences became very clear clear in the course, this gave us a possibility to learn from each other. By working in this cross-cultural setting I was given an experience and a possibility for learning that I believe I will never again get. Thank you!"

The feedback indicates that many of the students learned a lot from the international collaboration setup used in the course. Many of the students will work in international contexts after graduation, implying that the experience is valuable independently of their career path (entrepreneurs or not). This is also confirmed though the Pertex analysis[10]. The overall result reveals that there is an overwhelming advantage to mixing groups of students in many dimensions for academic work involving innovation, business planning and marketing. Hence, international collaboration is strongly recommended because it has proven to be very appreciated.

Impact On Career Choice

To find the frequency of entrepreneurship, we compared Swedish students from the three years who had taken 14 Technology Management classes prior to iMDE to those who did not enroll in iMDE. This revealed that, before the introduction of the iMDE course, ≤1 of 40 students (one student every other year) pursued an entrepreneurship career directly following graduation. In the three classes taking the course, 1-4 out of 40 chose entrepreneurship, an increase of about 500%. The course increases the number of startups among the students.

Possible Post-Course Improvement

One of the groups from the 2012 cohort continued collaborating after the course and have since applied for and received a patent in China. This work was all performed outside of their studies.

Presently, there is no help for students that wish to continue their work on innovation. It would be helpful to create a succeeding course on entrepreneurship that interested students could take. In this course, they could move forward with their invention and learn about fund-raising, pitching and entrepreneurial mindsets. These are aspects that are currently not included in the iMDE course.

VI. CONCLUSIONS

The world is becoming more international. Cutting edge marketing knowledge and engineering are becoming valuable assets on the job market in this global world. There is a lack of people with skills in both fields with the ability to connect market needs and innovations with product development, especially in an international context. International Market Driving Engineering (iMDE) is aimed at providing this knowledge and these skills.

The iMDE course was developed 2011/2012 and has since been run on a yearly basis. The course is six weeks long, takes place in China, and uses English as the course language. In the course, the students are grouped in eight teams of eight to ten students each. Each group consists of a mix of: Swedish and Chinese students; technology and business students; and men and women. For a course that strives to encourage innovations, it is vital to have diversity among the students. In the iMDE course, the diversity is manifested in terms of gender and different academic and national backgrounds.

	Total number of students	Swedish/Chinese	Technology/Business	Male/Female
2012	70	53% / 47%	60% / 40%	54% / 46%
2013	81	48% / 52%	58% / 42%	57% / 43%
2014	65	61% / 39%	52% / 48%	33% / 67%

Table 2: Gender, Academic Background and National Background Cohort Diversity Across Three Years

The course intertwines the two disciplines of technology and management in Sweden and China in four ways: students, teachers, subjects and cultures. Design is considered part of the technology discipline. The mix of design, business and engineering students is a powerful combination because knowledge in these three disciplines mirrors the three central characteristics of a successful innovation: feasibility, viability and desirability.

Each year, the outcome of course is a set of eight inventions. However, most important is the increased knowledge, understanding and interest in innovation processes and entrepreneurship that the students gain upon completion. The increased interest is confirmed by the Pertex analysis and through the increased number of students that continue the innovation path and create startups.

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