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Open Source, Open Vision: The MakerPro Network and the Broadening of Participation in Setting Taiwan's IT Vision Agenda

Guo Freeman, Jeffrey Bardzell & Shaowen Bardzell

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Guo Freeman,[1] Jeffrey Bardzell,[2] and Shaowen Bardzell[2]

[1] *Clemson University, USA*
[2] *Indiana University, USA*

HCI recognizes the importance of visions as both a design and futuring approach and a problem-solving technique. One challenge of visioning work is who can propose and shape IT visions and how they can achieve the widespread buy-in needed to make them efficacious. In this paper, we focus on the potential of making, open design, and open manufacturing for contributing toward, if not fully achieving, the broadening of participation in IT envisioning. We use Taiwan's MakerPro, a manufacturers and IT R&D community as a case to unpack what collective IT visioning looks like, how it shapes IT agendas concretely, and the implications for open design/open manufacturing research agenda in HCI. Our findings reveal how MakerPro members constructed and developed visions for open design and open manufacturing in Taiwan, obstacles to such visions, and how these obstacles can be collaboratively overcome through a participative and even democratic process. We also show that the collective purposiveness not only defines a regional vision agenda but also embraces an entire nation's future.

Guo Freeman (guof@clemson.edu) is an HCI and social computing researcher. Her research focuses on social dynamics forged surrounding technological objects and collaborative systems, including computer-mediated interpersonal relationships, team dynamics, and collective innovation; she is an assistant professor in the School of Computing at Clemson University. **Jeffrey Bardzell** (jbardzell@indiana.edu) is an HCI and interaction design researcher. His research foci include research through design, user experience and aesthetics, and digital creativity, with particular emphases on critical design and design criticism; he is a professor in the Department of Informatics at Indiana University School of Informatics, Computing, and Engineering. **Shaowen Bardzell** (selu@indiana.edu) is an HCI and interaction design researcher. A common thread throughout her work is the exploration of the contributions of feminism, design, and social science to support technology's role in social change; she is a professor in the Department of Informatics at Indiana University School of Informatics, Computing, and Engineering.

1. INTRODUCTION

Design and manufacturing have become opened up to increasingly democratized technological practices and new cultural ways (Lindtner, Bardzell, & Bardzell, 2016; Tanenbaum, Williams, Desjardins, & Tanenbaum, 2013; Fuchsberger, Lindtner, Murer, & Tscheligi, 2015a, b). Through these new practices, traditional technology users are taking up new roles, including that of the "creative appropriator, hacker, tinkerer, artist, and even co-designer or co-engineer" (Tanenbaum et al., 2013, p. 2609). Meanwhile, grassroots making and industrial production are reshaping societal, economic, and political processes, which dramatically influences how work forces, innovation, and power are distributed (Fuchsberger et al., 2015b). As a result, technological innovations are increasingly framed as sociopolitical agendas and not merely a technical issue agendas (Lindtner et al., 2016). Previously peripheral economies are rising as sites of both technological and cultural expertise that no longer split manufacturing and design innovation by geographies (Freeman, Bardzell, & Bardzell, 2018; Lindtner, 2015).

These new phenomena raise research questions that interest HCI researchers concerned with bottom-up innovation and democratizing technologies, such as: What alternatives emerge at the intersection of open design and mass production that might challenge existing market-driven structures? How is the global call for cultivating makers and entrepreneurs shaping both factory work and creative work? And how do makers and manufacturers collectively seek to configure, crowdsource, and develop a vision of open design and manufacturing that lead to their technological innovation? In fact, HCI as a field has long sought to support technological innovation (e.g., Culén & Følstad, 2014; Freeman et al., 2018; Lindtner et al., 2016; Lindtner, Hertz, & Dourish, 2014).

Prior research has suggested two broad ways by which HCI advances innovation—by articulating and pursuing a technology agenda and/or a vision agenda (Bardzell & Bardzell, 2014). A *technology agenda* focuses on developing effective computing systems and IT products leveraging emerging technical capabilities. An example of a technology agenda is computing's loosely coordinated development of theories, methods, technologies, user research, and technical protocols and standards in support of emergent technologies such as Internet of Things (IoT). Technology agendas are concrete, substantive, and actionable, and they thereby facilitate widescale collaboration in pursuit of its goals. In contrast, a *vision agenda* constitutes a broad sociotechnical vision, a desirable future influenced and even partly made possible by the realization of one or more technology agendas. Such a vision includes "new ways of thinking about information, interaction, and everyday human life" (Bardzell & Bardzell, 2014, p. 780). Vision agendas speculate, identify, and/or propose alternatives, which would shape both societal and technical ways of being for generations. An example is Weiser's vision of ubiquitous computing, which arose from and contributed to technology agendas, but which itself was something different: part technology prediction and part storytelling, even myth

creation. The vision agenda is normative, seeking to imagine what it would be like to live in a world where near-future technologies are mundane, choosing the more desirable from among those imaginaries, and seeking to shape technological agendas accordingly. Vision agendas also have the potential to shape massive investments from industry, government, and the research community.

We note that the establishment of vision agendas has, in the past, been largely limited to those in certain types of organization: research labs of IT multinationals, research universities, and government policy and funding agencies. Mark Weiser (1991), situated in Xerox PARC at the height of its influence, is an instructive example. However, the advent of global making/DIY culture, open source movement, technology startups, and seed accelerators (e.g., Bardzell, Bardzell, & Ng, 2017; Freeman et al., 2018; Haines, 2014; Lindtner et al., 2016, 2014; Tanenbaum et al., 2013) presents a different story; that is, the creation of the vision agenda is now decentralized and performed by a loosely connected collective. A case in point is the phenomenon of open design and open manufacturing. It is relatively easy to anticipate that digital fabrication, hacking and making, the digitization and robot-icization of manufacturing, and so forth will all be important in the coming years. Less easy to anticipate is how exactly they will come together and how to position different stakeholders—multinational IT firms like Intel, academic IT researchers, manufacturers, entrepreneurs—in the best ways.

In this paper we consider the roles of one such stakeholder—Taiwan's IT R&D community—in fostering, shaping, and envisioning the future of open design and open manufacturing in Taiwan. Taiwan is globally recognized for its precision manufacturing and has long been a leader in high-end consumer electronics engineering (Freeman, Bardzell, & Bardzell, 2017). But as sophisticated manufacturing continues to spread across the globe, Taiwan's dominance is threatened, and its manufacturers and IT R&D communities are seeking to develop a vision agenda for Taiwan. We have conducted an empirical study of one such network in Taiwan, known as MakerPro. We explore how a distributed collection of IT thought leaders, including makers and manufacturers, are collectively seeking to configure, crowd-source, and develop a vision of open design and manufacturing, which will guide the future of Taiwan's manufacturing-dependent economy in a new global order. Their agenda is more than a technical agenda; we argue that it is a vision agenda, in the sense that it emphasizes everyday life in Taiwanese society, rather than the specifics of technological development.

The present study has a number of contributions: First, we offer empirical evidence of how a distributed online community, following a culturally specific conception of democratic participation (i.e., Taiwanese makers' commitment to the open innovation model, with its implicit alignment with California IT libertarianism and contemporary neoliberalism), collaboratively developed an IT vision agenda. Such an agenda directly affects how an entire country perceives, envisions, and understands its future and technological development. Our findings show that the mechanisms of open design and open manufacturing have been adopted and

combined with social media and social movements in Taiwan to open up and (at least somewhat) democratize the process of constructing a vision agenda. Second, our data suggests that the underlying values of open design and open manufacturing structure ad hoc and distributed online organizations; and it also outlines the resulting vision agenda for Taiwan's economically important manufacturing and IT innovation sector as a kind of outcome of open design and open manufacturing thinking. This understanding sheds light on the intersection of people, technology, and politics and highlights the role of open design and open manufacturing in collectively envisioning and developing the future of societies and technologies.

2. VISIONS, HCI, AND OPEN DESIGN/MANUFACTURING

"Visions" have been regarded as a crucial component to stimulate and sustain a successful business in the fields of Business and Management Science. Lipton (1996) summarized five ways that visions can benefit an organization: enhancing performance measures; promoting changes; providing basis for strategic plans; motivating individuals; and keeping decision making in context. Similarly, Collins and Porras (1991) pointed out that a shared organizational vision is the key to promote innovation, accelerate decision making, and increase the sense of responsibility of people at all levels in a more democratic (or decentralized/flattened) organizational structure.

A vision can be loosely interpreted as "an over-arching concept under which a variety of other concepts are subsumed" (Collins & Porras, 1991, p. 32). A powerful vision should be concise, clear, abstract, challenging, future-oriented, stable, desirable, and inspiring (Kantabutra & Avery, 2010). Therefore, a vision should focus on the future but provide an enduring and concrete foundation for the present. It can be ambitious, which paints an ambiguous and sometimes surprising image of what the organization will do; but it is also realistic, making people believe that this image is recognizable and legitimate (Lipton, 1996).

A few approaches have been proposed to build effective and powerful visions. One is to emphasize three themes of visions (Lipton, 1996):

1. *mission* or *purpose* that addresses the fundamental reasons why a certain organization/business exists and what its ultimate goals and expectations are;
2. *strategy*, including actions and approaches to achieve the mission or purpose;
3. *culture*, which refers to the shared organizational values that direct and sustain the former two.

Another approach is to construct visions as two interdependent components: a *guiding philosophy* in the context of an expected and desirable future; and a *tangible image* that help people visualize the philosophy (Collins & Porras, 1991). Specifically, a guiding philosophy refers to a system of fundamental motivations, assumptions,

principles, and core values that guide the organization's decisions, policies, and actions throughout all phases of its evolution. In contrast, a tangible image includes both a *mission* that explicitly explains the efforts of the organization and a *vivid description* that depicts the mission in an exciting and engaging way.

The notion of visions has also been introduced to sociotechnical studies and become an important research topic in HCI. In Science and Technology Studies (STS), a related concept is *sociotechnical imaginaries*, which is often used to describe how visions of scientific and technological advance lead to implicit expectations and beliefs about public purposes, collective futures, and the common good (Jasanoff & Kim, 2015). Yet such imaginaries are more futuristic, less grounded in historical memory, and "less explicit, less issue-specific, less goal directed, and less politically accountable" (The sociotechnical imaginaries project, 2007). Segal (1985) summarized 25 visions of technological utopia in American culture from 1883 to 1933 and pointed out that these visions featured quantitative not qualitative differences from the present—"they multiplied what they saw as the outstanding contemporary trend and predicted the greater and greater advance and spread of technology" (p. 21). Yet such visions did not emphasize the abundance of machines and structures but "an increasing use of technology in establishing and maintaining an entire society" (p. 21). As a result, these visions of technology became a type of technosolutionism: they were expected to address the principal problems of the present and eliminate all problems forever in the future (Segal, 1985). In HCI, visioning/envisioning has been extensively used for imagining and demonstrating conceptual innovation and prototyping (Grudin, 2017), which often not only encourages the emergence and deployment of future technologies ("the technology agenda") but also introduces new challenges, expectations, reflections, and aspirations due to the intertwining relationship among people, technology, and society ("the vision agenda").

Some influential visions in the history of HCI include Licklider's vision of human-machine symbiosis in 1960 that brought computers into the formulative parts of technical problems; McCarthy and Strachey's vision of individual/personal computers in 1964 that promoted interactive computing through time-sharing; Ivan Sutherland' vision of computer graphics in 1963 that made computers more approachable and user friendly; Engelbart's vision of augmenting human intellect in 1962 that highlighted the potential for computers to increase people's capability to approach complex problems; and Weiser's vision of ubiquitous computing that predicted a world where computers would be present everywhere but invisible (Grudin, 2017). In particular, Weiser's (1991) ubiquitous computing later largely affected a few emerging visions, such as visions of virtual reality (VR), artificial intelligence (AI), and machine learning. In these society changing visions of future, VR technologies would shape how people work, live, and interact in everyday life (Reeves, 2012); the shift from direct symbolic expression to inferred statistical models of the world through AI and machine learning techniques would transform "the nature of the relationship between interactive digital systems and the people that use them" (Blackwell, 2015, p. 175), making data sources, authorship and

agency, politics and policies, and identity crises in digital lives new challenges for designing and using such systems.

In summary, HCI acknowledges and recognizes the importance of visions as both a design and futuring approach (Bardzell, 2018) as well as an approach to problem solving (Oulasvirta & Hornbæk, 2016). On the one hand, envisioning has been considered significant in HCI because it "mixes fictions, forecasts, extrapolations or projections into societal visions for technological progress" (Reeves, 2012, p. 1573); in other words, visions provide aspirational images of the potential future of existing sociotechnical systems and the emergence of new systems. They also offer rationales and promising directions about "what to design, what not to design, and how to design" (Reeves, 2012, p. 1579). On the other hand, studying visions highlights the nature of HCI research as problem-solving, which embraces all three types of main problems in HCI (Oulasvirta & Hornbæk, 2016): visions are empirical since they endeavor to create or elaborate how real world phenomena would be related to human use of computing; they are conceptual because they provide the future society with theories, models, and concepts as well as assumptions and expectations of potential consequences; they are also constructive because they contribute to understanding and constructing of one (or more) interactive artifacts and systems for future use.

A key challenge of visioning work is the question of who can propose and shape IT visions. Historically, visions have been largely produced by renowned research labs in industry, academics and scholars in research universities, and government bodies and funding agencies. Similarly, sociotechnical imaginaries are also often associated with active exercises of state power and the management of political dissent (The sociotechnical imaginaries project, 2007). Everyday citizens are generally limited to either accept or reject these futuring visions as opposed to taking part in constructing them. However, an alternative form of IT visioning is beginning to take shape, one that is more democratic and participative, in part due to the open source/open design/open manufacturing movement. As such, visions become mechanisms through which self-motivated and creative individuals can pursue their own imaginations and reshape the world (Turner, 2008). For example, it has been proposed that making is a new site of entrepreneurship, economic growth, and technological innovation (Lindtner, Greenspan, & Li, 2015). Designers, hobbyists, manufacturers, and researchers are collaborating to expand the hybrid (physical-digital) fabrication model that involves everyday materials (Devendorf & Ryokai, 2015), to challenge the traditional dichotomy of design as creativity and innovation versus manufacturing as supplier and execution (Lindtner et al., 2015), to reconceptualize making and fabrication not as a form of individual production but as a public life that supports wellbeing (Taylor, Hurley, & Connolly, 2016). Personal making/fabrication, thus, has been considered "a strategy of community formation around everyday expertise and open sharing" (Fuchsberger et al., 2016, p. 3551) especially with regard to its impact on design, sustainability, and education (Ames et al., 2014), such as how publicly accessible and shared information resources for design, development, and distribution of products and systems ("open design") can

support effective interaction between making and professional production (Fuchsberger et al., 2015a; Green et al., 2017). Other researchers further discussed how making, open design, and open manufacturing are reconfiguring visions of modern citizenship, ethnic identity, and national development. For instance, Irani (2015) focused on how a hackathon in India embodied both an entrepreneurial citizenship "that orient(s) toward Silicon Valley for models of social change" and a broader middle class Indian politics of speed (e.g., fast development) and vision (e.g., nation-building). Lindtner and Avle (2017) further explained the role of technology production and innovation in reconfiguring citizens in the U.S., China, and Africa not only as technological actors but also as economic actors and entrepreneurial actors. Their work highlighted how such imaginaries of a maker-entrepreneurial future necessitate political power and global order by (re)defining the relationship between the future of a nation and its modern citizenship.

These studies have well documented the democratizing potential of making, open design, and open manufacturing. Yet there has been less exploration of how exactly different stakeholders (e.g., makers, designers, government, policymakers, researchers, educators, manufacturers, entrepreneurs) come together, negotiate their roles, and collaboratively envision what technological practices will be, how they will shape everyday life, and the implications for broader society, economy, and culture. In this paper, we use Taiwan's MakerPro as a case study to unpack what collective IT visioning looks like, how it shapes IT agenda concretely, and the implications for open design/open manufacturing research agenda in HCI.

3. METHODOLOGY

3.1. Research Site: Taiwan and MakerPro

Taiwan is often considered the home of the most democratic Chinese society in the world, having established multi-party democratic elections in the early 1990s. Its two main political coalitions are defined largely by their positions in the hotly contested debate concerning Taiwan's status with regard to Mainland China: is it a renegade province or independent state? The coalitions are the Green (led by the Democratic Progressive Party), which tends to favor independent nationhood, and the Blue (led by the Kuomintang or Nationalist Party), which tends to favor eventual unification with China. Meanwhile, since the 1960s, Taiwan grew into a high-income economic entity dominated by a middle class (FocusEconomics, 2017): 2017 population: 23.6 million; 2017 GDP: 575 billion USD; 2017 GDP per capita: 24,402 USD. Taiwan is known particularly for its IT manufacturing and electronic products, which largely attributes to its citizens' preference to pursue a career in STEM related fields. According to *Report on Taiwan: STEM (Science, Technology, Engineering and Mathematics)* (Gao, 2013), in 2011, 13,248 of the 33,686 doctoral students (39.3%) in Taiwan enrolled in engineering comparing to only 4,745 in science and 3,563 in medicine. STEM graduates, especially engineering graduates, also often have advantages in the labor market in Taiwan: eight out of the top

ten highest monthly earning industries in 2011 were STEM-related fields (ACOLA, 2013).

Within the socioeconomic context of a manufacturing/electronics driven economy, dominant middle class, and nationwide focus on STEM (engineering in particular), MakerPro emerged as a popular tech community. Founded by Owen Ou in the November of 2014, MakerPro is a P3 (public-private partnership) with a focus on building a maker economy (http://makerpro.cc/) and cultivating a public sensibility and awareness of the future of technological development and manufacturing in Taiwan. It is located in the heart of Taipei and provides consulting services on crowdfunding and project management related to bottom-up innovation and entrepreneurship. It also regularly organizes roundtable discussions, seminars, factory-touring, and makerthons throughout the country. Its Facebook presence (facebook.com/groups/makerpro.cc/) is one of the largest and most active among similar groups in Taiwan, with more than 10,000 members. Facebook does not have a feature to reveal groups' demographic information and some MakerPro members do not report their age and gender online. Yet based on our observation of the posts and comments, direct checks of members' names and profile pictures, and experiences of interacting with MakerPro members, we found that about 60% of the active group members are male while 40% are female; most of them appear to be between 20 and 50 years of age.

Importantly, these members are not "makers" in the hobbyist sense. Instead, they self identify as "pro makers," who share a common goal to promote the maker economy in Taiwan and bridge the gap between making and market. According to the official website of MakerPro (https://makerpro.cc/about-makerpro-2/), most members are middle-class citizens—electrical/mechanical engineers, artists, UI/UX designers, handcrafters, developers/coders. Many of them occupy two or more of these roles. Many factory owners, IT managers, entrepreneurs, government officials, and educators also actively engage in MakerPro and making-related discussions. Typical interaction in its Facebook group includes exchanges of best practices and experiences of maker to market, discussions of issues related to Taiwan IT innovations, organizing online and offline collective activities (e.g., workshops, team projects, brainstorm meetings, and presentations), notifications, and summaries and reflections of organized activities, product and/or tool introduction and trouble-shooting among others. Though MakerPro members' activities are largely mediated by digital media (e.g., Facebook), this group appears to exhibit features of a collective action network (Bennett & Segerberg, 2012): this distributed collection of individuals shares a collective identity (i.e., pro makers) and is determined to achieve a common goal of constructing an actionable vision of Taiwan's technological future. In doing so, their online discussions center on "the processes of negotiating common interpretations of collective identity linked to the contentious issues at hand" (p. 751)—for example, the characteristics of visions for open design and open manufacturing in Taiwan and how they, as pro makers, can contribute to realize these visions; their offline activities also show a pattern of strong

organizational coordination—working closely with public and private sectors, MakerPro founders and members often coordinate with one another to pull together various information and resources to enact their missions and agenda and to make their work more visible and influential.

3.2. Data Collection and Analysis

The primary data we collected in this study were threads (e.g., posts and comments) of MakerPro members' discussions regarding reflections on design and production, the future of manufacturing, maker economy, Taiwan IT innovations (e.g., IoT), and entrepreneurship posted on the public MakerPro Facebook group. We focus on this data source for three reasons: 1) This Facebook group page has become the most active and popular online group for makers in Taiwan. Most makers and technologists, who are interested in seeking information, connecting with others, or further engaging in this community, often resort to this online page for mutual help, collaborative learning, social interaction, and in-depth discussions. Content posted and shared in this group not only provides a comprehensive image of the varied collective activities members conducted but also represents the shared interests and common goals of makers and technologists in Taiwan. 2) This group page fosters an open, friendly, and supportive social atmosphere for sharing ideas, discussions, and debates. It welcomes different opinions and perspectives. Both the founder and members of MakerPro have strong willingness to openly share their concerns, reflections, and efforts for technological innovations in Taiwan online. Thus, these threads become valuable documentation of their group actions, some of which may have been ephemeral and transient. 3) This group page has been perceived as a significant feature of innovation communities in Taiwan. As a MakerPro member notes, "*I think this Facebook group represents the core values and major trends of making in Taiwan: open, sharing, community, collaboration, conversations, and warmth. I cannot imagine discussing making and makers in Taiwan without looking at what's happening on this group page.*" (Unless otherwise noted, all quotes were originally in Chinese and have been translated here by the authors.) Analyzing data from this Facebook group provides direct access to one of the most vibrant sources of ongoing debates in Taiwan about collective visions of open design and manufacturing.

To collect data, we developed a social media crawler. We then automatically crawled all posts and comments on the MakerPro Facebook group using the Facebook API from December 11, 2014 (shortly after when the group was established in November 2014) to April 27, 2017. This study was approved by our university's institutional review board, and we followed all guidelines for research ethics when collecting and analyzing data. MakerPro leaders consented to our research, noting that sharing the data was in line with the open source, open data values that help define the MakerPro collective. As a result, 6324 posts with their associated comments were collected.

We conducted an empirical, in-depth qualitative analysis of the collected Facebook data to understand how MakerPro members envision, shape, and enact open design and open manufacturing agendas in Taiwan. Our coding and analytical process followed these procedures: (1) We filtered out posts of advertisements, general announcements, and product introduction as well as those with no or few comments. As a result of initial filtering, 386 posts along with their associated comments (total Chinese character count = 182,670, which equals 121,780 English words approximately) were included in our corpus for analysis. The average number of comments that these posts received was 36 (max. = 183). (2) We closely read through all the data to obtain basic familiarity. (3) We carefully examined and identified thematic topics and developed sub-themes based on the data. 3) We collaborated in an iterative coding process to discuss, combine, and refine themes and features to generate a rich understanding of MakerPro members' collective action in pushing Taiwan's IT agenda forward.

Two of the authors have been conducting ethnographic fieldwork in Taiwan on cultural and creative industry and IT innovation since 2011 and attended numerous MakerPro events and workshops in person and observed MakerPro members' interactions, discussions, and activities. In addition, they interviewed the founder Owen Ou (twice, once in 2015 and again in 2016), several MakerPro members, as well as government officials who have worked closely with MakerPro. In this study, these observations and interviews were used to contextualize our understanding of the MakerPro debates online and also to ensure that our data analysis and interpretations cohere with ethnographic data as well.

4. FINDINGS

In this section, we present our findings of how MakerPro members collectively constructed and developed visions for open design and open manufacturing in Taiwan. Our findings consist of two parts: the first demonstrates characteristics of such collective visions; and the second summarizes the roles different stakeholders (e.g., makers, manufacturers, artists, designers, and government) play in constructing and enacting these visions.

4.1. Constructing a Collective, Bottom-Up Open Design and Open Manufacturing Vision Agenda

There are complex relationships between the ideals of open source and open data on the one hand, and on the other the realities of to whom the code and data are open and to whose purposes their openness is useful. The phrase "bottom-up innovation" can denote anything from innovation by non-managers within an organization to a utopian democratic society. Our use is somewhere in between: we refer to a form of innovation that is not driven by industry captains and powerful politicians, but which instead is intended to

be shaped by a wide range of stakeholders. In the case of MakerPro, that group primarily comprises middle class engineers and other technologists, as explained in Section 3 above. Other legitimate stakeholders, such as *all* citizens of Taiwan who have an economic stake in Taiwan's IT industry, did not participate in MakerPro and so were excluded from our study. Likewise, those of whose socioeconomic standing means lack of opportunities in education, access to resources and social networks, and leisure time, were also not included. In spite of these exclusions, and based on the demographic and economic data presented in Section 3, we believe referring to this as "bottom-up innovation" is justified in the sense that it represents the collective views of workaday IT professionals, students, and hobbyists, though not the collective views of all of Taiwan's citizenry. Moreover, MakerPro participants share at least the intention to promote the values of openness and democracy, and the community's results were achieved in a collective and distributed way.

In this section we explore the characteristics of MakerPro members' collective visions of open design and open manufacturing. We also show their debates, reflections, and discussions involved in constructing these visions. The three-part vision framework developed by organizational informatics and management scholar Mark Lipton (Lipton, 1996) informed our findings. The reason is that instead of merely proposing "idle visions of a world someday somewhere" (Segal, 1985, p. 21), this framework points to the specifics of what constitute a vision, actionable approaches to realize it, and how such a vision would lead to a desirable future. However, it should be noted that we do not use this framework to map our data.

4.1.1. A Fundamental Question: Why Do We Need Open Design and Open Manufacturing?

A fundamental question emerging in MakerPro members' online discussion and debates was: *why do we need open design and open manufacturing?* For them, answers to this question would tackle some of their fundamental concerns such as the ultimate purposes and core values of their practices and endeavors. To address this question, MakerPro members highlighted short-term, mid-term, and long-term missions/purposes of their work.

The short-term mission is to facilitate hardware innovation in Taiwan. Maker-Pro members achieved a consensus that there has been a widespread anxiety in Taiwan's recent economic development: concerns about the failing OEM industry, confusions about the changing economic model, nervousness about the rise of mainland China as both a collaborator and a competitor, and alarms about losing Taiwan's own identity to the dominating Western/Silicon Valley business innova-tion model. The following quote posted by a technologist (male) well expressed such complicated feelings:

> Taiwan has long been the "Silicon Island." But now we are still saying that we want to be the "Silicon Valley" in Asia. Nobody doubts that Taiwan is the Silicon Island, but everyone is

> *wondering whether we can be something else beyond just the Silicon Island? There seems to be a trend to overlook hardware manufacturing in Taiwan – we used to be so good at hardware and engineering but now the world is so obsessed with software. The younger generation of innovators and entrepreneurs in Taiwan has no interests in factories and hardware; as a result, they do not understand what Taiwan's strength is.*

MakerPro members were well aware of the ever-increasing focus on software globally. Yet they also noted the recent trend to revive hardware (e.g., making and hacking, smart devices, Internet of Things). For them, the argument for open design and open manufacturing was to bridge the two sides of technological innovation: software development and hardware engineering. An engineer (male) and a startup owner (male) commented thus:

> *IoT is an opportunity for hardware innovation. As Internet, applications, and cloud technologies have penetrated into every aspect of our daily lives, hardware, engineering, and manufacturing look not so "cool." This is especially a bitter fact considering how successful we were before in engineering and electronics. I think it's important to provide an open platform or process through which hardware people such as engineers and software people such as technologists and designers could understand each other. If hardware people cannot change and make breakthroughs in their "hard" mindset, they will be forgotten by the world. This is an inevitable truth.* (Engineer)

> *Innovating hardware is very challenging. In the past, you could make your presence known if you made a website. Then you needed to develop an application to make money. You then needed to focus on providing service. Now you are required to know and be good at all three: innovative hardware, user friendly software, and high quality service. To do so, all parties should be open and transparent to each other – developers, designers, engineers, and even business people.* (Tech startup owner)

In other posts, many MakerPro members also agreed that hardware innovation could bring both opportunities and challenges to IT innovation in Taiwan. One of Maker-Pro's cofounders (male, venture investor) summarized in his post, "*it is more risky to innovate hardware because hardware requires the integration of large amount of resources – hardware needs software to be operated. If we understand the values and cost, if we are prepared, innovating hardware and making them more open sourced will revitalize Taiwan's traditional strength – the capability of manufacturing.*"

Building on the short-term purpose, a mid-term mission for MakerPro members to envision open design/manufacturing was to contribute to the maker-to-market model. MakerPro members considered maker-to-market a more realistic and appropriate model than maker to startup. A member (male, occupation unknown) commented on a post on the relation between entrepreneurship and making, "*Our goal is not to introduce an unrealistic dream of 'everyone can be a CEO' but to nurture our inner desire to make new things.*" This model involves a "zero to one to many" design/ production process (i.e., creation, design, prototype, production, and market) and requires a variety of open co-creation platforms, such as maker marketplace, design

community, IT solutions, factories and manufactures, and open source hardware and software (e.g., Arduino and Linux). A few members replied to the MakerPro's founder—Owen Ou's post regarding the maker-to-market model and pointed out how significant an ecosystem of open design/manufacturing would be for such a model:

> First we need to follow what Arduino and Rasberry PI did to establish an open ecosystem of design, software development, and hardware production in Taiwan. We need new open source platforms to bring everyone, everything together. Second we also need a fast open prototyping platform through which makers can directly produce prototypes and share with all the other parties such as designers and manufactures. If we can pool our resources to establish such open platforms, we will provide maker to market valuable product roadmap and even business roadmap. (Male, engineer and founder of a major maker collective in Taiwan, male)

> We need to foster an open environment or system to help innovators proceed smoothly from zero to one (idea to prototype), not to mention one to N (prototype to market). With such an environment/system, they could grow up from power user to prosumer, and to be successful on the market. I think such an open environment/system should consist of online/offline learning, channels for selling/exchanging parts, design tools (including both software applications and hardware manufacturing), on-demand design service, and interaction/exchanges among makers. (Male, CEO of an Internet company)

Ultimately, both short-term and mid-term missions converged as the long-term mission: constructing a vision that can guide the future of Taiwan's manufacturing-dependent economy in a new global innovation economy. For MakerPro members, their efforts to envision the future of open design and open manufacturing in Taiwan were not just about technology itself or a new business model (e.g., maker economy) but about achieve a consensus on an aspirational and desirable IT future for Taiwan. In MakerPro members' underlying consensus, such a future should be built on the legacy and traditional strength of mass production and manufacturing capabilities and also be powered by the expectation where Taiwan would rise as a leader in designing and developing innovative technologies. Many posts explained such a vision as well as confusions and challenges surrounding it:

> Nowadays the growth of electronics and engineering industry seems to hit a ceiling. So many people are calling for a shift of economic models. This shift will no longer focus on manufacturing and production capabilities. Then what will it be? Many people do not know. Many others believe that creating an innovation economy that is based on open, sharing, creativities, unique cultures, communities, and collaboration is the future. But this is a very embarrassing stage, as embarrassing as the transition from teenhood to adulthood. It is embarrassing because we do not know who we are now and who we will become in the future. The future is filled with uncertainties and risks but also hopes and expectations. (Male, freelancer)

> Forget about those strengths and advantages. They are in the past. What we need for the future is to confront the truth: we need to keep an open mind, cultivate new design thinking, and develop new industry models. The world is no longer the one where we became No.1 by just

> *accepting big orders from others. Creativity, innovation, customization, and service are the key to our success in the future. We need to make all parties connected so they can all collaborate together; we need to make resources open to everyone so we will have a continuous and steady flow of ideas and talents.* (Male, economist)

> *Twenty years ago we had a prosperous mold industry. Ten years ago we were famous for our OEMs. Nowadays owners of these factories complain about their dying business. What will happen to them in the next ten years? Vicious competition and industrial relocations have damaged the foundation of Taiwan's economy. Taiwan's industry needs not only new services and values but also a new direction.* (Male, engineer)

For them, the ultimate goal to transform old economic and manufacturing model in Taiwan is clear. Yet what the old model would transform to is still uncertain.

4.1.2. How to Achieve Open Design/Manufacturing: Uniting Makers and Manufacturers

With the short, mid, and long-term missions for open design and open manufacturing in mind, MakerPro members further speculated about a number of high-level potential strategies to realize them.

The first strategy is to establish a sustainable mechanism to match makers and manufactures who share mutual interests. MakerPro members believe that despite the fact that makers and manufacturers are practically in need of each other, no effective mechanism exists to facilitate their interaction and collaboration. Building and promoting such a mechanism will require manufacturers to move from an "OEM" mindset to a maker/innovator-centric paradigm. It will also require a system that better analyzes makers' needs and helps them identify the most appropriate manufacturer. The following posts from two MakerPro members further explain these two requirements:

> *Manufacturers should understand that the era of mass production is now in the past. Seeking cheap labor and chasing the original design companies for orders are no longer the ways to thrive, or even to survive. The willingness to spend time understanding your customers' products and the product users will be the key in the future, which will build a true partnership rather than just being a supplier. Many manufactures in Taiwan, however, still produce just for products. They only care about the blueprint. They have no interest in what they are producing and where their products will be used.* (Male, manufacturer)

> *Most seed accelerators and incubators in Taiwan mainly focus on offering courses/workshops and sales/marketing advice. Very few of them provide direct assistance to connect you with factories and manufacturers. In fact, what makers need most is not a list of factories that they have to contact one by one. Rather, they need platforms or resources that will identify the most appropriate manufacturer based on their needs, that will even plan the whole process and direct them to the next step. Such a mechanism will lower the potential time and opportunity cost for both parties.* (Male, CTO of a tech startup)

Nevertheless, a few members pointed out that even successful matches could still lead to failures because of makers and manufactures' unrealistic expectations for each other, which may arise due to the conflict between a top-down manufacturer-centric innovation model and a bottom-up maker/innovator-centric paradigm:

> *Will you head to a glorious success after identifying a manufacturer that best matches your needs? Not necessarily. Under many circumstances, manufactures consider makers a cure-all who will grant whatever is requested, or genius inventors, or cheap outsourcing; makers, in contrast, consider manufacturers contractors or suppliers who have little role beyond make products based on the blueprint. If they think like this, the collaboration will only lead to a dead end.* (Gender unknown, engineer)

> *In Taiwan, many designers distance themselves from manufacturers. Such unfamiliarity with the manufacturing process and resources negatively affect how well the product and/or brand can be manufactured and introduced to customers. As a result, awkward situations will often emerge, including some very superficial and meaningless arguments such as "factories prefer round products but designers like square products."* (Female, university professor)

Therefore, after the successful match, another necessary strategy to truly connect makers and manufacturers and to align the two different innovation models is to incorporate design and manufacturing through open innovation. MakerPro Founder Owen Ou described how open innovation, which highlights the open attitudes and reciprocal practices of giving/receiving from each side, should become a mainstream model that unites manufacturers and makers in Taiwan:

> *There are two ways of open innovation: inside out and outside in. Inside out is how manufactures can benefit makers: factories and manufactures can share their resources (e.g., production lines) with outsiders (e.g., makers), making customized products and small production of innovative products possible. They can also make their technologies and equipment open source, inviting outside experts to consistently upgrade and optimize them. Outside in is how makers can benefit manufacturers: makers can provide factories and manufacturers with fresh ideas and creative minds, which would help them quickly expand existing capacity, acquire new capabilities, and grasp opportunities for necessary transitions.*

Other members also replied to his post to suggest additional components of open innovation, including the sense of community and the focus on "made in Taiwan":

> *The key to a truly open innovation model is a specific mindset: respect the community, engage in the community, and return the favor of the community. Only if you achieve all the three can you build a meaningful, trustworthy, and solid partnership. In such a partnership, designers, makers, and manufactures will share a common ground and make efforts for a common goal.* (Male, university professor)

> *Traditional industries in Taiwan are eager to transform to a new business model so as to shine at the world stage again. Designers and makers in Taiwan are eager to revive*

factories and manufacturing in Taiwan. Identifying Taiwan's uniqueness and rebranding "made in Taiwan" is the way to connect both parties. Taiwan is not only well known for OEMs but also for the quality of traditional handcrafts. Though many factories are failing and equipment are rusting, those craftsmen' techniques and expertise are still invaluable and should be leveraged in developing Taiwan's economic futures. Cultivating a new meaning of "made in Taiwan"—one that combines craft, design, and precision manufacturing—should be the key driver of open innovation in the country. (Female, designer)

These two quotes further explain the role of cultural creativity and community support in open innovation. For MakerPro members, an effective strategy to truly unite makers and manufacturers does not only pinpoint their pragmatic and technical needs but also emphasizes their common cultural background and sense of belongingness—a shared concept of Taiwan: an island that embraces a traditional culture of delicacy and hand crafting, rises and fades due to the legacy of successful manufacturing/electronic industries, and is situated in a complex global political and economic order.

4.1.3. Free, Open, and Sharing: What MakerPro Believes About the Values of Open Design/Manufacturing

When identifying their missions and strategies to realize these missions, MakerPro members also extensively discussed how they should treat each other and work together, what values they should hold, and what they believed about themselves in co-constructing the future model of open design and manufacturing in Taiwan. These beliefs, values, and principles, in return, supported their endeavors to pursue the proposed missions and strategies.

Many members envisioned that free, open, and sharing would continue to rise as the core values for makers and manufacturers in the future. They often used keywords such as "information sharing, roundtable discussions," "open access and open source," "sharing tools and resources," "co-working," and "co-creation" in their posts. For example, a member mentioned that design and manufacturing in the future would be "intensely disorganized, but extremely democratic"—makers and manufacturers would share and use workspaces, tools, and resources for free; they exchange experiences of using and improving open source software and hardware; and the management of makerspaces, factories, and resources would be also open and transparent to everyone. MakerPro's founder Owen Ou summarized how such a vision would not only transform Taiwan's economic model but also shape people's social values in the future:

There have been two waves of innovation in the past 20 years. The first was dot com, and the second was mobile applications. The third one, and the most current one, is IoT and smart hardware. But what's the difference between the current one and the first two? It is the nature of open source. We are using the open hardware Raspberry Pi that is driven by open software Linux.

We are also learning all the technologies using open educational resources and tutorials provided by people all over the world for free. I think this will be the main trend in the future world, too. The spirit behind open source is an open mindset. This mindset is not born but needs to be learned and practiced. This learning process is also to establish such a belief: I'm not external to the society. Only when I contribute to a better society can I become a better person.

Some other members commented to Ou's post discussing the idea that "openness is not born but learnt." They noticed the tension between open/sharing and Taiwan's cultural traditions and expressed their cautions about the future of the open model in Taiwan:

I agree that openness and sharing is the key to making. Makers like to invite people, including peers and even factories and manufacturers to participate in the making and prototyping process, so as to improve their products. However, the concept of open source came from Western countries such as United States. It is very rare in Chinese culture to share all your experience and teach others everything you know. We always need to reserve something for ourselves – just to be safe. (Male, occupation unknown)

It is not easy to promote the open model in Taiwan. Traditionally, it is not a mainstream social value here. We also do not have the strong garage culture or DIY culture as the Western countries do to prepare for such a model. I am not pessimistic; I just think we need more time and dedication to make it happen in the future. (Male, designer)

These posts highlighted the challenge to bring different cultural values to Taiwan (e.g., the values of exploration, adventurousness, and openness) and to make any profound cultural changes. They also pointed out that such a challenge restrained how willing and open-minded makers and manufacturers in Taiwan would be toward collaboration and sharing. Many members especially advocated a culture that was friendlier to experimentation and risk-taking. Efficiency (i.e., to produce more with lower cost) has long been a key criterion to assess success in Taiwan's manufacturing industry. Therefore, the fear of failure (and the humiliation after failure) and waste of time, funds, and energy is deeply rooted in many Taiwan makers'/innovators' minds. It will be arduous for them to fully embrace the open innovation model unless a supportive and tolerable cultural atmosphere is fostered. For example, one (male, software developer) pointed to the prioritization of loss prevention over societal benefits in Taiwan: "*This may be due to the sociocultural context in Taiwan. However, such an attitude has become inappropriate in an era of global innovation. How can we maintain competitive advantage in this global landscape? Keep being OEM for others or have better control of price and platform? It's time to leave our comfort zone and explore the new frontier.*"

Others also argued for transforming the current educational policies so as to create an open culture for the next generation:

Our current educational system encourages students to work hard, follow orders, practice math, be pragmatic not creative, not to think too much, and be satisfied with the status quo. All of these are appropriate and work best for the ODM and OEM economy. Yet our current

education system hinders creativity and innovation in a long run. This is hurting our capability to build an innovation economy and transform our current manufacturing centric industry. That's why now we are in urgent need to cultivate risk-taking and independent thinking. What we need is to educate students about new cultural values: be creative, exploratory, adventurous, and ambitious. (Female, teacher)

We need to introduce the maker culture and startup culture to our educational system. The maker culture promotes DIY, learning from making, voluntary learning, be pragmatic and realistic. The startup culture encourages innovation, entrepreneurship, understanding market, teamwork, and planning ahead. All of these values are valuable for educating the younger generation in Taiwan, who will become learners, maker, and communicators, who will lead the shift of economic models of Taiwan's manufacturing industry in the future, and who will regain Taiwan's reputation as the island of technological innovation. That will be where we want to live. (Male, university lecturer)

These two quotes show that MakerPro members had witnessed and experienced one of the fundamental obstacles for open innovation in Taiwan—the lack of encouragement for creativity, innovation, and experimentation in the sociocultural setting. Yet they also realized that changing this status quo would be a long-term endeavor, which required a comprehensive reframing of the current educational policies/systems.

4.2. Stakeholders' Roles in Co-Constructing an Open Design and Open Manufacturing Vision Agenda

We now turn our attention to how various stakeholders in Taiwan's MakerPro community negotiate different roles, responsibilities, and obligations to co-construct an open design/open manufacturing vision. Their practices also illustrate how envisioning the future can feature democratic processes—everyday citizens, including middle-class IT professionals, students, and hobbyists, who constitute the majority of Taiwan's society, are participating in and contributing to proposing visions for a desirable future. In this process, they also acknowledge other stakeholders' roles and actively collaborate with them.

4.2.1. Partnership between Makers and Manufacturers: The Co-Existence of Top-Down Manufacturing Economy and a Bottom-Up Innovation Economy

Many MakerPro members emphasized the key role of makers and manufacturers in co-envisioning the future model of design and manufacturing in Taiwan, especially with regard to how they can promote an environment of open-sharing and democracy conducive in bringing about IT innovation in the country. Numerous posts in our data further explained the interdependent relationship between makers and manufacturers. For example, a CEO (male) of a tech company observed that these two parties could both thrive by collaborating through rapid prototyping and customization:

> *I think a more productive interaction between makers and manufacturers would be rapid prototyping. It will leverage the strong culture of SMEs (small and medium enterprises) in Taiwan and better meet makers' and startups' needs for small production of customized products.*

For him, these two represent how a top-down manufacturing economy and a bottom-up innovation economy could benefit each other: the former facilitates the production stage of the latter, materializing innovative IT products and making them more accessible to the customers; and the latter revives the traditional manufacturing industry by bringing in creative talents, originality, and novel design. One technologist in MakerPro further proposed that such a partnership between makers and manufacturers would foster a healthy ecosystem for open design and open manufacturing in Taiwan, leading to the emergence of a real innovation economy in the future and the rising of a stronger Taiwan in the global political and economic order:

> *How to make manufacturers and makers more open-minded and willing to share ideas and resources, and how to build an open ecosystem surrounding these two parties would be the key to build a real innovation economy in the future. Manufacturers will slowly die out if they do not have sufficient ideas and designs for innovative and desirable products. The disappearance of matches factories in Taiwan is such an example. Makers and startups usually have very limited budget. They will not succeed if no manufacturers are willing to take their small order for more customized products. I think a healthy collaborative relationship between these two would not only lead to a technological innovation in Taiwan but also put us on the world stage.*

While acknowledging the significance of such a partnership, other members nevertheless predicted various challenges to reconcile the tension between makers and manufacturers in the future open model due to their different interests and priories. Such challenges include the possibility of manufacturers misusing makers' creativities for financial gains, and the tendency of makers misusing manufacturers as source providers not as collaborators. Two MakerPro members expressed their concerns:

> *There are two types of makers: One has technology but no money and does not know how to sell products; the other knows how to sell products but has no money or technology. So the former knows how to make products but needs money and marketing skills to actually make and sell them; the later knows how to sell products but needs manufacturers to make the products first. There are two types of manufactures: The first type invests money up front to pay for manufacturing and then helps to sell the product after it is manufactured, but can only keep 30% of the revenue, so this manufacturer declines the offer. The second type invests money up front to pay for manufacturing, and the makers will be responsible for selling the products, and yet this manufacturer can only take 30% of the revenue and so declines the offer. This is the paradox in technological innovation in Taiwan.* (Male, former engineer now startup owner)

> *It would be challenging for manufacturers to establish a healthy interaction with makers who focus on bottom-up innovations. The biggest difficulty is to build a genuine relationship of co-creation instead of just taking advantage of makers' creativities to sell more products.* (Female, designer)

As shown above, many in MakerPro question how a true partnership (or even comradery) can be fostered between makers and manufacturers given such a partnership is crucial in building an open design and manufacturing environment for Taiwanese innovators. According to them, a top-down manufacturing economy and a bottom-up innovation economy might need to co-exist in Taiwan while this partnership is being cultivated. An IT professional who worked in an international corporation envisioned the necessity of such a co-existence and co-evolution for Taiwan's technological future: it is essential to incorporate Taiwan's traditional strength in manufacturing and electronic industries with its cultural creativity to revive its economy. It may also be the most appropriate (if not the only) approach to build the open innovation model for Taiwan's IT agenda:

> *The bottom-up innovation economy driven by makers is emerging and drawing interests from investors and large manufactures. It is even considered a significant national development policy in Taiwan. But would a perfect ecosystem for technological innovation naturally emerge with these resources and investments? I doubt it. I think the top-down manufacturing centric economy would never disappear. It will co-exist and co-evolve with the bottom-up innovation economy. They depend on and will benefit from each other. A harmonious integration of the two would be critical for Taiwan's future.*

4.2.2. Designers and Artists: Optimizing Taiwan's Artistic and Craft Traditions in Open Design/Manufacturing

As discussed above, how to elevate Taiwan's cultural tradition in IT innovation has been an important consideration in envisioning Taiwan's technological future. Therefore, MakerPro members recognized the vital role of designers and artists in constructing future models of open design and open manufacturing. Many members went as far as envisioning a future where makers are also designers and artists so they can be truly creative and innovative. They described such a future where innovators would be technological savvy with creative ideas and aesthetic appreciation:

> *Today creativity and innovation have become major economic drivers. But how can we be creative and innovative? I think makers should be like accomplished artists and designers so that they can create something novel.* (Female, blogger and designer)

> *Makers in the future should receive an in-depth humanistic education. It is how they can understand the emotional values of their products and better convey them. Makers' creativity should not only be to experiment new methods or to use old methods in new ways but to express*

> *emotions and aesthetics in creative ways through what they create, much like designers and artists.* (Female, government employee)

Other members admitted that not every maker could be an outstanding designer or artist. Instead, closely collaborating with designers and artists is a feasible and efficient way to envision and build an open design/manufacturing environment together. Taiwan's IT innovation has been influenced in part by the country's cultural and creative industries' policies. MakerPro members pointed out that Taiwan's artistic and craft traditions—when combined with Taiwan's regional strengths in precision engineering and manufacturing—offer a unique opportunity. MakerPro founder Owen Ou suggested:

> *Makers should serve as a bridge between manufacturers and designers/artists. We have the expertise and skills of our craftsman, such as in areas of welding, ceramic and wood working, and precision machining, etc. We also have designers and artists who engage in cultural creativity. They are treasures for Taiwan and constitute Taiwan's identity; however they have difficulties marketing their work in the international market. Makers are well-positioned to offer a new opportunity —"interdisciplinary co-creation." They can break boundaries and unite different actors – we will have cutting edge technologies, revolutionary ideas that can change the world, better designs and user experience, and capabilities of mass production. All of these together will lead to a more open, promising, and successful economy in the future.*

For many MakerPro members, this "interdisciplinary co-creation" represents a collaborative and balanced model where different content producers (e.g., artists, designers, makers, and manufacturers) can be connected, supported, and collectively contribute to open design/manufacturing. Yet they also pointed out the challenge to realize this model. Specifically, they highlighted how the current educational system discouraged creativity and innovation. A middle school teacher posted,

> *In middle school our goal is not to teach students skills required for working in a certain company or industry. Our goal is to educate our children how to be a "complete" human being with independent thinking. I led a summer making camp for middle school students once; after that I refused to do it again. What happened there was parents filling out the application form; parents drawing the blueprint; and parents making the project. When they called, the first thing they asked was would their kids get a certificate, would the certificate internationally recognized, and would they receive extra credit when applying for college.*

Many comments agreed and criticized the overemphasis on scores and neglect of creativity in Taiwan's society, for example, "*I hate how schools and teachers only care about some pragmatic criteria such as scores and exams. I hate how people always ask me 'why do you learn this' while I just love to learn it!*" (a female college student) and " *I got such questions a lot. People seem to only care about academic performance and extra credit for college. This makes me so sad. I don't know how to tell them it's not good to be trapped in the mindset of scores first. I also don't know how to help them change their mindset because what the society needs are students with high scores …*" (a female high school teacher).

4.2.3. Government: A Vision of Positioning Taiwan via Technological Entrepreneurship in Open Design/Manufacturing

The Taiwanese government launched the Cultural and Creative Industries Development Plan in May of 2009, followed by the Cultural and Creative Industry Development Act in February 2010. These policies sought to support and enhance a total of 15 specific cultural and creative sectors in Taiwan, including areas such handicrafts, product design, architectural design, film, and the construction and management of performance and exhibition halls throughout the county. The government expected the six flagship projects under the Cultural and Creative Industries Development Plan to generate a combined of US $33.3 billion in revenue and create more than 200,000 jobs through 2013 (Chung, 2011). These policies aimed to leverage skilled crafters, artists, and professionals in Taiwan, especially their abilities to integrate local resources, materials, and know-hows to create knowledge-intensive industries in the country. The government also implemented a series of related initiatives to create brands around crafts and Taiwanese products, develop licensing mechanism, establish incubation networks, and improve innovative R&D competitiveness for both the domestic and global markets (Bardzell, Bardzell, & Ng, 2017; Bardzell, Rosner, & Bardzell, 2012, Freeman et al., 2017, 2018). In this sense, the Taiwanese government, similar to the governments in mainland China, the United States, Africa, and India, influences the visions of open design and manufacturing in Taiwan by treating technological entrepreneurship as a way of nation building and transforming middle class citizens to necessary economic actors for a country's future (Irani, 2015; Lindtner & Avle, 2017).

While MakerPro members recognized the important role of the Taiwan government in shaping both the citizenship and the technological future, they had mixed feelings about the government's intervention. Some members welcomed the government's involvement, considering it an effective way to connect makers, creative professionals, and manufacturers that would then alleviate the risks for failure. The following quote illustrates such a view:

> *Recently I had a chance to meet with Taipei Mayor Ko Wen-je. He is very enthusiastic in making Taipei more supportive and friendlier for innovators and entrepreneurs. We chatted a lot about the future of Taipei and Taiwan and how government can help makers and manufacturers. Mayor Ko shared experiences of his visits to Silicon Valley and Stanford University. He pointed out that people in Taiwan do want to innovate and have the capabilities to make innovative products, but the risk of failure in Taiwan is just too high. He hopes that the government could establish more supportive policies in the future that lower down the risks and make people more wiling to experiment and try things out. I think this should become our government's key role and core responsibility in the innovation economy: providing makers and manufactures with resources and opportunities to experiment; encouraging them to keep trying after failures; and offering a mechanism for them to share lessons, experiences, and know-hows so as to transform failures to future successes.* (Male, university administrator)

In this quote, the government was perceived as a benevolent actor for the future of open design/manufacturing in Taiwan. Its power and authority to establish social and technology policies and its access to abundant information and resources can tremendously shorten the time gap between creative ideas and the actual products by better connecting and supporting the two essential parties for IT innovation—factories who pursue new ideas for desirable products, and makers who possess such ideas but require production capacity to materialize them.

Nevertheless, some other members expressed concerns and cautions about government's involvement in envisioning Taiwan's technological future as it introduced needless obstacles and inconvenience. In their view, the government seemed to privilege projects with strong business potential and/or projects that balance both the makers' and the manufacturers' interests. A member (male, software developer) shared his experience thus:

> I have experiences of applying for government funding to support my project and to find a manufacturer. I'm disappointed. It seems like the government only funds people with a history of successful projects. One wonders why we would need government's help if we are already successful. Second, one needs to provide evidence that there are other funding sources to support the project. I feel the government just wants to identify some "champion" projects so it's guaranteed they will get something back. Even if you do get the help and funding, you need to spend a long time documenting your expenses and activities in great detail. In addition, the government will usually cut 20% to 40% of your proposed budget. So you need to carefully anticipate your expenses in advance when you put together the proposal for the government or you risk losing money. I don't think the current model of government support is helpful at all.

The government aims to foster a civil culture of technological entrepreneurship in Taiwan, leading to improving Taiwan's global positioning. But while investing in startups is typically viewed as high risk/high reward, the government appears to have a low risk tolerance, affecting both its success rate and public perception of its efforts. In doing so, it may discourage citizens from participating in or competing for any government-funded tech projects in the long run.

In fact, many government officials have noticed these drawbacks of the current tech policies regarding innovation and entrepreneurship and makers' increasing discontent toward their intervention. Some of them directly interacted with MakerPro members to clarify the government's intention, explain its considerations, and invite potential solutions. For example, a male employee at the Executive Yuan explained in detail about how the government-sponsored platforms for tech innovation and start-ups work to better serve makers and manufacturers with the hope of reassuring MakerPro members' trust on the government:

> I hope we will have more government-sponsored platforms in the future, such as the Taiwan Start-Up Hub run by the Executive Yuan. This Hub not only provides lectures, tutorials, and workshops about technological innovation and start-ups cultures, but it also connects the government and the general public's creative talents. I think those platforms will greatly support those grassroots innovator groups and help our traditional industries: they offer large amount of

> *funds and resources and provide an official and reliable channel to connect makers and manufacturers. So makers can find the right factory to materialize their ideas and factories can solve their current issues (no idea, no order). Those platforms will build a new chemistry between makers and manufacturers, which may lead to new and creative products and open up new markets.*

Another example is the discussion surrounding a post that asked "can makers be trained?" While many comments criticized the government's approach to commercializing making and makerspaces by "producing" makers in bulk, a few policymakers engaged in the conversation, defending the government's stance to a certain degree, and seemed open to future suggestions/solutions. For example, a male employee at New Taipei City Government pointed out that the fundamental issue regarding the tension between makers and the government was not whether the government should be involved but how it should be involved:

> *I think makers can surely be trained. It is just a matter of whether we want to do it or not. Many makerspaces are already offering workshops and classes to provide systematic training. So why cannot the government do so? Are nongovernmental makerspaces truly "perfect"? Is enthusiasm the only thing we need? I don't think so. The issue with government is never the government involvement itself but that the government does not involve enough in a right way. How can the government be involved in a right way? All of us should carefully think about this and have an open conversation. The government wants to help you innovate not to slow you down.*

A more critical comment highlighted some misunderstandings in both the government and the maker communities due to their feelings of insecurity and suggested the necessity to build a genuine trustworthy collaborative relationship among makers, manufacturers, and the government:

> *I feel we Taiwanese are characteristic of our feeling of insecurity. This insecurity drives us to immediately define how to deal with new phenomena otherwise we cannot sleep. This is our biggest mistake. Making is relatively new; the making economy is also new. Both the government and makers are still in the process of figuring out a win-win strategy. But some in the maker community may have the idea that since we don't like governmental intervention, we will just get the money from them and then kick them out of the innovation process. Alternatively, some in the government may have this idea that we just need the best innovations and do not care about helping makers. Both attitudes are wrong. Regardless of who you are – policy makers, factories, or makers, the only way to success is working with each other with an open mind and building trust.* (male, employee at a local government)

In summary, there remains as yet little consensus on what role the government should take and how much it should be involved in envisioning and building future models of open design and open manufacturing. The government is broadly seen to represent external political power with authority, resources, and top-down decision making capabilities—and it is but one member of a network of stakeholders who

collectively construct and enact these visions. However, both makers and the government are actively engaging in conservations and debates to explore "the right way" through which top-down interventions can facilitate rather than undermine the bottom-up innovation process—for example, funding a wide range of experimental projects, offering government-sponsored sharing, trading, and education platforms, and increasing transparency to build mutual trust.

5. DISCUSSION

We have shown how MakerPro members collectively constructed a bottom-up open design and open manufacturing vision agenda. Our findings explain the characteristics of their visions, including motivations to propose such visions, strategies to realize them, and the beliefs, values, and principles embedded in them. We have also described how various stakeholders participated in co-constructing such visions: the partnership between makers and manufacturers represents the co-existence of top-down manufacturing economy and a bottom-up innovation economy in Taiwan's technological future; involving designers and artists represents a feasible way to optimize Taiwan's unique strength, that is, artistic and craft traditions, in open design/manufacturing; and the governmental intervention offers an aspiration of positioning Taiwan via technological entrepreneurship in open design/manufacturing .

These findings begin to add up to a story of how IT innovation is unfolding in hardware- and manufacturing-oriented Taiwan. The story is situated within a larger backdrop of a globally recognized precision and electronics manufacturing industry that is adapting to global changes in design, innovation, and production. Taiwan's hardware-centric industry struggled in the mobile application era, which was dominated by software innovation. The turn to the Internet of Things, with its obvious implications for hardware and manufacturing, would seem to play into Taiwan's hands, but that is not how stakeholders are experiencing it. Instead, as we have seen, previously successful models are breaking down and new successful models are slow to emerge. MakePro participants outline a range of impediments to the formation of a new model, in spite of quite a bit of underlying consensus.

5.1. Impediments to Open Hardware Collaboration

Before identifying the impediments, it is helpful to identify where consensuses already exist among Taiwan's innovation economy stakeholders. Manufacturers, government, makers, and entrepreneurs all recognize Taiwan's recent historical strengths in precision and electronics manufacturing. All recognize that Taiwan can no longer afford to manufacture other countries' innovations at scale (the paradigm example arguably being Taiwanese firm Foxconn's manufacturing of Apple products) and increasingly need to cultivate a homegrown innovation

ecology. Many stakeholders also have an underlying belief in the cultural and creative economies agenda, that is, the idea that a region (in this case, Taiwan) should leverage its art, craft, design, and heritage traditions as a resource for regionally distinctive innovation. This consensus has helped diverse stakeholders to collectively co-construct a vision agenda of Taiwan's technological future and to offer a blueprint for how this ecology of open design/manufacturing and open innovation might unfold. Though other alternative movements of technological development may likely exist, Taiwan's unique social structure (e.g., dominant middle class with engineering as a popular career path), complicated political discourse (e.g., a both collaborative and competitive relation with mainland China and an alliance with the United States), a globally acknowledged historical reputation in electronics manufacturing, and an aspiration to reclaim Taiwan as a leader in IT innovation, together with its strong artistic and craft traditions, persuade most Taiwanese to believe that the vision agenda of open design and open manufacturing is the most appropriate approach for Taiwan's future. This confidence is also shaping technological agendas in Taiwan accordingly, leading to massive investments from industry, government, and the research community in cultural creative industries, hardware innovation, and IoT.

However, there are also many impediments to the successful implementation of this consensus view of Taiwan's technological future. One underlying problem for Taiwan, according to the MakerPro group and all available evidence (e.g., Bardzell, Bardzell, & Ng, 2017; Freeman et al., 2018), is the challenge to foster a creativity/innovation driven economy. Homegrown innovation depends on creativity, but that has not been one of Taiwan's strengths. As our data show, many blame Taiwan's educational system, with its focus on standardized tests and academic excellence. The hope is that cultural creativity, as both a theoretical stance and also a well-funded policy agenda, will fill in this gap. Cultural creativity seeks to acknowledge and valorize existing traditions of creativity in Taiwan, and to investigate their potentials for economic innovation. Globally, this agenda has met with at best mixed success, and its implementation in Taiwan has been controversial (Bardzell, Bardzell, Lin, Lindtner & Toombs, 2017). Further, lacking structural educational reforms, it is difficult to imagine cultural creativity having widespread systematic impacts: quotes from high/middle school teachers in our study show that many of them believed that such creativity appears to be trained out of children at the middle/high school stage.

Adding to the problem is a strong cultural fear of failure, visible both in the data presented above and throughout our data over years of interviews, observations, and study of policy documents. Taiwanese leaders in government, industry, and education alike are, by Western standards, risk averse: no one wants to shoulder the blame of a failure, no matter how well intended and justifiable the underlying effort was. Risk adversity is fundamentally at odds with investments in startups, so the influences of Silicon Valley so strong in many ways in Taiwan, cannot be fully realized. Our data echo Nguyen's (2017) observation of a tension between the (re)

configuration of Vietnamese ethnicity and the Western trend to cultivate a professional class of technoentrepreneurs.

Another equally fundamental issue is the conflicts between top-down and bottom-up models of innovation. Manufacturers take a top-down stance, but the Silicon Valley and creative economy models of innovation both embrace bottom-up innovation. The top-down stance fits traditional leadership and governance models in Chinese culture, while the bottom-up stance reflects predominantly Western values and practices. Restructuring Taiwan's family owned factories as bottom-up seems all but impossible, while Taiwan's makers and entrepreneurs—and the government policies that support them—embrace a bottom-up approach. What is missing is an infrastructure—boundary objects, platforms and tools, practices and languages—that allows these two ways of working to cooperate. Each side has its own set of practices, incentives, assumptions, and attitudes, which have led to different sorts of misalignments. One is pragmatic and technical: makers and manufacturers understand that they need each other, but they lack adequate mechanisms to find matches according to technical needs. Emerging technology standards and platforms could help, but these are slow to coalesce into a coherent domain. Another misalignment is more economical: the balance of risks and rewards. Our data suggest that makers tend to hold one view of risks/rewards, and manufacturers hold another, so even if their respective technical needs are in alignment, the collaboration can still fail.

Finally, the translation of widely embraced ideals such as openness and democracy into technologies, practices, and processes is messy. Taiwan has a capitalist economy and so many of these industries are in fierce competition with one another, particularly at a time of economic belt-tightening. This creates incentives for partial collaboration; as one participant put it, actors share but also hold something back at the same time. Creating meaningful market differentiation between two manufacturers' competing IoT prototyping and production platforms while democratically developing IT standards and processes is understandably challenging, and hardly unique to Taiwan. It suggests an underlying ideological conflict between values of capitalism, entrepreneurship, and market advantage on the one hand, and openness and democracy on the other—a conflict that can be navigated but probably not resolved.

MakerPro's collaborative visioning can help hardware innovation ecology stakeholders in Taiwan to navigate these tensions between entrepreneurial and cultural creativity, experimentation and failure-aversion, and top-down vs. bottom-up organizational styles. They have done so by collectively articulating a mission, strategies, and a culture, and translated each of these into stakeholder roles. The mission—to transition to a bottom-up innovation economy guided by the principles of open source/open hardware—is clear. Strategies and their obstacles are also well articulated. More importantly, MakerPro members are well aware of their actions to co-construct a vision agenda and would like to make their efforts more visible: as the official website of MakerPro specifies, they recognize Taiwan's great successes

with traditional manufacturing but admit that this model is in decline; they sense the urgency to shift the economic mode in order to reestablish Taiwan's place on the broader global economic stage; they use their Facebook presence to foster a sense of community and coordinate collective actions and brainstorms; they also actively interact with other stakeholders such as policymakers in the hope of proposing useful strategies for building an innovation economy and eventually contributing to Taiwan's technological development.

With this awareness, MakerPro members have labored to diagnose the diverse breakdowns inhibiting greater collaboration between hardware innovators and manufacturers today, as well as the cultural hurdles (e.g., the fear of failure) that inhibit this vision. Strategies to overcome these obstacles include encouraging mutually open dialogues between inventors and manufacturers and prioritizing the development of tools and platforms to mediate these relationships. Likewise, they have constructed a projection of the kind of culture that they want, one situated in, yet seeking to change Taiwanese democratic, educational, and innovation traditions. These visions have also identified key stakeholders—manufacturers, makers, designers, and the government—and proposed aspirational roles for each of them.

In addition, we stress that this vision agenda has relatively little to say about technology itself. Although the participants are highly technical, the conversation we have been tracking has more to do with values and aspirations—the construction of a story or a blueprint of an innovation ecology that is appropriate to their own sociocultural identity and situation—than a technical characterization of, for example, the features that a cloud-based IoT prototyping platform for makers ought to have, a grand challenge to improve the resolution of environmental sensing, or to strengthen the security of peer-to-peer networks for IoT. This vision agenda is more of a cultural story, in which a certain optimistic narrative of Silicon Valley-style bottom-up innovation and entrepreneurship, fueled by commitments to cultural creativity and Taiwanese democracy, engages and transforms an ageing manufacturing industry implicitly associated with an older Chinese autocratic ecology.

5.2. The Emergence and Construction of Regional Visions of Taiwan's Future

Though scholars acknowledge the importance of visions in HCI research, there is no unifying definition of what a vision is and what qualifies an effective vision in our field. Throughout this research project, we focused on how a collective, bottom up co-construction of visions for open design/manufacturing in Taiwan, intertwining with Taiwan's unique political and economic pursuits, leads to the potential of IT innovation as a site for democratic and participative visioning. In this sense, these visions of Taiwan's technological future are regional because they focus on redesigning the role of Taiwan as a region in a global innovation economy and optimizing Taiwan's distinctive cultural features in this process. They are sociotechnical because they are built on a shared

understanding of the near past and current trends and lead to an actionable IT agenda. Yet they are not merely sociotechnical *imaginaries* because they are grounded in collective historical memory, point to explicit future goals (e.g., Taiwan as a leading innovation economy), and intertwine with concrete economic policy and political agenda (e.g., innovation as part of the government's Key Performance Indicators). Therefore, such visions are no longer a type of tech-nosolutionism (e.g., it is not expected that they will solve social issues in Taiwan) or a top-down policy-making. Rather, they represent the interplay among Tai-wan's economic and cultural legacy, an emerging trend of participatory citizen-ship in terms of tech entrepreneurship, and a consensus on aspirations for Taiwan's future. Open design and open manufacturing, therefore, are no longer a technological paradigm for IT innovation but an actionable agenda for socio-political restructuring.

In this study, we were struck by MakerPro participants' unspoken embrace of *Taiwan* as the appropriate unit of analysis and their strong attachment to Taiwan as a region. In MakerPro, the wellbeing and distinctive features of Taiwan are very much foregrounded throughout. It seems that a shared concept of Taiwan is doing some important intellectual work for MakerPro, and in doing so, enriches the emergence of regional visions for how a desirable future of Taiwan can be strate-gically achieved. For example, Taiwan's particular implementation of creative indus-tries policy is not so much about turning crafters into better business owners or exporting its television and films but about creating new culturally specific pipelines that will foster homegrown innovation in the hardware and IT sectors in Taiwan. It is also worth noting that a distinctive feature of Taiwan's overall economy is its heavy dependence on manufacturing and engineering, so that in some ways it makes sense that a vision of Taiwan would link the future of manufacturing to that of Taiwan. Another regional feature is that Taiwan's IT professionals tend to be politically active. The open source/open hardware movement has unusually close ties to the open government movement; all three come together in the high profile hacker collective, g0v.tw, one of the driving forces of the politically significant 2014 Sunflower Protests. In diverse ways, political and IT/manufacturing leadership are more tightly coupled in Taiwan than most Western countries, making visions of Taiwan's future technology development more activist and culturally sensitive.

Our data also offers insights into how regional visions of Taiwan's technological future can emerge in a democratic and participative way. MakerPro represents a network of stakeholders. Our data suggests that these stakeholders are manufacturers, maker-entrepreneurs, designers and artists, and the government. Note that they do not include consumers, because Taiwan is economically dependent on exports, so the network is producer oriented. This network has no traditional power structure or other formal hierarchical structure; as a network its structure is more rhizomic and distributed. Of course, various stakeholders themselves have such hierarchies, including different levels of governmental agencies, manufacturing associations, and individual firms. But none of these is in charge of the process of envisioning.

The participative co-construction of a vision agenda does the work of creating both cohesion and buy-in. What holds the stakeholders together are a small number of ideological commitments as well as shared identity and goals. The ideological commitments are democratic, but in a Taiwanese way. That is, the operational view of democracy is quite distinct from the views of democracy in other regions that have been studied in the literature on open design and open manufacturing. For example, in the Scandinavian view, participatory design is a manifestation of democracy as it entails a shift from "democracy at work" to "democratizing innovation" (Björgvinsson, Ehn, & Hillgren, 2010). In this view, participation is largely geared toward the relationships among diverse stakeholders, including end users, managers, and designers, destabilizing power structures so as to distribute control, learning, and beneficial outcomes (Vines et al., 2012). In Ghana, democracy in technological innovation is shown as the conscious avoidance of state efforts (due to the government's failures to support innovation) and active involvement of non-governmental organizations and NGOs (e.g., The World Bank) to build an ecosystem for tech entrepreneurship and tech production for a technologically advanced future for Ghana (Avle, Lindtner, & Williams, 2017). In Palestine, visions of open design and open innovation are intertwined with the invisible and often unnoticed "infrastructural accessibility" in trans-local situations, which is related to "location, community, funding, digital platforms, politics, and history" (Bjørn & Boulus-Rødje, 2018). And in India, visions of the nation's technological future are closely tied to the middle-class politics that prefer speed and action and transnational cultures that favor Silicon Valley for successful models of social change (Irani, 2015).

Yet in Taiwan, the principle of *openness*—particularly as it has evolved in the global open source, open hardware movement—reaches beyond organizational relationships toward (trans-)national ones. Beyond MakerPro, we have seen this principle transposed onto other social movements, for example in the open government movement (inviting citizens to openly design digital platforms to improve the transparency of government ministries such as g0v.tw), and even in agricultural contexts (e.g., "open hack farming" in Shenggou Village in Yilan county, Taiwan—a village known for experimental agriculture). This view of openness features transparency and sharing, a skepticism toward proprietary technologies, and more than few hints of California IT libertarianism—the view that everyone is free to join in and equal to everyone else (i.e., the ideal of a flat hierarchy). Like California IT libertarianism, there can be little awareness of ways that the movement falls short of its own ideals of freedom and equality. For example, few MakerPro members explicitly acknowledge that their open design and open innovation agenda still privileges certain types of actors, usually male, middle class, tech savvy, and educated users.

This co-construction of regional visions is MakerPro's particular approach to bottom-up innovation, and it is typical of other agendas in Taiwan. Taiwanese IT leaders of all stripes have blended together the values of open design/manufacturing, Silicon Valley-style entrepreneurship, and the global creative industries policy to construct a set of defined roles within a productive structure in order to produce an

outcome. Innovation begins in creative clusters, specifically "culture and creative parks" that co-locate artists, crafters, makers, entrepreneurs, and technologists in cultural parks (envisioned as the creative equivalent of traditional industrial parks). These cultural parks are situated in newly renovated public areas, featuring co-working spaces, traditional art/design studios, and maker/hackerspaces collocated with museums, theme cafes, lifestyle shops, and performance venues. Designed to attract the young and creative, these spaces are intended to optimize the chances of the kind of alchemy that leads to innovative product concepts and IPs: new ideas, technological savvy, aesthetic execution, strategic business expertise, and flowing capital. This alchemy will produce new, local customers for Taiwan's manufacturing industry, hopefully leading to Taiwanese products and IPs for global distribution. The government's role is that of benevolent investor, helping to set up the culture and creative parks while building programs that help put the right people together—inventors, engineers, investors, manufacturers, business strategists, designers, lawyers—that can execute the whole innovation process from idea to mass production, all within Taiwan.

In summary, the underlying ideological values (i.e., the commitment to the open innovation model, with its implicit commitments to California IT libertarianism and contemporary neoliberalism) joined with a widely understood, if loose and somewhat ill-defined, structure of stakeholders and roles, enable MakerPro to pursue its objectives: as the "about us" page of MakerPro shows, this group was founded based on the shared mission to build a maker economy through online innovation; and its main activities to achieve this mission involved community building, collaboration, and crowdsourcing. One of the mechanisms of this pursuit is that of cooperative vision-making. And while there is no doubt that engineers are having separate conversations constructing and pursuing technology agendas, this is a regional vision agenda, grounded in yet not substantively engaging the underlying technological agenda, mixed with mythological topes (i.e., the entrepreneurial self, open government, distinctively Taiwanese creative actors), and producing an overall image of prosperity, one part tractable and one part utopian.

6. CONCLUSIONS

Taiwan is undergoing a series of changes. Its manufacturing industry is optimized for a global economy that no longer exists, one where foreign innovators would turn to Taiwanese engineering and manufacturing to produce electronics at high quality and a massive scale. Today, the capacity remains but the orders are drying up. One of Taiwan's responses is to construct a vision agenda, that is, a narrative that combines distinctive regional features, technological advancement, social and political movements, and an anticipatory storytelling about an alternative future being pursued.

The construction of this vision agenda is unfolding in a Taiwanese way—albeit one with complexities and contradictions. Traditional Chinese top-down thinking is meeting theories of bottom-up innovation imported from California. The latter

appeals to Taiwan's democratic values and increasingly democratic ways of life, but clashes with entrenched attitudes toward authority as well as risk-aversion. An island that depends on exports is decreasingly able to depend on foreign companies to help design and sell them. It turns inward, seeking to develop an internal innovation ecology creative and potent enough to replace erstwhile foreign investments.

The blueprint for this vision is developed following many of the core values and governance protocols of open source, open hardware, and open government. Maker-Pro is a Facebook group featuring many of the island's IT and manufacturing thought leaders. We have summarized the contents of their vision as a view of bottom-up innovation joining up with top-down manufacturing guided by the values of open hardware and democracy, where the theory of "democracy" seems almost to be an extension of the open source/open hardware computing ethos. In doing so, MakerPro and all different stakeholders—IT/manufacturing, maker-entrepreneurs, designers and artists, and Taiwan's government itself— participated in a process of co-construction visions for open design/manufacturing based on a common understanding of Taiwan's historical strengths and weaknesses. As a result, the collective purposiveness not only defines a regional vision agenda but also embraces an entire nation's future.

NOTES

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