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Open Prosperity: Breaking Down Financial and Educational Barriers to Creating Physical Goods

The Internet has been a topic of discussion in *IEEE Technology and Society Magazine* for the past 15 years. Throughout this time, it has been recognized that the Internet can fundamentally change the creation and distribution of information [1]. Recently, another opportunity for fundamental change has become apparent. That is, the potential of the Internet to fundamentally alter the creation and distribution of physical goods. In particular, the Internet, combined with new digital technologies, can break down financial and educational barriers to the invention, design, manufacture, assembly, and sale of goods [2].

Consider, for example, the activities of the following Internet-based organizations. Kickstarter applies crowdfunding to enable individuals to quickly secure investment funding for their new ideas [3]. Open Materials enables individuals to source the latest production materials and methods [4]. Arduino offers micro-electronics that can be used to make almost any physical good interactive [5]. Thingiverse is focused upon enabling the digital design of new types of physical goods [6]. Makerfactory and 100k Garages enable individuals to easily find their closest providers of digitally-driven manufacturing services, such as additive manufacturing and computer-numerically controlled (CNC) machining [7], [8]. Sculpteo and Shapeways enable individuals to design, make, and then sell, physical goods [9], [10].

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These organizations' combinations of the Internet plus digitally-driven technologies break down financial barriers to going from idea to production to sales. These new processes eliminate the need for large investment in market research and production facilities. Rather, the Internet can be used at little cost in order to determine the extent of interest in a potential new good and to receive pre-orders. Then, time on digitally-driven manufacturing equipment can be paid for as needed. This is a radical departure from having to make big investments in moulds, presses, and assembly lines in order to achieve efficient production. Hence, the potential now exists for anybody anywhere to invent, design, produce, and sell physical goods [11].

In addition to breaking down financial barriers, the Internet plus digitally-driven equipment can do much to break down traditional educational barriers involved in taking an idea for a new good through market research in to production and on to sales. For example, the direct transfer of digital data from digital photographs, digital scans, and/or digital designs eliminates the need for people to convert detailed information from measurements and/or designs into detailed production information. This greatly reduces dependency on education in production engineering. The use of digital photographs, digital videos, and digital scans to define measurement data also eliminates the need for education in the development of three-dimensional drawings from sets of one-dimensional measurements

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made with tape measures, vernier gauges, etc. This is because they can be automatically converted into three-dimensional digital computer models through photogrammetry software [12].

Many new tools are reducing the amount of education required to be able to represent an idea for an original good as a digital design. For example, digital pens enable rough sketches to be drawn on paper and other surfaces to be rapidly converted into digital computer models [13]. Also, many new CAD tools have intuitive user interfaces, for example: Alibre, Blender, Google SketchUp, Tinkercad [14]. Accordingly, lack of prior skills in the use of CAD software is no longer a significant barrier to product design.

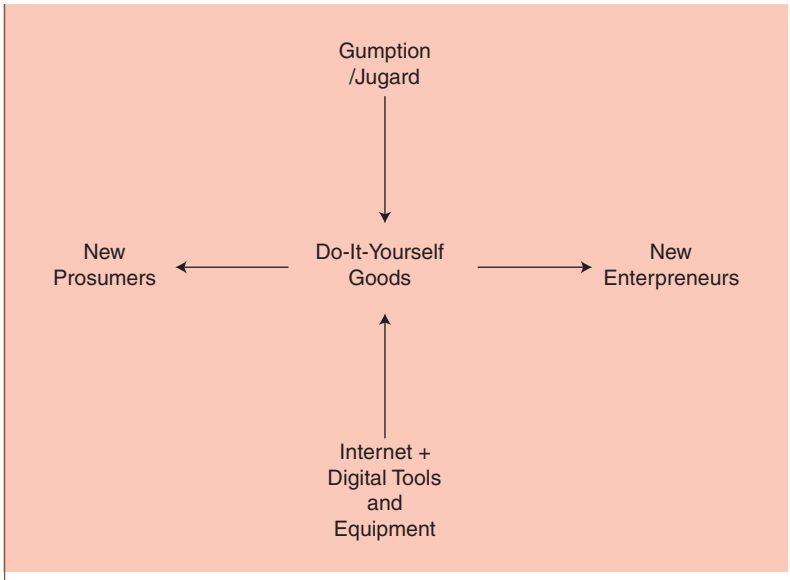

Fig. 1. Open prosperity.

The digitally-driven manufacture of components direct from digital photographs, digital scans, and digital designs reduces dependency on education that has previously been required to be able to shape components using traditional tooling, such as saws, lathes, and chisels. For example, computer numerically controlled (CNC) routers can be used for cutting, drilling, and carving components into shape. Also, additive manufacturing equipment can build up complex physical geometries direct from digital computer-aided design files [15].

With regard to the assembly of manufactured components, it is possible for digitally driven manufacturing equipment to produce one design in two different sizes from the same computer file. This first offers the possibility of production of a scale model for the purpose of learning how to put the components together into the designed product. Second, full-sized components can then be produced for assembly into a completed product. Also, the components produced can have numbered friction-fit/snap-fit joints [16]. Thus, the need for prior education in assembly work is greatly reduced.

The Internet plus digital technologies can facilitate the invention and production of goods as large as buildings. Importantly, there no technological constraints to the creation of goods that are original in design and that are also consistent with local aesthetic preferences [17]. Moreover, digitally-driven manufacturing machines can be housed within freight containers and transported to any location that a lorry can reach. This means that anybody anywhere can make use of digitally-driven manufacturing technologies to produce original products. This is very important in land-locked countries, such as Burundi, where up to 75% of the cost of goods can arise from transportation [18].

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As summarized in Fig. 1, combining the Internet with easy-to-use digital technologies for design, manufacturing, assembly, and sale of goods opens up opportunities for increasing prosperity in two directions. First, people can themselves produce the goods that they need: i.e. they can become prosumers. Second, people can sell what they produce: i.e., become entrepreneurs. In either case, the breaking down of financial and educational barriers enables many more people to create goods themselves from their own original ideas. This is very different from so-called open innovation where big name brand holders harvest the original ideas of individuals through online communities and competitions. There, the brand holders continue marketing, design, and production from centralized locations behind high financial and educational barriers [19].

By contrast, the combination of the Internet with easy-to-use digital technologies for design, manufacturing, assembly, and sale of goods opens up opportunities for anybody anywhere to profit directly from their own gumption. This is boldness of enterprise, which combines resourcefulness to come up with new ideas with the determination to turn new ideas into new realities. Throughout history, humans have

used their gumption to create prosperity as they have moved around the world. For example, this was true when people left Europe to settle in Australasia and North America. Throughout the world, many millions of people invent and persevere their way through life by drawing upon their gumption, or "jugaad" as it called in India [20]. Now, through the Internet and digital technologies, those people can have better opportunities to prosper, rather than just survive.

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