Fab City Hamburg: A living lab approach to explore new forms of open, distributed manufacturing in an urban context

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Abstract – **Within the present paper we illustrate how the living lab approach has been operationalized, in order to establish a real life experimental urban setting in which open distributed manufacturing concepts (ODM) can be tested and further developed and investigated. The living lab approach is a type of transdisciplinary, participatory action research, which aims at creating user-centered, iterative, open innovation ecosystems that integrate concurrent research and exploration processes within a public-private-people partnership. We focus on the geographical area of the metropolitan region of Hamburg that has recently become a so-called Fab City as part of a global association and network of cities that share the common goal to** ***produce a good part of its needed products locally.*** **This makes it a particularly interesting case to empirically explore and theoretically conceptualize not only open distributed manufacturing, but more general emerging forms of cosmo-localist approaches to (re-)industrialization.**

Keywords – distributed manufacturing, open production, living labs, cosmo-localism, urban transformation, open source hardware, local production sovereignty

I. Introduction

As part of the globalisation and diversification of supply chains, the last decades have seen a significant offshoring of manufacturing and further specialization along value chains towards knowledge intense processes, servitization and data based business models in so-called advanced economies [1]. This development has fostered global integration, but at the same time established strong interdependencies and unequal developmental outcomes with massive ecological consequences. It has also led to a lack of awareness, knowledge and last but not least control of how and by whom the things we use and consume in our daily lives are actually made and where they come from. This counts especially for the urban space and its continuous increase in consumption and the amount of material resources needed for their sustenance.

Meanwhile, events such as the COVID-19 pandemic, increasing international tensions and conflicts and the overall ecological crisis have shown that the complex structure of globally integrated production networks is quite fragile and susceptible to external shocks and disruptions [2, 3]. Production shutdowns, component shortages, shipping disruptions and export controls have led to a growing uncertainty as well as rising transaction costs pushing firms around the world to reconfigure their global-spanning value chains. According to some authors this will 'ultimately lead to a more regional and less globalized world economy.' [4]

As a consequence, the current system of global economic integration and its dependence on capitalist models has been increasingly put into question. Critique on existing globalized production models becomes for instance apparent in a growing activism (e.g. around the G8 and G20 summits, Fridays for Future, etc.) and emerging public debates across the entire political spectrum [5]. These debates - whether among researchers or within society in more general - are linked through their strong emphasis on prevailing and **new forms of localism** and their request for alternative production models.

Although potentials for reshoring and **(re-) industrialization** have been existing before, it was certainly the pandemic that put them in the focus of interest [6]. Simultaneously, concepts of open source hardware and an exponential growth in related projects and open makerspaces in different domains are providing easy access to knowledge and small-scale production means on a local level. This is increasingly recognized by industrial actors and policy makers in terms of independence, resilience and innovation in the EU economy [7]. In order to protect environmental wellbeing, local industries and the resilience of communities, old notions such as protectionism, autonomy and self-sufficiency have been revived and found their way into current debates. As a consequence, questions of local industrial capacities and the future of local manufacturing sectors are gaining more academic as well as public interest.

Researchers have been for instance investigating cases of local food sovereignty and alternative food networks or local textile production [8]. However, less attention has hitherto been placed on what might be described as a type of ***local production sovereignty*** and alternative production models that relate to the strong global interdependencies in the manufacturing sector evident across many goods and commodities.

Scholars investigating post-industrial paradigms in the field of economics, engineering and innovation have predominantly stressed the decoupling of growth from material (and human) resources (e.g. through, digitalization, platformization/ servitization) as well as from the idiosyncrasies linked to its local embedding (see for ex. [9]). We argue that one major inaccuracy of these assumptions and related imaginations of a fourth industrial revolution lies in its (assumed) dematerialization of value creation. In most of the economic literature, so-called advanced economies in the Global South are based on knowledge, information and service orientation driven by an almost innate need to constantly innovate. The endless stream of commodities and goods traveling across the globe seem to have been flowing so steadily and reliable that only recent events have really reminded us of our dependency on material things, on goods and raw materials shipped in mostly from the Global South. It is time not only to bring 'the local' back into the debate but also to (re-)introduce 'the material' into the analysis, especially when it comes to environmental well-being.

The point here is not to trap into naïve categories of the local, but instead to focus on **concrete strategies proposed for (re)locating production** that neglect neither its material manifestation nor its multi-dimensional global interweavings. Hence, going beyond existing approaches, it is worth – and by all means necessary - examining a broader, more plural space of economic possibility and pay attention to alternatives that have previously not been on the radar [10].

Within the present paper we introduce an extensive real life experiment in which we focus on one particular upcoming strategy of re-industrialisation and re-localization of manufacturing that is based on a cosmo-localist approach to ideas of community-oriented, open production models. Although not a coherent concept yet, in the field of production engineering and supply and operations management it is predominantly referred to as **distributed manufacturing (DM)** [11] [12] or open production [13]. DM describes a post-fordist production model (quite in opposition to traditional mass production) that basically relies on a network of loosely coupled micro production units that enable local production on demand.

After an introduction of the central underlying concepts and its already existing instantiations, we outline the major challenges that come along with the actual realization of such production models and the lacking empirical evidence regarding major claims and promises made by authors and advocates of the approach. This serves as a basis to deduct key research questions that will be addressed in the subsequent empirical analysis operationalized within a living lab research framework designed around the metropolitan region of Hamburg that has recently become the first so-called Fab City in Germany pursuing the ambitious goal of producing almost everything that is consumed locally by 2054.

II. Theoretical and Conceptual Framework

Design GLobal, Manufacture Local: The promises of distributed manufacturing and cosmo-localism for circular urban production models

The following paragraph introduces the theoretical and conceptual framework as well as the rationale underlying the strategy of re-industrializing urban spaces based on a cosmo-localist approach to community-oriented, open production models that are aiming to establish small-scale regional economic cycles.

Cosmo-localism, Distributed Manufacturing and the free circulation of design ideas

Around the overall growing discourse on reshoring, re-industrialization and the relocalization of production and manufacturing different strategies have emerged in order to meet the above outlined challenges. Among them is a cosmo-localist approach that basically suggests 'the mutualization of planetary knowledge for use in localized production, solutions and development, to support positive social and ecological goals.' [14]

Cosmo derives from the Greek word for universe. Hence, cosmo-localism (a neologism created from 'cosmopolitan localism') explicitly addresses interactions and interdependencies between different spatial scales, actors and resources distributed around the globe.

The main ideology and vision behind cosmo-localist approaches to value creation (and manufacturing in more particular) is to reduce the global circulation and movement of material goods (i.e. atoms) by simultaneously enabling or facilitating the international circulation and transfer of designs, ideas and knowledge (i.e. bits) on how to realize and produce these ideas locally [15]. In doing so, it prioritizes a more pluriversal conception of autonomy and creativity trying to avoid the development of universal solutions to local problems [14, 16].

A more concrete operationalization of the concept can be found – though under different notions – in discussions and research on distributed manufacturing systems [12, 17–21].

Opposed to conventional mass production in a few very large production sites, DM relies on a network of loosely coupled actors providing micro production units that can offer local (customized) production on demand. It is basically enabled by advanced manufacturing technologies in the field of additive manufacturing (commonly known as 3D-printing) and the digitization of design, construction (CAD) and manufacturing tools (CAM/ CNC) in more general that have become more accessible and affordable during the last decades [11].

DM is associated with several positive outcomes most notably the reduction of logistics (i.e. transport), and shortening of process chains (e.g. through additive manufacturing), which will lead to a reduction of traffic, pollution and energy [22, 23]. In the field of production engineering, the potential of the model has been hitherto mainly discussed and validated in the context of emerging markets and early stages of industrialization in less industrialized areas or areas which are otherwise less attractive for manufacturing plants due to their remote location. This is also the reason why the concept is increasingly acknowledged and applied in the field of development cooperation. DM is estimated to foster social sustainability (e.g. higher employment rates), increase innovative capacities, foster local development and lead to an overall more sustainable long-term development and societal benefits that are valuable for both industrial and public/ institutional actors (for instance on the municipal level of cities [22–24]).

However, DM is not a coherent concept yet, and its actual realization in the industrial sector remains partly unclear until today. There are indeed different types of DM that can be basically distinguished along the following dimensions:

- the degree of openness
- the degree of consumer involvement
- the degree of vertical integration of activities
- the degree of formalization
- the degree of scalability (economies of scope versus economies of scale)

In its most extreme form, DM relies on prosumers (a neologism that designates the blurring boundaries between producers and consumers) often organized in globally dispersed virtual networks that engage in peer-to-peer production relationships enabling the 'personal fabrication' of goods on a small-scale local level. In this case there is a maximum level of openness (no conventional IP protection/ designs are open source) and maximum consumer involvement (i.e. consumers become producers). Activities are not vertically integrated, but instead decentralized and often self-organized in heterarchic networks. Thus, technologies, interactions and transactions are characterized through a low level of formalization and standardization. We refer to this form as ***the open, distributed manufacturing model (ODM)*** in the following. In practice there already emerged small ODM networks for instance in cases of community-based locally initiated production of protective equipment such as face shields [25]. These new patterns of building up (ad hoc) manufacturing capacities locally also took place in Hamburg.

On the other end of the continuum, less 'extreme' forms of DM can be aligned with mass customization [26]. Here the producer remains in control over the degree of consumer involvement. IP is more conventionally protected and it can be scaled up easily showing a tendency towards modular and batch production [12], which is based on high levels of standardization and formalization. In theory, between these two ends of the continuum, multiple configurations and expressions of DM are possible that range from an orientation towards degrowth models to forms of distributed capitalism and building a fertile ground for further exploration and research.

Cosmo-localist approaches to production can be classified as a specific expression of ODM since they are intrinsically linked to commons-based and alternative open-source modes of production (e.g. open source hardware). In this stream of literature**,** ODM is associated with the empowerment of people to 'democratize' production and gaining back power over local production and consumption practices. This is also the reason why it is increasingly associated with economic degrowth trajectories [27] and has been adopted by activists and social movements that criticize existing capitalist growth-based models of the economy.

> *DGML describes the processes through which design is developed, shared and improved as a global digital commons, whereas the actual manufacturing takes place locally through shared infrastructures with local biophysical conditions in mind.* [28]

Hence, in the core of this approach lies the conjunction of open source and open design and production logics at the global scale with local-network production capabilities at a regional scale [29]. In practice this means, that beyond traditional IP frameworks, designs are not protected, but are open and can be shared through different license models (e.g. creative commons) that have been established in the recent decade. Compared to developments in software development, open source hardware (OSH) projects and related online communities have evolved in various fields of technologies and applications ranging from medical devices [30] to land machines, drones, consumer products, cargo bikes and automotives. People distributed around the globe coming from very heterogeneous backgrounds (from students, to professionals, consumers, researchers and designers) virtually gather to develop, revise, improve and freely share hardware designs and documentation [30]. According to the underlying license model, the may also build, adapt, use and sell physical artefact based on these open designs.

Whereas Open Source Software is a well-established phenomenon, practitioners are still in an experimentation phase when it comes to the economic 'value' of OSH. However, recent case studies could generate further insights into these alternative modes of knowledge sharing in value co-creation and identify new business models in this field [30–32].

In the context of building up local manufacturing capacities, one promising approach is the development of standardized open source machine tools [33] that enable easy replication, modification and adaptation through standardized, modular architecture and can consequently be the basis for building low-cost local manufacturing capabilities and a technical infrastructure for manufacturing.

Although there are different approaches to DM (from more open community-oriented/ commons-based small-scale approaches to large-scale operations in the field of mass customization), there seems to be consensus on what predominantly enables them at least from a production engineering perspective. It is the interplay between 'infrastructural provisioning and network configuration, which determines the development and performance of localized production models.' [12] There is consensus that DM requires lower investment in physical or cyber-physical infrastructure as previous forms of so-called advanced manufacturing (e.g. I4.0, IoT) [34, 35]. DM production networks and start-ups require considerably less capital investment due to shared infrastructures and due to their ability to shorten development, design and product testing time as well as the fact that they do not need complex supply and distribution chains [34].

Associated technologies can be low-cost, easy-to-use and adjustable to local needs making them feasible for small-scale operations and potentially enable people to 'become more autonomous by controlling the manufacturing of their means of production' [27]. This could be accelerated by affordable, standardized open source machine tools that can be easily replicated.

Taken together, ODM bears the potential to promote what has been earlier referred to as a form of ***local production sovereignty*** through providing cyber-physical infrastructures for manufacturing on which local value chains can be build and related production networks can evolve. However, besides a local physical infrastructure for manufacturing (that can be certainly achieved with far less capital investment), what has been much less in the focus of scholars in this field is the digital infrastructure that ideally enables both: the operation of DM at the local scale with minimal transaction costs, as well as the development and sharing of design ideas and knowledge on a global scale. What comes closest to this necessary emerging (cyber-physical) infrastructure in the existing literature can be partly found in the concept of smart cities [35].

In most of the sources, the imagination of cosmo-localism as well as the potential associated with DM is indeed linked to the urban [36]. The last section of this chapter intends to introduce the Fab City movement and briefly discuss the potentials of ODM for urban strategies of transformation towards self-sufficiency and circularity.

III. Urban Transformation and the Fab City Movement

Cities are considered to be the main sites and drivers of economic growth and at the same time they produce 50% of the world's waste, 80% of the world's pollutant gases while consuming 75% of natural resources. Cities still rely predominantly on linear production models based on a massive energy consumption and lacking waste recovery [37]. Since urbanization is growing rapidly assuming that 68% of the world's population will live in cities by 2050 [38], policy makers are seeking for strategies that enable circularity as well as the resilience of cities. In search for solutions to foster circular economy the focus of most studies and approaches is on the reuse and repair of products, the reduction of consumption as well as the recycling of materials [39]. Less attention has hitherto been put on questioning the current global economic integration and modus operandi of complex global production networks. Exceptions can be mainly found in the agricultural production and food supply or the textile and fashion industry. Whereas the concepts of smart and resilient cities have different roots they seem to increasingly intertwine [40]. Originally the concept of smart cities has been pushed by large tech companies (Cisco, IBM, Philips) starting around 10 years ago to promote the deployment of ICT as a driver for economic growth and competitiveness. In contrast, the concept of resilient cities has been mainly promoted by international organizations and associations to strengthen a city's capability to respond to natural hazards (e.g. hurricanes, floods, tsunamis). Nowadays, both concepts have evolved into a rather multi-objective and participatory strategy that aims at tackling environmental deterioration and other external shocks while trying to foster sustainability, inclusion and building social capital [41].

The Fab (Fabrication) City ideology and movement combines insights and issues from the three dominating strategies for urban transformation: circular, smart and resilient cities. Proponents of the Fab City aim to radically transform how cities meet their needs and produce for themselves, while at the same time facilitating a global community of designers and makers [16]. According to them, Fab Cities bear the potential to support 'the development of localized circular economies that can transform the waste system and waste paradigm'. This is estimated to support 'cities and regions in becoming auto-productive, to form complex cosmo-local value chains for greater resilience' and keep 'production within planetary boundaries' [14].

In order to better understand the aspirations and rationale behind the Fab City concept, we briefly summarize its origins in the following section.

Origins and Visions of the Fab City Movement

Fab City is basically a spin-off of the FabLab movement initiated by MIT's Centre for Bits and Atoms around the beginning of the millennium. Neil Gershenfield's famous class on 'How to make almost anything' in 1998 was the starting point for an educational movement that aims at providing engineering knowledge and expertise to everyone. It resulted in the founding of the Fab Foundation which over the years fostered the development of at least 1.500 open workshops for manufacturing, so-called FabLabs, in over 90 countries as well as a globally distributed educational programme called the Fab Academy [42].

Fab City originated in 2014 during FAB10, the 10th global annual reunion of the Fab Labs network and has been issued by IAAC, MIT's Centre for Bits and Atoms, the Fab Foundation and the Barcelona City Council. Given its origins in the field of engineering, it is marked by a strong techno-optimism that ascribes transformative potentials to technologies, although actually following a community- and human-centered approach. During the last 8 years it evolved into a global association that has gathered 44 cities and regions under the common vision of becoming auto-productive by 2054. This ambitious goal should, however, rather be interpreted as a symbolic (motivating) vision than a realistic achievable goal. It is pushed forward through local communities within the participating cities, which are connected globally and meet annually face-to-face at a week-long global summit.

In order to become a part of the network (i.e. a Fab City) one has to gather a consortium consisting of local FabLabs, start-ups and other third parties integrating at least local municipalities (e.g. the mayor of the City, the Senator for economy etc.). In 2018, exactly 20 years after Neil Gershenfields' class on 'How to make almost anything' the publication of 'Fab City: Mass distribution of (almost) everything' [43] has been launched presenting best practices from the existing network including digital technologies such as blockchain and artificial intelligence. This is probably also why it has been increasingly interpreted as a critique on and alternative to existing conceptualizations of 'smart cities' [44]. Here, it becomes particularly apparent that the initial idea of technological empowerment of citizens in terms of 'making things' (i.e. manufacturing) has emerged into a project that aims to redistribute the power of monitoring and control over a territory 'by democratizing advanced technology, and enabling networking of users in a digital space.' [45] As a result, it has meanwhile grown into an initiative that aims to 'redefine common grounds for citizenships, helped by technology' [45].

However, in its actual manifestation each city seems to follow a quite unique strategy and interpretation of what it considers to be a Fab City building on different networks, institutional settings and trajectories of how they have come into being. The Fab City Hamburg initiative is strongly influenced by manufacturing and open source production ideologies connecting thematically to the origins of the movement.

Key Research Interests and Dimensions of the Project

The overall goal of our research programme is to gain empirical insights into the technologies, governance, institutional framework, material, and value flows of the open production model suggested in the prior sections. The gained knowledge can serve as a basis for developing a more coherent multi-dimensional framework and advance existing technologies and the processes used to create them.

The main aims of the development of the prototypical Fab City setting in Hamburg (on a more strategic managerial level) is to set a breeding ground for innovation in community-oriented manufacturing and urban production by building a physical (i.e. technical) infrastructure, local networks and communities and promoting knowledge transfer and education. Hence, in terms of urban transformation and setting up a real life experiment key research interests lie in optimal citizen and user involvement, diffusion (of innovations) and business models, legal issues (liability and licensing models), educational formats and urban transition governance.

Whereas research questions, interests and outcomes within the entire project are distributed among different disciplines and dimensions, they are all somehow linked through their striving for innovation and change. The overall project can therefore be placed in the field of open innovation studies choosing an open collaborative approach to public private sector innovation and institutional change as the following paragraph will show. The presented case is particularly suitable for investigating the iterative cycles in which top-down strategies (i.e. the ambitious vision of becoming an auto-productive, circular city with regional economic cycles) adapt to bottom-up answers in a very open heterogeneous setting. The principal openness in terms of networks, IP and knowledge sharing is considered a fertile ground for the development of fitting solutions and future models and the engagement of a variety of societal actors.

Thus, the Fab City Hamburg project is both a research and a development project. The focus of the given paper is on the more practical topic: the development and implementation of the prototypical Fab City setting. Here, we primarily focus on how emerging forms of ODM can be promoted and further explored in Hamburg. Or in other words: how can we create spaces for innovation, exploration, dialogue and co-creation engaging a broad already existing community in Hamburg and abroad? The focus in terms of implementation lies in promoting and gaining knowledge on:

- the establishment of a physical infrastructure for ODM through developing modular, standardized open source machine tools and how to foster their diffusion and adaptation,
- local networks and the development of local value chains,
- local/ regional economic life cycles, local sourcing, recycling and repair,
- promoting capabilities and knowledge transfer (education).

This comes along with several more practical oriented questions such as:

- Who are the actors that already provide small-scale open production sites in the city of Hamburg?
- How can they be connected and institutionally integrated?
- How can they be supported in building up local manufacturing capabilities in terms of ODM (technically, financially and institutionally)?
- What kind of sectors and fields of action are particularly suitable?
- What kind of products and services can be created in an ODM context?

METHODOLOGY AND OPERATIONALIZATION

In order to examine how the premises of the cosmo-local distributed manufacturing approach can be realized in practice and to clarify how or if it can transform or at least contribute to new forms of urban value creation we build a real life experiment based on the living lab approach. In the following section we introduce the approach and illustrate how it has been operationalized in the given case study. Since the study is still in a preliminary stage, we conclude with some reflections on challenges as well as an outlook that outlines key questions for future research.

IV. PARTICIPATORY ACTION RESEARCH AND THE LIVING LAB APPROACH

The COVID-19 pandemic has highlighted the importance of open, collaborative approaches to private as well as public sector innovation that involve a variety of different stakeholders to co-create solutions in order to find economic alternatives and alternate production models that help to rethink current economic principles and revive the economy [46] . In this context, Living Labs (LL) have gained increasing attention and have become a popular approach to collaborative innovation [47] as well as urban transformation [48, 49] among scholars, practitioners and policy makers (see for ex. the European Network of Living Labs/ EnoLL).

Living Labs can be classified as a participatory action research paradigm, since they emphasize participation as well as action by communities directly and indirectly affected by that research seeking to understand the world by simultaneously trying to change it collaboratively. It relies on collective inquiry and experimentation that is grounded in experience [50] and hence demands for a qualitative research methodology that focusses on exploration rather than hypothesis testing.

There currently exist many different definitions and approaches to LLs. We rely predominantly on literature from the field of innovation management focussing on collaborative innovation, user-centered design [51] as well as urban studies that are most suitable to our extensive case study focussing on the Metropolitan region of Hamburg and the innovation strategy behind making Hamburg a 'Fab City' through enabling and promoting DM infrastructure and practices.

Thus, following Westerlund et al. [52] we consider LL as platforms providing shared resources (i.e. physical and digital infrastructure for small-scale DM approaches). These platforms or innovation eco-systems bring together a variety of private and public stakeholders (i.e. FabLabs, Makerspaces, SME, municipalities, researchers, users, citizens, NGOs) to gather, create, communicate, and deliver new knowledge. Within this public-private-people partnership existing and developed concepts, products, services and processes can be explored and validated, in order to 'facilitate professional development and social impact in real-life contexts.' [47] The outcome or 'product' of a living lab can have very different forms ranging from objects, to services, technologies, applications, processes or systems.

In terms of operationalization (especially in a more research than practice oriented perspective), LL is a multi-method approach that combines methods and tools originating from the fields of ethnography, sociology, psychology and strategic management, design science and engineering. In our case, the LL field trial is both a technological as well as a social experiment that makes it a testbed as well as an ethnographical research setting in which processes of socio-technical co-creation can be observed [53]. The focus is on exploring (and evaluating) the prototypical realization of ODM in the Fab City Hamburg context from a multi-dimensional perspective. Hence, our lab approach is not intended and designed to foster urban transformation in the first place. The impact of LL on processes of urban transformation is probably quite limited [54]. Our LL is mainly designed to investigate and advance processes and practices of emerging forms of ODM.

Building a living lab initiative in a more practical sense, is a challenging endeavour. Depending on the specific problem a living lab initiative wants to explore and seek a solution for, there exists a variety of different approaches how to practically establish and manage an LL setting. We rely mainly on the suggestions made by Steen and van Bueren [55]. As opposed to the conventional organization of living labs around the development of a particular innovation they suggest that living labs can be also designed around a 'geographical area that forms the arena for multiple living labs focusing on various problems.' [55] In such place-determined projects multiple single lab initiatives are connected by a platform that can be a fertile ground for innovation. The main challenge here is to really assure stakeholders engagement and integrate single activities into a coherent framework and platform. The development can be roughly divided into 8 phases within a generally iterative development cycle shown in FIGURE 1.

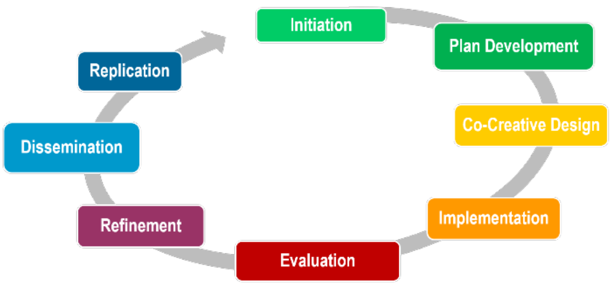

FIGURE 1: LL DEVELOPMENT CYCLE.

Since the project is still in a preliminary stage, we focus only on the first stages here. In the initiation phase, problems that the LL wants to find solutions for are defined and fitting partners (inclusion of the right capabilities) and places for realization are identified. In the second stage of plan development, shared visions and process design are developed together in a co-creative iterative process and an appropriate management structure and work flows are established.

A lot of participants in LL initiatives contribute to innovative co-creation work and activities on a voluntary basis. Therefore, participants cannot be managed in a conventional way. Instead of forming a strong hierarchical authority the development process manager(s) should carefully motivate and inspire stakeholders and focus on building trust and strong relationships [55]. Ideally, one can identify a visionary leader that is already engaged in the community and that is moreover able to translate between the different groups of stakeholders and find a common language. The developed institutional framework should be flexible and participants should be aware of changing roles and role expectations. Last but not least, in the early development phase a suitable infrastructure for communication and sharing needs to be established.

V. BUILDING THE FAB CITY LL HAMBURG

FINDING PARTNERS AND PLACES

In the initiation phase of the given project that started already in 2017, we researched Fab Labs around the world, identified existing Fab Labs, maker and hacker spaces as well as other institutions in Hamburg and started a networking process that resulted (among other things) in the foundation of the Fab City Hamburg e.V. There are currently 21 full members ranging from NGOs, to start-ups, educational and research institutes to Fab Labs and makerspaces [56]. The association is steered by an elected management board that represents the diversity of interests of the members.

The municipal authority also supported the application of Hamburg as a Fab City committing voluntarily to its manifesto and so Hamburg became the first German city to join the global network in 2019. This set the starting point of a community building process in which various actors like SMEs, non-profit organizations, fab labs, universities and individual persons and communities have been engaged to participate and formulate a common vision and mission for Hamburg. They have been already successful in acquiring funding for own R&D projects and operation. In the given project, we are building on that existing communities, structures, projects, prototypes and networks as the heart of our LL. Open production workshops provide ideal conditions as they are spaces of mutual learning, creativity and experimentation. In this sense, the Fab City Hamburg e.V. can be considered as **an institutionalized LL platform** that links single lab initiatives distributed across the city.

Based on the overall vision, the mission statement [57] of the co-creative development process can be summarized as follows:

- Support and development of existing and new open production sites (Fab Labs, makerspaces etc.) promoting a physical/ technical infrastructure
- Development and diffusion of a digital infrastructure for collaborative design and value co-creation in the Fab City network (this project is realized with support of massive EU funding [58])
- Establishment of a Fab City Haus as a central hub for all activities carried out by the community and a prototypical testbed and demonstrator for open design and small-scale distributed manufacturing practices
- Citizen engagement and Fab City incubator programme through city wide idea challenges generating product and design ideas that are further developed into prototypes
- Development and implementation of educational formats targeting lay persons, more advanced makers, designers, companies and workers (e.g. mainly in the field of vocational trainings)
- Development of a Fab City Index relating to the Index already developed by the Fab City Paris actors. The

index aims mainly at mapping current production capacities as well as consumption and material flows, to identify gaps and potentials on the way of becoming a Fab City

To implement the mission statements, in the next steps, we identified suitable fields of action and partners providing specific practical expertise and scientific substantiation regarding our research and development goals, in order to create more specific single lab initiatives, test beds and research cases. These include:

The ***OpenLab Starter Kit*** or how to build low-cost standardized open source machine tools. In this context we develop a set of at least 12 machines out of which some have been already prototypically developed before the start of the project in formal cooperation with a start-up realized at their manufacturing site in the eastern part of the Metropolitan Region of Hamburg.

The ***OpenLab Circular Textiles*** or how to rethink textile production and consumption in Hamburg at the community-level in formal cooperation with a local textile start-up and their network partners realized in an interim temporary use of a vacant building in the centre of Hamburg.

The ***OpenLab Port*** or how to introduce advanced open source machine tools to the port industry, in order to produce unique spare parts locally on-demand realized in formal cooperation with the Hamburg Port Authority in a container lab provided by the HomePort project in the port district.

The ***OpenLab Mobile*** or how to empower local craftsmen to use digital manufacturing tools in formal cooperation with a public-private partnership institution that promotes economic and regional development in the structurally less developed southern part of the Elbe river. The OpenLab Mobile will be realized in a truck that will be equipped with several machine tools (depending on the target group) that brings the machinery in demand to the people rather than vice versa.

The ***OpenLab MedTech*** or how to enhance user innovation and knowledge sharing in the field of medical engineering and health services. This will be realized in collaboration with the Physikalisch Technische Bundesanstalt (PTB) responsible for the further development of an open source MRI technology as well as the hospital of the Federal Armed Forces in Hamburg Wandsbek that provide the physical space as well as access to users and practitioners.

The ***OpenLab Circular Plastics*** which will be realized together with an NGO in Wilhelmsburg promoting the local recycling of plastics with open source machine tools (e.g. shredding and pressing/ moulding) including people with disabilities on the shop floor.

The ***OpenLab Agri-Food*** in which we further develop and explore small-scale digital technologies like a farmbot and a wheeding bot (EcoTerrabot) developed by TUHH students on a testbed provided by the Klimaschutzstiftung e.V at Gut Karlshöhe and explore more general questions of urban food sovereignty in collaboration with partners from the Kühne Logistics University (KLU).

Last but not least, one of the most challenging parts has been the realization of the intended **Fab City Haus**. The location close to the harbour and the city centre is now a co-working space (open for the entire LL community) with a small makerspace and enough space for showcasing some of the demonstrators and products developed in other contexts. The envisioned open micro-factory (as part of the original concept for the FC Haus co-created with the commmunity) will be now realized in an adhoc pop-up factory within a to be defined interim use of a vacant building in the city.

In order to support scientific substantiation **additional research partners** have been formally integrated in the project consortium to give support in the fields of supply and operations management (KLU), innovation marketing and diffusion (Technical University of Hamburg/ TUHH), innovation-accompanying legal research (Transnational IP Center at Bucerius Law School/BLS), citizen innovation (KLU), urban transformation governance (Hafen City University/ HCU), as well as local agri-food supply chains (KLU). FIGURE 2 shows an overview of the different groups of stakeholders.

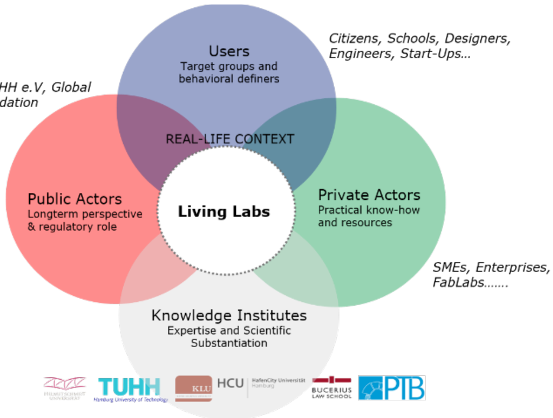

FIGURE 2: OVERVIEW STAKEHOLDERS.

Establishing a common communication infrastructure has been technically based relying on NEXT Cloud (self-hosted collaboration platform), GitLab (collaborative design), and Element (instant messaging). A common communication and PR strategy is still in the making as is the development of an efficient evaluation concept for the LLs that is able to integrate findings into a coherent framework in the end.

VI. CONCLUSION AND OUTLOOK

In the prior sections we have introduced the rationale behind theoretical and conceptual frameworks that underlie the Fab City Vision and its potentials for strategies of transforming existing practices of urban production towards more resilient, circular and community-oriented production models.

Until now, a lot of the suggestions and assumptions made by the advocates of the movement and related communities are lacking profound empirical evidence. What might be working in a small community in one specific place, cannot be easily transferred. Although the cosmo-local approach to production stresses a pluriversal solution space trying to avoid universal solutions to local problems, it still lacks a broader more consistent and empirically grounded theoretical framework. It is still a niche phenomenon; but certainly one that can widen our horizon and pave the way for exploring a more plural space of economic possibility.

In order to gain deeper empirical insights, we have chosen a LL approach to develop prototypes, processes and models that can be explored and further validated in a real-life setting. The chosen approach is likely to generate diverse insights on different dimensions of the open production model and cosmo-local approaches to (re-)industrialisation in more general ranging from technologies, governance, institutional frameworks, material, and value flows to more specific questions of citizen and user involvement, urban transition governance, legal issues and the future configuration of local value chains.

Last but not least the project is likely to stimulate learning and networking processes, foster technical literacy and awareness and create a breeding ground for innovation, new business models and the development of small-scale regional economic cycles.

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