Economic Inclusivity through Networked SME Production: A Case Study in Kenya

by

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Abstract

As global manufacturing systems shift towards flexible and small-batch production, product developers and policy-makers have an opportunity to encourage more inclusive industrialization strategies. It is hypothesized that networks of informal-sector producers can provide an effective and ethical model for production; yet, due to a lack of research into these possibilities, both product developers and policy-makers are unaware of the latent potential.

This thesis addresses the gap by analyzing a globally-competitive firm comprised of informal-sector producers, and making comparisons with other manufacturing models across both the developed and developing world. The author develops a categorization system for better understanding the costs and benefits of each model, and creates a framework to explain how new product developers evaluate key tradeoffs in making manufacturing decisions.

The author then explores the prospect of creating a "virtual factory" of distributed microfactories through a case study of the ethical jewelry producer Soko in Nairobi, Kenya. Soko coordinates brass, horn, and bone jewelry production across 2500 craft microfactories, and its wares are cost-competitive with mid-tier jewelry brands in major retail stores worldwide. Soko's overall effectiveness is analyzed through quantitative analysis of the company's finances and impact reports, in-depth interviews with the company's co-founder, and field research in Nairobi. The tradeoffs inherent in Soko's production model are evaluated through the lens of the aforementioned decision-making framework. Key questions include, can artisanal microfactories compete with large-scale automation and industrialization? In what cases might smaller-scale production have an advantage over larger-scale models?

Under the right circumstances, the case of Soko proves that networked microfactory production can be both cost-competitive (especially when handmade qualities are accentuated) and ethical; Soko creates opportunities for advancement across its network of artisans, who maintain ownership over their means of production. It is concluded that systems such as Soko's can provide a model for socially-inclusive production strategies that build upon informal infrastructure. Even if Soko itself only impacts a small number of full-time artisans, a series of ethical, aggregating producers like Soko could collectively provide a larger-scale benefit.

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All mistakes and inaccuracies are my own.

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Chapter 1. Introduction

While manufacturing jobs have historically been a stable route to social mobility, today's under-educated workers may not be able to rely upon this strategy as technology and globalization continue to advance. The global manufacturing value added as a percent of GDP has steadily decreased from 21.5% in 1995 to 16.6% in 2017 (World Bank 2017). The overall global percentage of employment in the industrial sector has remained relatively constant around 22% (World Bank 2017), though unethical working conditions such as forced labor, underpaid homeworkers, and dangerous factory conditions have posed a persistent challenge– especially as manufacturing profit margins have decreased. Low-skilled factory jobs are increasingly being replaced by automation and part-time, contract jobs (the "precariat" or "gig economy"). Even middle-income countries such as China and India are no longer employing as many unskilled factory workers in the sorts of stable jobs that used to lead to class mobility.

Across sectors, 61% of the world's employed population– two billion people worldwide– – make their living through the informal economy (ILO 2018). Informality is vaguely defined; characteristics include operating out of households rather than dedicated shops or facilities, a lack of connections to established businesses, a failure to go through official routes for legal registration, and a general avoidance of business taxes. Due to the lack of transparency among informal sector homeworkers and the prevalence of exploitative middlemen, homeworking is often treated as a problem in supply chains (Sommers 2018); firms strive to employ proper factories where they can visit and ensure ethical conditions, rather than hire networks of homeworkers who may be paid illegally low wages, work under dangerous conditions, or even be indentured laborers.

Still, the breadth and entrepreneurial creativity of the global informal sector present a major opportunity for inclusive production models. While larger enterprises tend to aggregate in urban centers, informal-sector jobs are prevalent in rural areas and could help to prevent unsustainable urban migration. Additionally, people who work from home– particularly women– can take care of their children, elderly relatives, and other household needs throughout the workday.

Even though the informal sector employs more than half the world's workers, I have identified a lack of thoughtful research into its possibilities. Thus, my research addresses the following questions: How can manufacturers contract with existing cottage industries for large-scale production? Are informal-sector jobs ethical, and how do their working conditions compare to traditional manufacturing? What do ethical jobs even entail? Finally, what are the costs and benefits of creating an industrial-scale factory out of networked small producers? It is hypothesized that such networks ("Networked SME Production") can indeed provide an effective and socially-inclusive model for industrial production.

Motivation

The key motivation behind this work is the goal of sustainable development, defined by the United Nations as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and

Development for the United Nations General Assembly 1987 quoted in Peinovich 2012). Despite recent interest in the vaguely-defined fields of "social entrepreneurship" and "ethical production," and a longstanding interest in the manufacturing sector more generally as a mechanism for social mobility (especially for women), there has been little modern research around the potential for harnessing the vast informal sector as a means of sustainable development. Current academic literature tends to focus on either high-tech facilities using high-tech networking capabilities (the German "Industrie 4.0") or low-tech workshops without any modern networking capabilities (the roadside "informal sector" or "industrial slums" of emerging markets). As discussed in the next section, the growing body of literature around the "Maker Movement" tangentially addresses these questions, but rarely engages with questions of global competitiveness and overall scalability. This research attempts to address these gaps in current research, through an in-depth case study of the Nairobi- and SF-based jewelry company Soko's informal sector-based production system. Through an analysis of Soko's business model and manufacturing strategy, I endeavor to illustrate the strengths and challenges of Soko's Networked SME Production using metrics defined by our tradeoff framework for production decisions.

My thesis begins with a literature review on contemporary manufacturing models; I evaluate production models across the developed and developing world, and propose a new framework for categorizing production distribution. Building upon managerial and sociological literature, with considerable help from my advisors and other mentors, I then explore the tradeoffs that play into manufacturers' production decisions with a particular focus on ethical considerations around "good jobs." In Chapter 3 I present a brief introduction to the complex world of modern jewelry manufacturing, before diving into a case study of the jewelry company Soko and a brief history of production decisions made by firm's co-founders. I then examine how our manufacturing tradeoffs apply to Soko and explore the overall effectiveness of the firm, and finally draw conclusions on policy implications and overall lessons from Soko's successes and challenges.

Methodology

This research employs a mixed methodology approach, combining quantitative data from Soko's financial statements and impact reports with in-depth interviews and field research. My advisors and I developed a framework by which to evaluate manufacturing decisions and the ethical dimensions of production, through a literature review and extensive discussions with manufacturing experts. Guided by this manufacturing decisions framework, I spent around five hours over the course of 18 months interviewing Soko co-founder Ella Peinovich, through a mix of structured questions and conversation. These interviews were mostly qualitative, with a few numerical questions around numbers of artisans and financial success over time. My advisor Georgina Campbell Flatter and Megan Mitchell provided field-work to supplement this case study, visiting several Soko microfactories and holding discussions with a dozen artisans and Soko employees.

For my quantitative financial analysis, Soko staff Marylene Otieno, Judith Mwangangi, and Tirus Ndung'u granted me access to Soko's 2017 profit and loss statements, the firm's

quarterly impact reports from 2014-2016, and the year-end impact report from 2017 with results from several surveys of Soko's artisanal network. I personally interviewed Mwangangi and Otieno for clarification on many of Soko's numbers. I analyzed these statements with considerable support from Sloan MBA student researchers Kasmira Pawa and John Howard. For comparison Mass Production cases, I did online research into the modern jewelry industry and, thanks to John Howard, conducted quantitative interviews with Linus Drogs, founder and president of the jewelry company Au Enterprises, and John Croston, owner of Jewelers Consulting Services with over 30 years of experience in production operations. These interviews focused on American and international jewelry production, and Drogs and Croston provided me with cost breakdowns of typical jewelry production methods.

For my final analysis, we had the opportunity to present our Soko case study across five MIT classes to undergraduates, MBA students, Sloan fellows, Legatum fellows, and D-Lab engineering students– thanks to Georgina Campbell Flatter, Sorin Grama, Professor Fiona Murray, and Dr. Anjali Sastry. We worked with students to explore and question Soko's business model, and to tease out insights around the broader effectiveness of Networked SME Production and its potential for sustainable development. This case study has also been presented at Legatum event around the world.

Chapter 2. Literature Review on Production Systems

Introduction

Manufacturing has changed considerably over the course of human history– from the pre-industrial days of cottage industries and skilled artisanal production; to the division of labor typified by Adam Smith's pin factory in the mid 18th century, in which unskilled workers perform specialized, repetitive tasks along an assembly line; to factory mechanization throughout the Industrial Revolution of 1760-1840; to the highly-standardized parts and tasks of Ford's assembly line in 1920; to today's predominant and highly varied model of "Post-Fordism" characterized by specialized, smaller-scale producers. Over the past few decades, there has been considerable enthusiasm across academia around new, less centralized manufacturing models characterized by Small and Medium Enterprises or SMEs: flexible specialization in Germany, Japan, and China (Piore and Sabel 1984); putting-out in Italian knitwear (Lazerson 1995); and digital fabrication and 3D printing worldwide (Gershenfeld 2008). Yet there has been little consensus on the vocabulary to describe these potential models, and even less agreement on the direction in which we are heading. Additionally, despite general shifts toward more flexible and less vertically-integrated production models, historical models such as craft production and Fordism have remained prevalent internationally. This literature review attempts to categorize and compare various manufacturing models, and to hopefully define some common vocabulary to facilitate future discussion.

Typology

Based on the literature review described below, I present five basic categories to describe the extreme bounds of manufacturing systems. My unit of analysis is the fully-assembled product described in the last column of Table 1 (a wax mold or complete necklace), rather than the production firms themselves; I define all my terms following the table below.

Table 1: Bounds of Production Systems

	Scale of production	**Batch Size**	**Product Integration**	**Production Distribution**	**Example manufacturing for a necklace**
Craft SME	Local	Small	Varied	Centralized	Local artisan (pg. 11)
Flexible SME	Varied	Varied	Varied	Centralized	Au Enterprises (pg. 13)
Specialized SME	Industrial	Varied	Components	Centralized	Wax mold-making company (pg. 14)
Networked Specialized or Flexible SMEs	Industrial	Varied	Components	Distributed	H&M's 747 outsourced factories (pg. 15)
Networked Craft SMEs	Industrial	Small	Units	Distributed or Decentralized	Soko, Fabindia, subcontracted homeworkers (pg. 16)
Mass Production	Industrial	Varied	Units	Centralized	Fossil's assembly factory (pg. 18)

Practically speaking, these categories are most useful as archetypes rather than pure descriptors, since this typology of production presents more of a spectrum than a firm set of criteria. There is a long tail of manufacturers internationally (see Figure 1), and many fall somewhere between small-batch Small and Medium Enterprise (SME) Production and Mass Production. To demonstrate, here is a chart of the number of factories in the USA (Manufacturing Census Data 2012) sorted by number of employees, a decent proxy for the overall size of a firm:

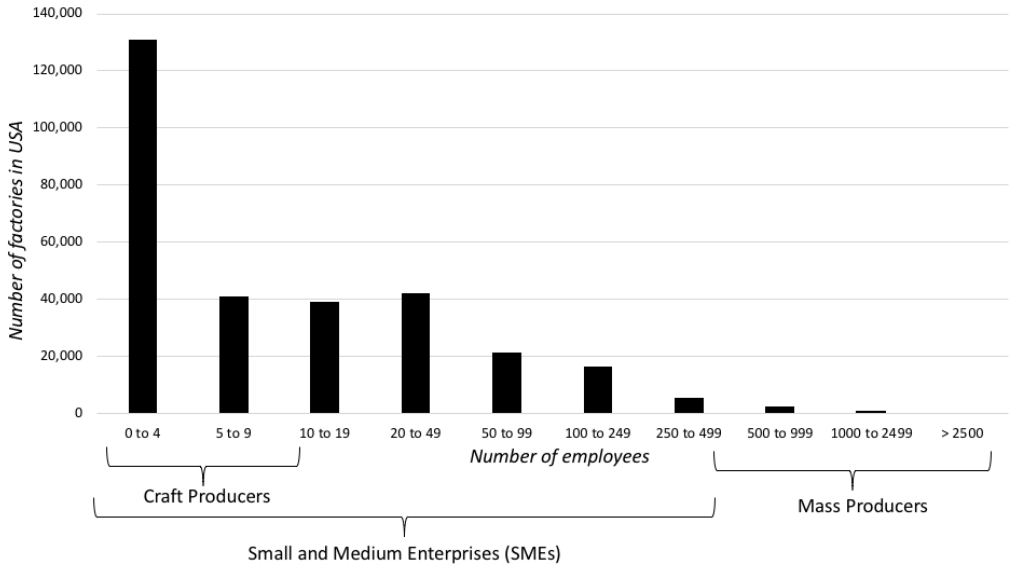

Figure 1: USA Factories by Employee Count (data from USA Manufacturing Census 2012)

Firms with fewer than 10 people on this chart are definitely craft producers, and firms with more than 500 people are certainly mass producers; those with employee counts in the middle could potentially go either way, which is why I will classify all factories with fewer than a few hundred employees as SMEs. I list four key types of SMEs, although many SMEs may fall into multiple categories:

- Craft SMEs: a subset of SME production, characterized by very few employees and a widely-variable "job shop" production workflow, which changes from one product to another. These typically employ low-tech equipment and significant manual labor, and may not be formally-registered businesses.
- Flexible SMEs: small and medium factories that likely follow a more organized production workflow, and can produce a variety of goods using modern, automated equipment such as digital fabrication.
- Specialized SMEs: small and medium factories that likely follow a more organized production workflow, and produce a narrow selection of specialty goods using modern equipment.
- Networked SMEs: a collection of SMEs that, in aggregate, can produce large volumes of goods. These SMEs can fall into any of the above categories, though I only include Networked Craft and Networked Flexible above.

Typology Criteria

I employ four sets of criteria to categorize manufacturing systems, as represented in the first row of Table 1:

- **Scale of production**: how many products are produced in total, across all the factories involved in production? This ranges from the "local" scale of producing just enough to

satisfy local demand, to the "industrial" scale of competing with other producers on a global level.

- **Batch Size**: how many components or units are produced in a single batch, in any one factory? Whether a production run counts as a "large" or "small" batch depends upon the industry; thousands of high-end wedding dresses might count as "large-batch" production in retail, whereas thousands of plastic necklaces are "small-batch" by mass-production jewelry standards.
- **Product integration**: are the majority of components involved in the final product manufactured and integrated all-at-once (unit-level), or are components mostly produced across a network of smaller firms and sent elsewhere for integration (component-level)? A large factory that takes in beads, chains, and clasps as inputs from various suppliers and then sells necklaces as outputs follows a "component" integration model, whereas a network of hundreds of home-workers making their own beads and stringing together complete necklaces follows a "unit" model. Most products today involve some blend of these integration models.
- **Production distribution**: what distribution pattern best characterizes the flows of information and parts, and is there a hierarchy of production? Following Baran's (1962) seminal paper on computing networks, I propose three basic models: centralized, decentralized, and distributed:

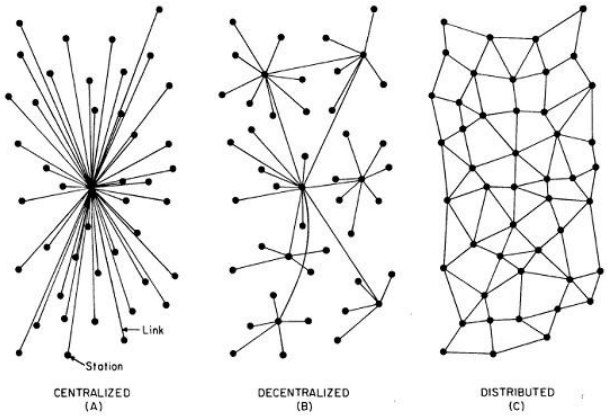

Figure 2: Distribution Models (Baran 1962)

  - **Centralized***:* This is the traditional Fordist model, in which all manufacturing takes place in a central location. It is rare, today, to see a completely centralized production model. One could categorize the jewelry and watch producer Fossil as having a centralized factory for the bulk of its production and assembly, though many of Fossil's components are produced in a decentralized manner through networks of Specialized SME contractors and sub-contractors. During the Industrial Revolution, giant and centralized textile mills performed all production stages from spinning cotton into threads to weaving threads into fabrics to cutting and sewing final garments; most of these stages now take place across smaller factories, although such vertically-integrated textile mills are still prevalent in India today (India Brand Equity Foundation 2018).

- **Decentralized**: This model employs more of a hierarchy than the Distributed model, in which small factories manufacture some product for a larger firm or platform. Products may undergo additional assembly and/or processing in a centralized location. For example, a rural jewelry artisan might sell necklaces to a middleman, who takes them to a craft market in the city. Alternatively, a Networked SME Production might contract thousands of SMEs to manufacture jewelry to its own unique specifications. Flexible Specialization primarily follows this model, in which a company like H&M has separate microfactories producing jackets, glasses, shoes, or other items of apparel according to H&M's requirements (H&M 2011). Some microfactories work exclusively for one company, while others produce a panoply of parts for a wide variety of large firms (Piore and Sabel 1984).
- **Distributed**: This model allows the customer, who may be a consumer or another business, to purchase some product directly from the producer via a retail shop or web platform like Etsy. (While Etsy does act as a centralizing platform, Etsy artisans still sell and ship directly to consumers.) Most SME production follows either this model or the decentralized model. For example, local tailors across China make customized clothing for local customers on a just-in-time basis. There have been some attempts across the open-source hardware community to encourage fully-distributed Networked SME Production, with products designed to be fabricated locally and on-demand by local producers without any need for interaction with the original designers. Examples of distributed production at scale might include purchasing sewing patterns to make clothes on one's home sewing machine, or Ikea's at-home furniture assembly model (although Ikea's furniture parts are all mass-manufactured).
- **Blended distribution**: Often, a given product will utilize different distribution models for various steps. Zara's clothing, for example, is designed at Zara headquarters in Spain and then manufactured in a decentralized network of factories over three continents. Some factories shipped fabrics back to Zara headquarters for assembly, while other fabrics are turned into clothing more locally and shipped directly to Zara stores worldwide (SCM Globe 2016). Using this typology, one could say that Zara employs a combination of Specialized SME Production and Mass Production in a distributed manner.

Types of Production

SME Production

Humanity's very first model for the production of goods was characterized by *unit-level* production in small batches across semi-specialized cottage industries, with these microfactories generally located close to the point of final sale. The earliest fabrics date back to around 34,000 BC. Consider the thousands of independent wool spinners, weavers, cloth-dyers, and tailors who would combine forces to make clothes for their regions in pre-industrial times (before mechanical looms emerged in the 18th century). These microfactories produced small

batches of some complete unit, often using just-in-time production rather than stocking inventory.

Most SMEs are owned by the head artisans or factory managers themselves, though some are part of a regional or even global franchise. (Examples to follow.) For many SMEs, it is typical for junior artisans (who are often relatives of the head artisans) to grow up to inherit the factory– or to start their own independent factory once they acquire the necessary skills and can secure financing to start their own business. It may be difficult for lower-tech SME producers to scale up into larger-scale production, as different tools and equipment may be required to process higher volumes.

Craft SME Production

Figure 3: Example of Craft SME Production – brass jewelry artisans using hand-tools in Nairobi (via Soko)

Internationally, the global craft sector– comprised almost exclusively of so-called "informal" enterprises– is the second largest source of jobs in emerging markets after agriculture (ILO 2016). I define "craft" enterprises as SMEs that retain traditional artisanal or handicraft methods of production, rather than employing automation or industrial-scale equipment. Craft SMEs tend to lack clear divisions of labor, and are run in a "job shop" style in which workers use whatever materials and equipment happen to be available– rather than the "flow shop" method of scheduling tasks and workflows in advance.

The ILO (2018) defines "informal employment" through the following flowchart:

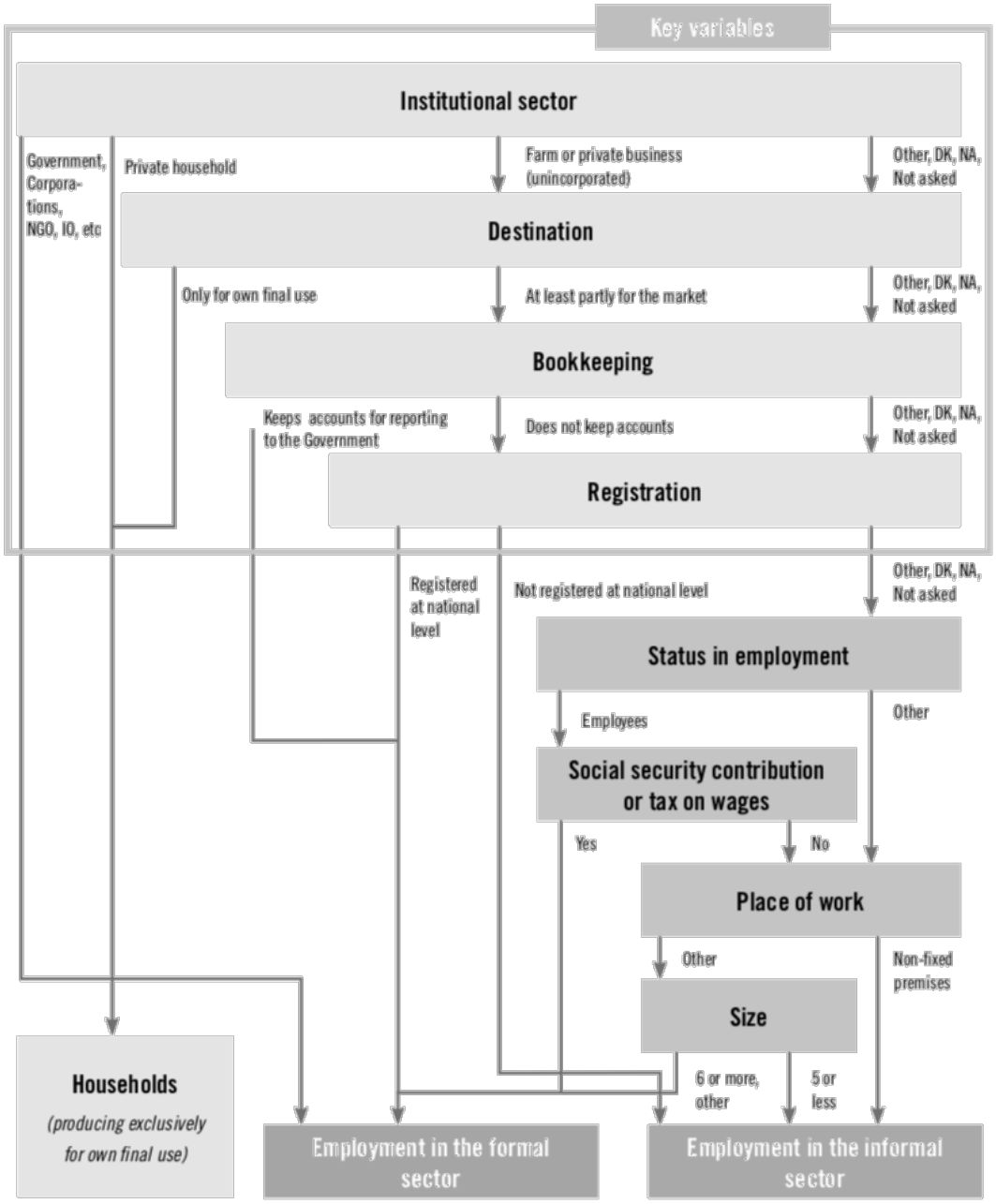

Figure 4: Definition of informal sector employment from ILO (2018)

Despite its predominance, few people actively choose to work in the informal sector– wages tend to be low, there are few influential unions or other workers' organizations, and informal businesses are subject to exploitation, accidents, and unreliable supply chains. There are few mechanisms for legal protections or insuring one's property. Due to the small scale of most informal firms and the general lack of literacy and education, informal workers have difficulty procuring loans and expanding their businesses– so most enterprises tend to focus only on local needs (ILO 2016). Such an environment leads to highly-variable profits and constant stress, and most informal workers must work several different jobs at the same time to make ends meet.

As a result, informal firms are only about 25% as productive as small formal firms overall (World Bank cited in Daniels 2010). Nonetheless, the informal sector provides many benefits such as flexible working hours, allowing women to look after their children during the workday, the provision of jobs outside of major urban areas, and very low capital expenses for building a workshop.

As mentioned, 61% of employed people globally work in the informal sector (ILO 2018). The Kenyan National Bureau of Statistics (2017) estimates that the informal sector accounted for 83% of Kenya's employment in 2016, employing around 13.3 million people. Out of 832,900 new jobs created in Kenya in 2016, a full 747,300 of those jobs were created in the informal sector. That year, 2.7 million Kenyans worked in the informal manufacturing sector– including 0.5 million craftspeople (Kenya National Bureau of Statistics 2017). Across the entire African continent, 89.7% of employed women are in the informal sector as compared to 82.7% of men, though the ILO classifies women's informal jobs as more "vulnerable" and lower-paid overall (ILO 2018).

Formal-sector examples of craft SME production include formalized artisanal shops (furniture, handicrafts, etc.) around the world, tailor-shops, and 3D print-shops. To avoid the hype surrounding on-demand digital fabrication shops and modern manufacturing technologies, I will ignore the question of whether producers are using high-tech equipment and focus only on the factory organization question– in which the concept of local production using local 3D print-shops bears more similarities to ancient traditions of craftspeople in cottage workshops than to industrialized production. An extreme example of modern craft production is fully-distributed or **personalized production**, in which individuals make their own products at home or in neighborhood workshops; examples include personal 3D printers and sewing machines, and Ikea's at-home furniture assembly.

Flexible SME Production

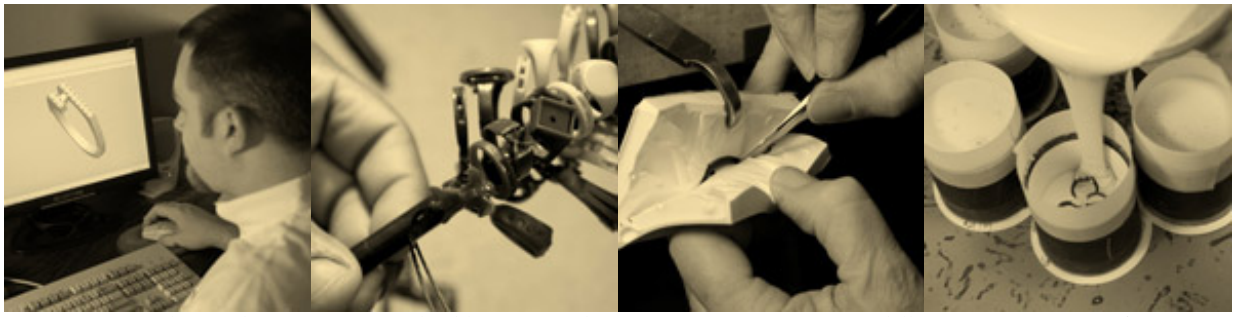

Figure 5: Jewelry production stages at Flexible SME Producer Au Enterprises: CAD modelling, preparing a set of 3D printed rings for casting, pouring wax into a mold, and taking a finished ring from the mold

Many craft producers have successfully scaled up into medium-sized manufacturers, with fabrication following more of an organized flow shop production model rather than a job shop. I refer to these semi-organized factories that use machine tools (rather than mostly manual labor) and standardized factory processes as Flexible SMEs. As evidenced from the diversity of tasks that take place at Au Enterprises (see Figure 5 above), flexible small factories tend to have a wide range of state-of-the-art tools and equipment, and they hire workers with

higher skill levels. While Craft SMEs tend to compete with other Craft SMEs due to a lack of rigorous quality standards and relatively high costs of production, Flexible SMEs often competitive with mass manufacturers on a local or industrial scale.

Specialized SME Production

Figure 6: Specialized factory in Guangdong producing wax molds for rings (photo by Eric Welch courtesy of Chow Tai Fook, Hsu et al. 2014)

Today's predominant form of large-scale production is geographically distributed and "lean" or minimally vertically-integrated; instead of mass-manufacturing and assembling all components within one mega-factory, many large-scale manufacturers today purchase a majority of their specialized components from external SMEs, and then perform the assembly or integration either in-house or through SME contractors. Specialized SME Production provides the SMEs themselves with the advantage of being able to compete on choice and quality rather than just price, depending on the needs of their industrial contracts. Note that many modern companies use some hybrid of Networked Specialized SME Production and Mass Production, often for reasons of safeguarding sensitive IP, ensuring quality control, and/or the difficulty of sharing complex process knowledge.

The SMEs in this model tend to produce a small variety of highly specialized components. Piore and Sabel (1984) call this model **Flexible Specialization**, whereas Fox and Alpetkin (2017) refer to it as **Distributed Industrial**. For machined parts such as electronics and automotive components, the SME producers are known as ***mittelstand*** in Germany and ***cellular manufacturing firms*** in Japan. In Shenzhen, China, the ***shanzai*** microfactories that produce small batches of electronics—including numerous knock-off smartphones and chips— are also more-or-less part of this trend. Contemporary fashion examples include H&M, which purchased both components of clothing and completed garments from 747 specialized, independent factories across Asia and Europe in 2011 (H&M 2011).

Distributed Manufacturing based on Desktop Manufacturing is a particular model of Networked Specialized SME Production described by DeVor et al (2012) for intricate

components (ball bearings, camera shutters, etc.) and future nanotechnologies, involving desktop-sized production units and digital fabrication technologies. They describe how this model could facilitate mass customization, decrease power and space requirements, and minimize the initial investment needed for production. WTEC (2005) details a similar model for nanoscale-fabrication.

Networked Flexible and Specialized SME Production

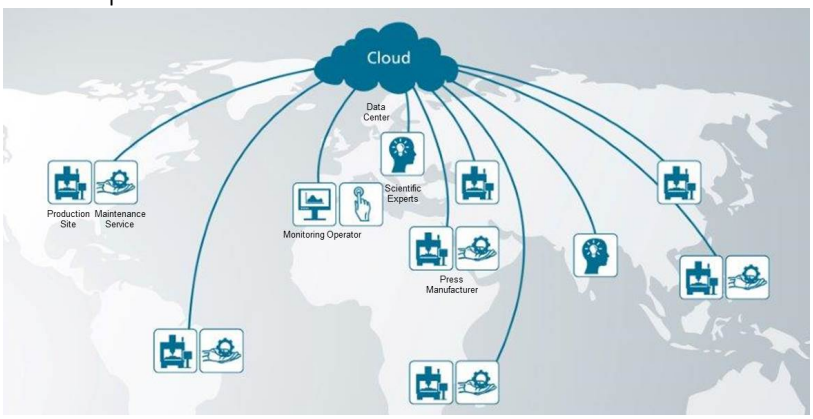

Figure 7: Diagram of hypothetical, multinational Networked SME Producer from Fraunhofer IWU (iMain 2013)

In networked production models, individual SMEs are somehow networked together to manufacture in bulk across the entire agglomeration of firms. My literature review identified several different models that can be classified as Networked SME Production outside of the craft sector: **microfactory retailing** (Wells and Nieuwenhuis 2004), **moveable microfactories** (Fox 2016), **Fab Cities** (Diez 2016), and **smart microfactories**. Flexible models involve more flexible small and medium manufacturing facilities, in which identical (or nearly-identical) entire units are produced across multiple factories, in a massively parallelized fashion; specialized models follow Piore and Sabel's (1984) description of **flexible specialization** in which many smaller factories each make a single component, which are often integrated in a centralized location.

Examples of high-tech, Networked SME Production include franchised fast food chains such as McDonalds and the futuristic model described by Anderson (2012) that extends the notion of local copy-shops and print-shops into fully-fledged, neighborhood digital fabrication shops that can make a wide variety of physical products on-demand. This theoretical **smart microfactory** concept allows for the manufacture of a wide variety of products across networked, geographically-distributed microfactories through some match-making intermediary—which can be an online platform, a large firm, or merely word-of-mouth. Gershenfeld (2007) alludes to a world of Star Trek-style Replicators in the distant future. Anderson (2012) refers to this production model as "the factory in the cloud," and the German government references this model in their discussions of **Industrie 4.0**. Berger (in Locke and Wellhausen 2014) describes a potential Smart Microfactory model as a "massively distributed, massively parallel" network of independent, contractor manufacturers. A large firm in this futuristic model "taps into a national network portal and places a computer-aided design (CAD) description of the part it desires, and the numbers it needs, on [a digital] portal… Meanwhile,

software systems from small manufacturers around the country prowl the portal looking for parts to bid on." The Smart Microfactory model primarily has been imagined to use formal-sector firms employing advanced digital machinery. It provides both large firms and contracted SMEs with the advantage of agility and low startup costs, since large firms can test out new designs through their contractors without incurring significant startup costs—and anyone who is skilled in production can theoretically start their own cottage microfactory and start accepting contracts. Another advantage is the fact that SMEs can operate locally from rural areas. The disadvantage, obviously, is the lack of economies of scale. Several startups are attempting to provide digital platforms to facilitate this type of redistributed production, including Fictiv, 3DHubs, and Shapeways which all connect people with local 3D printers or CNC machines to make one-off parts.

Putting out differs from the Smart Microfactory concept in its strong focus on asset-financing and support for SMEs, as well as its use of more rudimentary technologies such as manual tools and person-to-person networking rather than a focus on interconnected digital fabrication machines.

Networked Craft SMEs

Figure 8: Soko's coordinated network of diverse, on-demand SMEs

Putting out is a popular term for Networked SME Production in the garment industry and informal industrial sector; this has been particularly well-researched among high-end Italian knitwear producers (Lazerson 1995). Under this model, a large manufacturer delegates work to numerous, often geographically-distributed craft workshops– which I will refer to as "microfactories" throughout this thesis. Although most decentralized production along these lines disappeared with the advent of the industrial revolution, select industries and regions have found putting out to be competitive with traditional mass-production. Lazerson (1995) describes the Italian knitwear industry as one case in which Networked SME Production actually provided higher profits for firms than traditional mass-manufacturing— and cites an OECD report (1983) that reaches the same conclusion. Many putting out knitwear firms closed down in the 2000s after the rise of fast fashion and highly-automated apparel factories, but the model still survives in parts of Italy and Eastern Europe today. By providing centralized asset-financing, quality control, and market awareness to disconnected craft producers who act as contractors, this model can theoretically solve the perpetual collective-action problem faced by microfactories who have little incentive or ability to formalize their businesses.

While putting out firms tend to be legally registered and SME owners often have some formal training, the term **homeworking** is often used in the supply chain literature to refer to

contracts made with informal sector firms. Homeworking is regularly used by the fashion industry in emerging markets– including Soko in Kenya, the subject of the next section's case study, and the $172M Networked SME Producer Fabindia. Founded in 1960, the fashion brand Fabindia started as a platform for bringing crafts made by the SMEs of rural India to international markets. The company shifted towards the Indian market by opening a retail store in New Delhi in 1975, and eventually began hiring their own designers and contracting out to industrial factories for mass-production. Fabindia today leverages a network of over 55,000 craft producers across India for handloom fabric production, fabric printing and dying, and some sewing and other handiwork (Fabindia 2018). While some of Fabindia's craft producers run their own small and medium factories, many artisans work out of their homes.

The **Intermediate Technology** movement (more commonly called Appropriate Technology today) was first proposed by Schumacher (1973), who built upon Mahatma Gandhi's ideas to advocate for "human-centered" rather than purely profit-driven production and enterprise. This model considers low-tech, labor-intensive SMEs as local supplements to and/or replacements for global mass production. Intermediate technologies might include agricultural processing, artisanal production, repair, healthcare and other low-tech but critical forms of local production for local consumption. Schumacher (1973) proposed this concept to bridge the gap between high-tech modern and low-tech craft workplaces, and suggested building up thousands of cottage industries across rural regions of the world instead of focusing purely on urban mass production:

> If we define the level of technology in terms of "equipment cost per workplace," we can call the indigenous technology of a typical developing country—symbolically speaking—a £1-technology, while that of the developed countries could be called a £1000-technology... If effective help is to be brought to those who need it most, a technology is required which would range in some intermediate position between the £1-technology and the £1000-technology (Schumacher 1973).

This model lacks the potential for industrial scale provided by Mass Production or even Networked SME Production. To achieve a larger scale, many Intermediate Technology practitioners hoped to create regional or even international knowledge-sharing of fully *decentralized* Networked Craft SMEs– but Schumacher (1973) focused more on local production rather than exportation or competing internationally. The scale of this vision was never achieved, especially as most developing countries abandoned their protectionist policies in the 1980s-90s in favor of cheap imports (Powell 1995). Since this model provided technological improvements that allowed rural areas to retain traditional modes of production rather than competing with the rest of the global economy, it could theoretically provide a sustainable model by limiting growth and increasing jobs. The question was, however, could these simple technologies provide the same quality of life as more traditional models of industrialization?

Figure 9: Assembly-line workers in a mass production jewelry factory in Hong Kong (from Hong Kong Galaxy Jewelry)

The standard vocabulary in manufacturing literature refers to the original mass-production manufacturing model as **Fordism**: a vertically-integrated mega-factory that processes raw materials, manufactures components, and assembles final products all under one roof (Janoski and Lepadatu 2014). Supply chain literature refers to a factory like the original Ford plant as both a *Tier 1* and *Tier 2* factory: after the mining/extraction and basic processing of Tier 3, a Fordist factory then processes raw materials and turns these into components (Tier 2) which are assembled into products (Tier 1). As long as a factory can achieve a continuous flow state of production, and can produce entire units to complete on a global scale, that factory can typically be classified as a Mass Producer.

Confusingly, mass production is increasingly employed for small batches of customized products, in addition to traditional large-batch production. A common oversight in the hype around **mass customization**, as enabled by 3D printing and other digital fabrication technologies, is the techno-deterministic assumption that just because a technology *can* lead to more distributed production models, it *will* naturally produce such models. The digital revolution provides a good counter-example: although major software companies could theoretically allow all their employees to work from home or from localized offices, in practice such companies have followed traditional practices of agglomerating their workforce regardless of the technological potential for distribution. Indeed, companies may find it more profitable and/or easier to continue their traditional high-volume manufacturing models than to shift to a more distributed SME paradigm. Consider the case of GE's new mega-factory in Maharashtra, India: an agile factory employing modern digital fabrication technologies, allowing the company to rapidly produce small batches of customized products. Although the tools themselves would be equally productive if spread across a network of microfactories, GE has decades of expertise

and sunk-costs in high-volume production and complex supply chains; they had no particular incentive to decentralize their manufacturing and pursue an SME-based production model (Chatsko 2015).

Methodology and Conflicting Paradigms

Given the recent enthusiasm around **distributed production**, also referred to variously as **redistributed**, **design global manufacture local**, or **distributed microproduction**, my typology emerged from an attempt to bridge discussions among those academics who focus primarily on ethics and sustainability, and those in the management sphere who are mostly concerned with scalability and competitiveness.

I did not conduct an exhaustive literature review. I identified 24 relevant papers through the search terms "distributed" and "redistributed" manufacturing/production, and also selected a number of papers on "microfactories," "SMEs," and the "informal sector." Many of the papers reviewed here were actually recommended by the authors directly, or cited in other papers (particularly Kohtala's (2013) extensive distributed manufacturing literature review). I posit that some of the current confusion around classifying distributed production systems derives from the fact that researchers tend to approach the topic from two different paradigms, each with their own set of values, units of analysis, and basic vocabulary.

The first paradigm is purely capitalistic; it focuses on the firms in question and their potential for maximizing profits, rather than the nebulous potential for "democratization," sustainable development, or other societal benefits. This approach tends to ignore social questions of equality and fairness in favor of firm competitiveness and technological considerations. The concept of consumer participation is irrelevant, so Apple's network of specialized, contracted microfactories would be considered just as "distributed" as the hypothetical Fab City filled with locally-produced goods for local consumption.

The other paradigm I identified is essentially sociological, although some engineers and designers have also subscribed to its worldview. Academics in this mindset approach the topic from the perspective of society, focusing on the *relative inclusivity* of particular methods of manufacturing: who has access to and ownership over the means of design and production, both within and outside of the workplace? What degree of participation characterizes the relationship of a consumer– "customer, user, pro-sumer, or 'maker'" in the words of Kohtala (2013)— to the final product?

The sociologist's use of the term "distributed" does not refer to geographical distribution (whereas the managerial paradigm uses this phrase primarily to describe factory location). The sociologist's use of the term comes from a paper by Johansson et al (2004) on "distributed economies," defined as the pursuit of competitive, experimental regional development strategies combined with "a renewed balance between large- and small-scale and between resource flows that take place within and across regional boundaries." Another key aspect of this worldview involves the so-called Maker Movement, or what Fox (2014) terms "Third Wave Do-It-Yourself": a novel, high-tech production paradigm combining the "read-write functionality of Web 2.0 with computer-aided (CAD) design and additive manufacturing."

This sociology paradigm tends to leave out the question of scalability and overall competitiveness with mass-market production, electing to focus on "economies of *scope,* not of scale" (Commons Transition Primer 2017). This body of literature often references open-source organizations that pursue localized production, such as Local Motors, Wikifactory, OpenDesk, and the Global Village Construction Kit. Despite purportedly revolutionary invention and production systems, not one of these companies has built more than a few dozen final products. Instead, they emphasize user creation and customization as well as open-source licensing– focusing on economies of scope rather than scale.

The phrase **Distributed Manufacturing** (Bianchini and Maffei 2013; Johansson et al 2005; Kohtala 2014; Armes et al. 2015; Fox and Alptekin 2017) is tied to the distribution of socioeconomic benefits and distributed ownership models, rather than solely related to geographical distribution. Srai et al. (2016) define the main factors for Distributed Manufacturing as "digitalization, personalization, localization, new enabling technologies and enhanced user and producer participation." The main advantage of this model is argued to be the potential for social and environmental sustainability on a regional scale. The co-location of production with research and development could theoretically increase consumers' creative engagement (thus decreased unnecessary consumption), as well as minimize supply chain risk. An RCA report (2015) defines **Re-distributed Manufacturing** in a similar vein: "technology, systems and strategies that change the economics and organizations of manufacturing, particularly with regard to location and scale." I could not find a clear distinction between "Distributed" and "Re-distributed" manufacturing, although the "Distributed" literature seems to have a central focus on democratization and inclusivity, whereas these issues are implied rather than explicitly discussed throughout the "Re-distributed" literature. Many different types of small and medium-scale production– what the managerial paradigm refers to loosely as **Post-Fordism**– could be classified under this category.

To confuse matters, some academics within the sociological paradigm use the term "manufacturing" to refer to anything from single-unit prototyping to craft production up to traditional mass production, sometimes encompassing the design phase. In this research, I use the term "manufacturing" only to refer to the physical manufacture of physical goods; design and prototyping are treated as separate phases of production.

Janoski and Lepadatu (2014) follow in the Marxist tradition of analyzing production based on the "divisions of labor" within firms. Since these labor questions are mostly independent of production distribution models (although they can be closely related), I will save the question of labor divisions and workplace wellbeing for the discussion of ethics in the next chapter.

Fox and Alptekin (2017) lay out an informative distribution chart under the sociological paradigm:

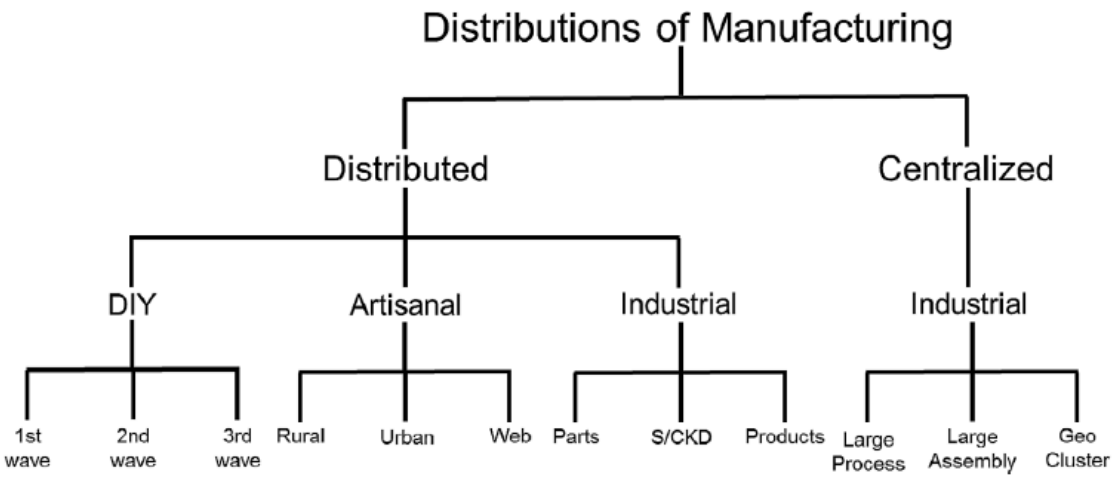

Figure 10: Distributions of Manufacturing Chart from Fox and Alpetkin (2017)

In this chart, the authors provide three varying degrees of the consumer-as-producer concept described above as **Do-It-Yourself** (DIY):

- 1st Wave DIY: people making simple goods for personal consumption using rudimentary tools
- 2nd Wave DIY: people purchasing factory-made kits for home assembly and occasional modification
- 3rd Wave DIY: people making advanced goods for personal consumption or for sales, using high-tech tools and digital connectivity

To evaluate the emerging model of industrial-scale artisanal production (which may or may not count as DIY, and may or may not lead to "distributed" socioeconomic benefits), I combined most of these "distributed" or "post-Fordist" models into SME Production. I then separated the notion of "industrial vs artisanal" scale into two distinct variables: "batch size" and "overall scale." This allows for the investigation of the scalability and profitability demands of the managerial paradigm, while considering some of the ethical and sustainability concerns of the sociological paradigm. In my categorization, all forms of Craft Production and some forms of Specialized SME Production could be considered "re-distributed" or "distributed" production.

My classification deliberately left out the degree to which consumers are directly involved in the design and production process; both ownership over product design and the ability to capture an equitable fraction of production revenue seem to be mostly independent of the manufacturing model in question. The distributed garment manufacturer Fabindia, for example, sometimes adopts ideas from village artisans around fabric printing or other design elements, but the style of the final garment itself is determined by Fabindia's professional designer team (Fabindia 2018). Specialized SME Production demonstrates a similarly nuanced relationship between the small factories producing components– who may have specific ideas

about the best designs for components like buttons or jewelry clasps– and the large fashion brands that source from these contracted producers.

To take another example, exploited garment homeworkers may own their sewing machines, but they are still illegally underpaid; their production model is geographically but not socioeconomically distributed.

Chapter 3. Framework for Evaluating Production Tradeoffs and Effectiveness

How do new product developers make their manufacturing decisions, including both entrepreneurs and established companies with a new production line? Here, I use the term "producer" or "product developer" to refer to a company or individual that is responsible for the overall supply chain and production of some product or component, whether or not this entity performs any of the manufacturing steps. I use the term "manufacturer" to refer only to entities engaged in the physical manufacture of goods.

In order to support more equitable and socioeconomically distributed production systems, and to evaluate the different manufacturing models described previously, we must first develop a basic understanding of the rationale that goes into production choices. These early decisions often mean the difference between success and failure of a new product; a disproportionate number of hardware startups fail at the very point when they are about to properly start production. This drop-off between very small-batch production and commercialization—when startups generally take on their most significant financial risks—is often dubbed the "valley of death":

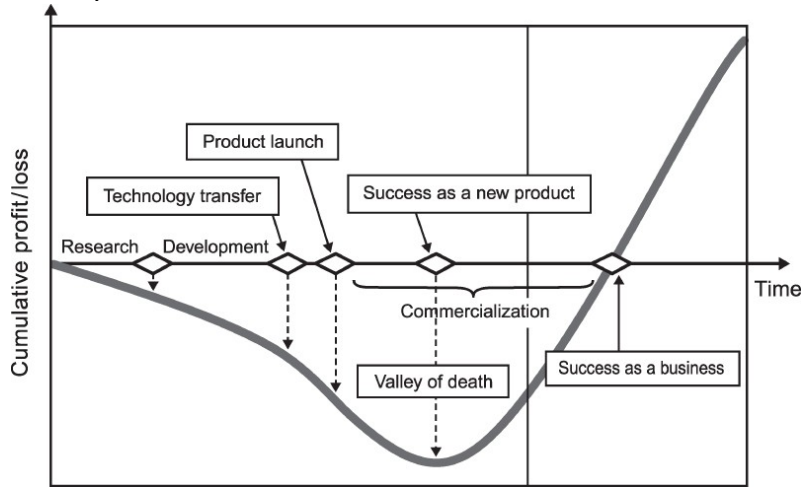

Figure 11: Valley of Death Chart from Osawa and Miyazaki (2011)

To both mitigate this risk and to support ethical decision-making, it is important to think clearly and critically about the underlying values within a firm that drive production choices. The key question here is how a firm evaluates whether a particular product or component is *effective*– in other words, what are the firm's criteria for success? Different firms may value different tradeoffs more than others, and some firms may have situations in which certain

tradeoffs act as complements to reinforce one another. After performing a literature review, writing several production case studies, and conducting informal interviews with a variety of experienced manufacturers and product designers, I worked with a number of mentors (product developers, supply chain experts, and engineers from biomedical, electrical, mechanical, aerospace, pharmaceutical, food production, and industrial sectors) to identify a set of six value tradeoffs that factor into how firms make production decisions:

Table 2: Production Tradeoffs Within Firms

Costs **OpEx**: opportunity/time, inventory, resources, labor **CapEx**: construction, training, automation	**Level of Service** Throughput, time to market, responsiveness, agility	**Competitive Advantage** IP protections, location, product differentiation, vertical integration
Scalability Ability to profitably scale up production	**Quality** Product, process, certifications, reliability, longevity	**Ethics** **Social**: Worker wellbeing, societal wellbeing **Ecological**: environmental impact, resource depletion, materials reuse, disposal

In a business setting, the factors referred to in Table 2 can all be reduced to monetary values and compared through a cost-benefit analysis. The problem with this approach is that it washes over the nuances involved in making choices, and particularly obscures the last question of ethics/sustainability. Ashford and Caldart (2008) highlight the difficulty of relying purely upon cost-benefit analyses to make policy decisions, and explain how the process of quantifying benefits and costs can become highly subjective and politicized. Thus, I consider all these factors separately in order to explore both the correlations amongst tradeoffs, and the effects that these factors have upon eventual production outcomes.

These value tradeoffs are distinct from (but closely enmeshed with) the exogenous factors that determine decision-making, such as the following:

- Consumer preferences
- Product design requirements
- Technical constraints (manufacturing, distribution, etc.)
- Sociopolitical environment
- Legal requirements
- Competitive landscape

In Figure 12, we distinguish eight different stages of production that the production

tradeoffs in Table 2 and the exogenous factors might influence, although these production stages often blend into one another and rarely happen perfectly in sequence. A more vertically-integrated production system exercises tighter control over all aspects of production, whereas a decentralized system may involve multiple parties with different responsibilities.

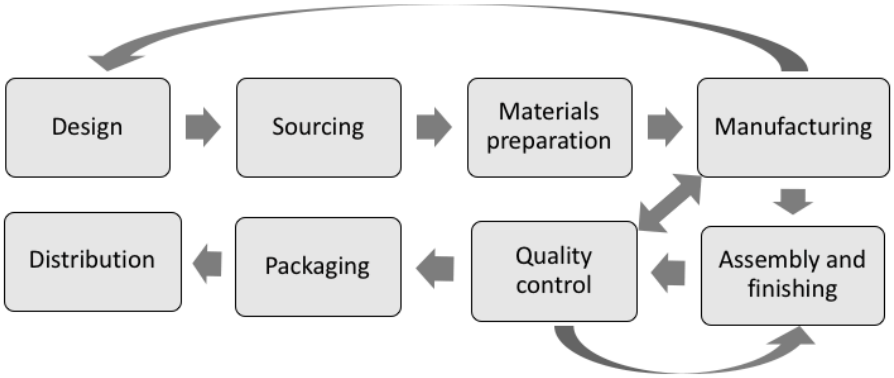

Figure 12: Loose depiction of production stages

1. Design: from the initial conception of the product to the concrete plans for manufacture
2. Sourcing: obtaining the raw materials for production
3. Materials preparation: preparing the materials for production
4. Manufacturing: the physical manufacturing of all relevant components
5. Assembly and finishing: the stage in which different components are put together into the final product, and final finishing steps (polishing, grinding down seams, etc.) occur
6. Quality control: an inspection process at the end of manufacturing and at multiple stages along the way, to ensure that the materials, components, and/or final product meet all relevant quality standards
7. Packaging: preparing the final product for shipping
8. Distribution: shipping the project out to the purchaser and/or end user

We also consider the set of eventual decisions that producers must make, keeping in mind the set of production tradeoffs. These decisions include:

- Components
    - Can components be purchased off-the-shelf, or must they be newly manufactured?
    - Are components different and/or customizable, or all homogenous?
- Level of vertical integration (by component):
    - Is production in-house or outsourced?
    - How many facilities are required?
    - Where are the suppliers or factories?
    - Who designs the product?
    - Who sources materials?
    - Who performs quality control? At what stage?
- Batch size

    - How much is produced now?
    - How will this change over time?
- Assembly and finishing
    - Where and how does the final product get assembled?
    - How are relevant quality standards met?

Literature Review and Methodology

I started with a literature review, mostly of the management literature around manufacturing production choices. In the 1920s, German geographer and economist Alfred Weber was among the first to propose a mathematical "Theory of Location of Industries," based on minimizing labor costs and transportation costs, including the regional price of material and the cost of reaching consumers. His key decision-making factors were "locational weight", the labor coefficient, and the "form coefficient" (of the final product). These can all be geometrically optimized through pre-digital technologies such as the Varignon frame in Figure 13 to find the lowest-cost point at the intersection of various factors:

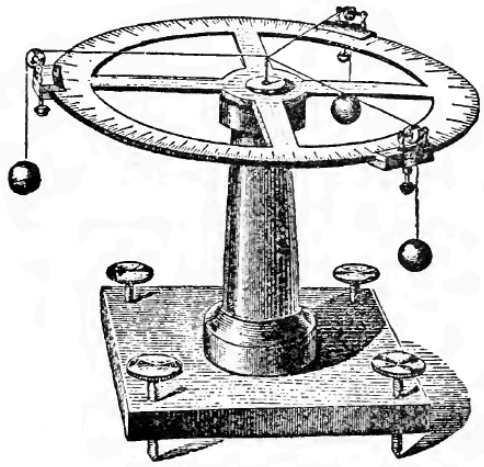

Figure 13: Geometric tool for optimizing location from Weber (1920)

For example, the left quadrilateral in Figure 14 shows how a firm that uses materials from deposits M1, M2, and M3 and sells its product at C would optimize its location in order to minimize costs: it could either split its production across P1 and P2, or produce at P. The triangle in Figure 14 expands this to a generalized solution involving even more material deposits:

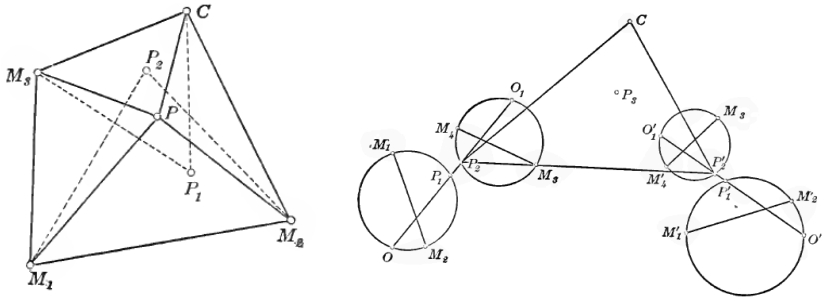

Figure 14: Diagrams for determining factory location from Weber (1920)

While Weber's theories were very influential throughout the early 20th century, these factors diminished in importance as large-scale shipping became cheaper, and the benefits of innovation clusters began to take precedence over transportation costs, such as electronics in Shenzhen or silicon wafers and later computer programming in California's Silicon Valley. Recent surveys of manufacturers (Manyika et al. 2012, Sirkin et al. 2012) indicate that the minimization of cost is no longer the key component determining their localization decisions.

Beckman and Rosenfield (2007) provide industry decision-makers and consultants with detailed steps for how to manufacture new products, implicitly defining an effective business as one that can scale up its operations and dominate the market. The authors identify the number of facilities, the location of these facilities, and the "Make-Buy" tradeoff as key decisions to be made. At the heart of the location decision, according to Beckman and Rosenfield, is a trade-off between improved market access to customers, the amenability of local policies and customs, the ability to get rapid feedback in the case of production shifts, and access to local capabilities (labor, technologies, and suppliers). They argue that access to markets and capabilities is far more important than cost minimization in today's market; otherwise, a producer may simply have a transitory advantage until the local region develops and/or local policies change.

Beckman and Rosenfield (2007) also detail a list of production tradeoffs, including the following:

- Batch size vs. diversity of products: depends upon the market
- In-house vs outsourced production: depends upon the relevant cost curves, and at what point the operating expenses can make up for the high capital expenditures of building a new factory
- Dimensions of "facility focus"
    - Process-focused to satisfy the needs of a particular supply chain segment
    - Product-focused to satisfy the needs of a certain component or product
    - Market-focused to satisfy a particular local customer base
    - Service-focused to satisfy the need for repair, customization, or other services
    - Unfocused/flexible facilities that attempt to meet a variety of the above foci

I conducted dozens of personal interviews with entrepreneurs and established producers, in which a majority of people identified "trustworthiness" as the single most important aspect in choosing their supplier or deciding where to build one's own factory– although "trust" is of course difficult to quantify or evaluate. When possible, most producers

preferred to rely upon their existing networks and contacts rather than gamble on new suppliers. Manufacturing decision-making seems to be an ongoing process of managing tradeoffs, rather than choosing one correct answer. A firm might even value certain tradeoffs differently from one component to another within the same product, resulting in a complex array of decision-making factors.

While product developers in established industries have complex mechanisms for calculating optimal supply chains and making make-buy decisions, entrepreneurs often lack the sector-specific expertise and personal connections to properly evaluate their decisions– and they frequently do not have the time to do proper research. Thus, entrepreneurs may end up going with the most convenient option, or following the advice of more experienced mentors in the field. Sorin Grama acknowledged that many of his important manufacturing decisions came down to a haphazard judgment made on incomplete information; his company Promethean initially tried to go with suppliers they knew and trusted but, failing that, they were forced to contract with any company they could find that seemed capable of doing the job. Kipp Bradford notes the wide range of Kickstarter product blogs that discuss manufacturing failures as though these entrepreneurs were all discovering the production process for the first time, even though many common mistakes would be entirely preventable if these product developers knew more about manufacturing from the outset.

In the venture capital-driven environment of Silicon Valley, startup incubators prioritize rapid scaling, and encourage hardware entrepreneurs to focus on their companies' core competencies (which do not usually include manufacturing expertise). Luke Iseman says the incubator Y-Combinator "treats hardware like software," emphasizing that entrepreneurs should outsource both basic software development and most manufacturing to outside firms that specialize in these skills. This allows entrepreneurs to then spend their limited time capitalizing on their current expertise.

To narrow down all these considerations into a series of tradeoffs, I first discussed a basic set of tradeoffs with my advisors Fiona Murray and Georgina Campbell Flatter. Through extensive whiteboard brainstorming sessions with Kipp Bradford and Sorin Grama, we developed a basic set of optimizable criteria. I also worked with Harald Quintus-Bosz and Angi Acocella to first figure out what to evaluate, and then to narrow our manufacturing decisions framework down to a final set of tradeoffs. Here is one of my whiteboard brainstorms with McCambridge and Bradford:

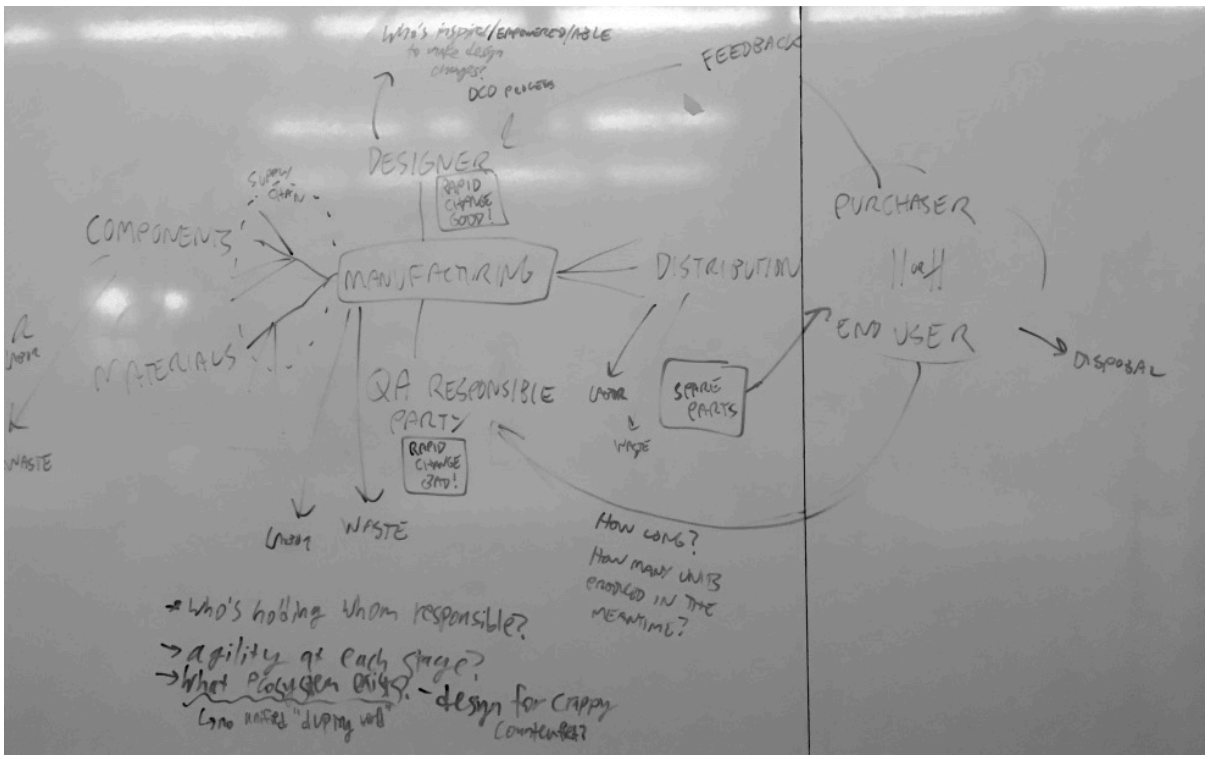

Figure 15: Brainstorming manufacturing decisions

We iterated upon this framework through discussions with a number of colleagues in the manufacturing space, and I drew upon modern conceptions of quality control, responsiveness, and speed from Professor Stanley Gershwin's class *2.854 Introduction to Manufacturing Systems*.

Production Tradeoffs

Costs

Overall cost is the most important criteria for an effective product run; most companies must be profitable if they want to survive. Nonetheless, minimizing costs is not always the most critical issue for a given component; high-end goods might prioritize quality, and some consumers might happily pay a premium for ethical production. It is very important to consider time variance in this category, as some companies might have to minimize capital expenses whereas others might minimize operating expenses. For any given production run, there is likely a point at which the up-front costs of building a factory or installing robots will be more profitable overall than the continued overhead of outsourcing production, paying workers, or other high operating expenses.

Naturally, SMEs have lower capital costs and higher operating costs, while Mass Production firms tend to have higher capital costs and lower operating costs due to economies of scale– although these calculations may only hold for large batches of product, as traditional Mass Production factories often have to pay higher costs to retool their equipment and change product lines. This comes down to the marginal cost of production.

Capital Costs

What does it cost to set up initial production? This may include purchasing land, equipping the factory, building infrastructure, making molds, training workers for the first time, building automated systems, or other up-front costs. Are there significant opportunity costs– i.e., would time and money be better spent elsewhere? Depending on the sector, the long-term discount rate of capital might play a role in favoring higher operating expenses over spending more money up-front. On the other hand, a company that recently received a large influx of capital may favor holding onto physical assets such as a land and/or factory equipment.

Operating Costs

What are the ongoing costs of day-to-day operations? These include labor, materials, rent, electricity, supplies, inventory costs, taxes, fines, the overhead involved in outsourcing production, and other continuing costs. The calculation of operating costs and the need to have relevant expertise is often a driving force in the make-buy decision of whether to contract with existing suppliers or to set up one's own factory.

Scalability

What is the potential for an enterprise to scale up the production of a given product, and to break into new markets? This category is only vaguely defined, since "scalability" might depend not only on costs (both short and long-term) but also on the mission of the company itself and the willingness of the firm's founders to grow at a given time. Perhaps a firm knows that scaling up a certain product would turn a profit, but it also poses a grave enough risk that the firm would rather focus its limited resources elsewhere.

Aulet and Murray (2013) use scalability as a core criteria in distinguishing between Innovation-Driven Enterprises (IDEs) and traditional SMEs. IDEs must constantly innovate in order to remain globally competitive, through continual process and product improvement; since SMEs need only compete with other local businesses in order to remain in business, they tend to remain local rather than scaling up and breaking into new markets. A local tailor is an SME, whereas a major fashion brand like Zara or H&M is an IDE. The benefit of Networked or Specialized SME Production over simple SME Production is the fact that an effective network can potentially grant individual SMEs an ability to scale through aggregation and connections to other firms– allowing these SME networks to collectively act as IDEs.

Products designed for scale often need to consider scalability from the initial design phases. Key scalability questions include:

- Are our suppliers and/or factories capable of increasing production using current techniques? If not, can we find new suppliers/factories or shift to new manufacturing techniques? Injection-molded parts, for example, are much easier to scale up than 3D printed or hand-crafted parts.
- Does scaling up production make sense from a cost-benefit standpoint? From a business strategy standpoint?
- Will there be a large enough demand for our product? Will our product be competitive

in new markets, and at a large enough scale?
- At what point do economies of scale in production break down, if at all?

For many products and processes, the economies of scale achievable through mass-manufacturing will never be matched by craft production models (whether Networked, Specialized, or otherwise). A key question for this thesis is, **under what circumstances might smaller-scale production have an advantage over other strategies**? Lazerson (1995) explains, for example, how production rate asymmetries in various stages of knitwear manufacturing can limit the efficiency of large-batch production and provide an advantage to just-in-time craft producers: "some knitwear tasks remain highly labor-intensive while others are automated... unfinished garments can easily pile up, thereby increasing inventory costs and delaying deliveries" (Chandler, 1977 and Mariotti and Cainarca, 1986 quoted in Lazerson). Large-batch yet small-scale production will be most viable for products and processes that, like knitwear, do not benefit from typical economies of scale: specialized components like airplane engines, customized products such as wedding rings and one-off repair parts, and labor-intensive products like handmade jewelry and embroidery.

Scalability: SME Challenges

Given the prevalence of informal sector SMEs, why have so many of these firms failed to scale up and formalize? The problem is, many entrepreneurs who wish to start growth-oriented businesses in emerging markets begin their metaphorical race significantly behind the starting line. As Gerschenkron (1962) observes, the movement towards industrialization must occur "simultaneously along many lines of economic activities. This is partly the result of the existence of complementarity and indivisibilities in economic processes." Entrepreneurs in emerging markets lack the tools, infrastructure, and amenable policy frameworks to form new companies.

Access to capital is among the most important complements to industrialization identified by Gerschenkron. Very few small firms can acquire enough capital all at once to grow their businesses—and many working in the informal economy remain at or below the poverty line. Based on their research among small businesses in developing countries, Banerjee and Duflo (2011) provide the following qualitative graph (black circle has been added for emphasis):

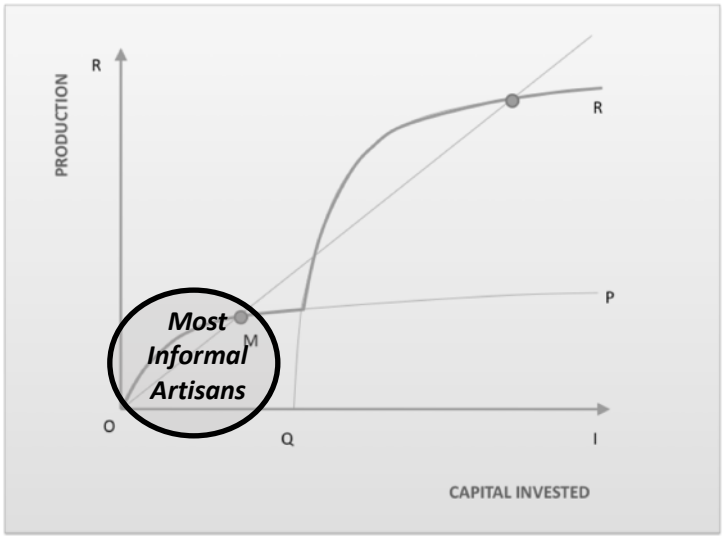

Figure 16: Investment vs. Returns for Informal Firms (Banerjee and Duflo 2011). R = Returns; M = Majority of small firms; I = Investment. Curve OP = representative of low investment; curve QR = representative of high investment.

As shown in this graph, small business growth requires a rapid rate of capital investment that is beyond the means of many small firms. Small (and typically informal sector) firms become stuck around the point M inside the circle, where incremental investments do not yield significant returns; if a firm cannot obtain the full amount of capital required all at once (Q) to scale up production along curve QR, there is little incentive for attempted growth. This phenomenon results in highly conservative firms that spend their funds on everyday expenses rather than upgrading their facilities. Growth or any form of innovation becomes risky and resource-intensive, since the purchase of new equipment or materials can be counterproductive and cause a firm to spend years in debt.

Among small manufacturing firms, the lack of growth can often be attributed to the difficulty of obtaining locally-appropriate modern technology (Powell, 1995). Schmitz (cited in Basant, 2002) stresses that the upgrading of technical capabilities requires continuous investment by local firms in people, organization and equipment. Since artisans in the developing world lack the resources and working capital required for this investment, the impetus may need to come from outside the informal sector— as observed in the study done by Morrison et al. (2008), and as evidenced by the case of Soko's horn and bone artisans. For innovation to occur, any knowledge that is introduced must be tailored to local needs; artisans must understand new concepts and machinery well enough to fully appropriate these and develop their own technologies.

An additional scalability issue is the fact that informal firms have little outside incentive to formalize their business practices. Cash-based, small firms have trouble keeping track of their finances, so they are often ineligible for significant loans from banks—while the government officials who could amend these policies have little reason to assist the informal sector. Many small firms view the road to formalization as a series of byzantine regulatory statutes and high fees, without any corresponding benefit from government services. When interviewing informal artisans in Ghana, I found it is a common practice in one auto-mechanics' cluster for workshop owners to text all the neighboring firms whenever someone notices a government official

coming around to take a census or collect taxes. This gives the artisans time to either close shop or to convince their uninformed children and/or young apprentices to staff the workshop for the day. This mutual lack of trust discourages informal businesses from registering their firms or seeking government assistance, while policy-makers disregard the informal sector as frustrating and illegitimate. The perception among Ghanaian auto-mechanics was that the government rarely used its tax money to effectively support informal artisans, so they saw no point in contributing to corrupt officials who would pocket the money rather than improve their infrastructure or businesses.

Finally, most informal industries only have access to local markets, even though international consumers could be interested in their wares. The few firms that do get the opportunity to reach a global market are often unsuccessful, due to their ignorance of international preferences and the small scale of their operations. The Networked SME Production models used by Fabindia and Soko offer a possible solution for overcoming the collective action dilemma faced by large numbers of competing SMEs, as these agglomerating firms have helped their supplier artisans compete on a global, industrial scale through providing fashionable designs and asset-financing to upgrade SME equipment.

Level of Service

Level of Service: Throughput

What is the lead time for production, and how long does each stage of production last? How quickly can a company get its hands on a necessary component, and how long does it take for the final product to reach customers? Is there any bureaucracy involved? Is a firm able to pay for its components promptly, or does it require suppliers that can wait for payment? If a product can fall out of fashion quickly, or if a firm has already made promises to its customers, then high throughput may be very important. Alternatively, if a product is complex or requires very high precision, then production rates may be sacrificed in favor of quality control.

Speed differs from *Responsiveness* in that this factor can be independent of flexibility; Fossil's outsourced factories, for example, can quickly injection-mold a metal clasp, but cannot change the style of that clasp without significant time and expenditure for retooling. On the other hand, a 3D metal-printer allows for highly flexible clasp production– but printing just one item will take many orders of magnitude longer than injection-molding.

Level of Service: Responsiveness and Agility

How easily can some product or process be changed? How agile is the production process itself? Can the production rate shift up or down? Can a firm handle risks in its supply chain due to weather, unexpected competition, or geopolitical instability? Can a component be produced by multiple suppliers, or does it require high start-up production costs and/or considerable tacit knowledge that cannot be readily transferred? The fast fashion industry changes product lines every few months and often needs to adjust rapidly to unpredictable shifts in demand, as evidenced by Zara's decision to produce more clothing in smaller batches closer to its Spanish headquarters (SCM Globe 2016).

Two related global consumer trends (Hagel et al., 2014) support a push toward smaller-batch production both within and outside of the fashion industry: the desire for personalization and customer engagement, and rapidly-changing regional fashions leading to faster product turnover. Due to advances in software and digital fabrication, small-batch production and agile factory configurations are easier than ever before. Manufacturers can digitally upload a new design to an entire factory or network of many interconnected factories, rather than re-tool every single machine whenever they switch products. With the advent of internet-connected sensors and controls, factories can become more digitally networked and less dependent upon controllers who must personally oversee the production lines.

Today's digital fabrication machines programmed to mill, cut, and/or 3D print are affordable and relatively easy to employ for both personal and SME applications. Desktop 3D printers can cost under US$1000, and the graphical interfaces of modern machining software provide a much lower barrier to entry than CNC machines of past decades, which required skilled machinists to numerically program step-by-step toolpaths. However, the potential for small-batch manufacturing does not necessarily correlate with increased SME Production; large manufacturers such as GE are already experimenting with mega-factories full of agile manufacturing equipment for small-batch runs, as mentioned in Chapter 2 (Chatsko 2015).

Competitive Advantage

This category includes sector- and location-specific factors on the consumer side that may be relevant for a given product. What traits would give some product (or components of a product) an advantage over its competitors? Only a few sub-categories are highlighted here, but there are a variety of other traits that might play a role. For example, the "fashionability" of catering to changing consumer tastes, or a wide variety of other market differentiation strategies could all be relevant factors in decision-making.

Competitive Advantage: Ethical Branding

As indicated by local and organic food movements across the US and Europe, some consumers are willing to pay a premium for ethically produced and/or locally-made goods. In cases where local production is more environmentally sustainable, consumers and firms may also voluntarily support local craft producers over global supply chains (Rauch et al., 2016). According to the JUST survey (2017), 85% of 72,000 USA citizens surveyed were willing to pay "at least a little more to buy a product from a company that is more just," and 38% were willing to pay at least "a moderate amount more." The Nielsen Company's global consumer survey (2015) found that "commitment to the environment" can sway product purchase for 45% of surveyed consumers, while "commitment to social value" influences 43% of respondents and "commitment to the consumer's community" influences 41%.

Location can also play a strategic role in branding practices. A "Made in America" jewelry company potentially has an advantage among certain consumers and jewelry designers, because both designers and customers know that workers will be paid well and have decent working conditions. Patriotic consumers may also wish to support producers from their home region or nation.

Networked SME Producers may have a difficult time advertising their production methods to customers, due to recent trends of exploited homeworkers.

Competitive Advantage: Location

Is there an advantage to locating production in a certain area? This could apply to individual components of a product, to the completed product, or even the entire firm– as discussed by Weber (1920) in the early days of industrialization. Some firms may decide on production locations for purely strategic reasons, such as local resources, protecting IP, or locating within an established local ecosystem.

It is important to consider what regional ecosystems of knowledge, connections, and resources already exist, and whether these will provide a significant advantage. An electronics startup that locates in New York City rather than Shenzhen may be at a disadvantage, whereas a finance startup in Shenzhen would miss out on the opportunities available to financial firms in New York City. However, Shenzhen does not have the same IP protections for producers as New York City, and an electronics startup in Shenzhen may risk its suppliers counterfeiting the product. Or, as Huang (2014) points out, a young firm could conceivably benefit from Shenzhen's more relaxed environment of collaborative innovation without stringent property protections– whereas a similar startup might not have such access to prior work in the USA due to a stronger culture of litigation.

Policy incentives for localization and small business development can also play a significant role. In Italy, Lazerson (1995) notes how putting out firms were aided by subsidized equipment loans for SMEs in Modena that qualify for "artisanal status," as well as zoning laws favoring SMEs over Mass Producers in both Modena and Emilia-Romagna. Trade protectionism could also affect decision-making, as could subsidies for local job creation— especially as automation continues to eliminate low-skilled jobs across emerging markets. Mass Production facilities are particularly well suited for large-scale automation, especially if companies hope to compete internationally, given China's commitment to subsidizing automation nationwide. Citigroup estimates that increasing automation could replace up to 75% of jobs in emerging markets (Citigroup 2016), so perhaps certain policy-makers would be willing to sacrifice the efficiency and competitiveness of their manufacturing sector, and support more types of SME Production in order to provide jobs for their citizens– especially since high employment is key to successful economic growth (Keynes 1936).

Risk management is another key factor when considering the responsiveness of production. Distributed networks involving SMEs can be more resilient than centralized Mass Production networks, since having multiple suppliers will make a firm less susceptible to shocks in the supply chain. Gledhill et al. (2013) forecast that the unpredictable effects of global warming may have disastrous ramifications for global shipping costs—which could lead to increased local production, especially for large household appliances (such as washing machines or refrigerators) and vehicles that cannot be easily flat-packed into shipping containers. Rauch et al. (2016) also cite increased difficulties for global supply chains and rising transportation costs as key predictors for locating production closer to the end consumers.

Comparative Advantage: Vertical Integration

The degree of vertical integration of a firm is also an important criteria, which plays a particularly large role in the profitability of the jewelry companies in this case study. It is unusual in the jewelry industry for firms to both design and manufacture their wares, but those that can manage this full spectrum of product creation may be able to capture higher profit margins overall– as long as they maintain competitiveness across both design and production. On the other hand, a firm could easily spread itself too thin by pursuing too many verticals; it may not be able to attract the right talent, it may lack the diverse expertise required to maintain both a solid brand and an efficient factory, or the company's managers might not be able to juggle such different teams within the same firm. Mass Producers tend to be more vertically integrated, while SME Production strategies tend to be more specialized.

In conversation, Vladimir Bulovic pointed out that some products, especially those designed using nanoscale engineering, are so novel that there is no current competitive landscape– and even no existing "foundry" in the world that can manufacture them. In this case, the only viable choice for the inventors is to invent their own foundry and production processes, or perhaps to partner with a firm that has the expertise and resources to do so.

Quality

How important is quality control for this product, and for the processes involved in production? What are acceptable tolerances? How long should the product last, and is it designed for reparability? Does the product require any certifications to prove that it is safe for use? How important is consistency across products? In the supply chain literature, quality is often combined into the category Level of Service, but I separate the two here in order to discuss the tangible product quality as distinct from the quality and timeliness of customer/supplier interactions.

Even within the same type of product, product quality standards may vary widely. One can note, for example, whether or not the seams and tabs on an injection-molded jewelry clasp are visible (as on a lower-quality product), or whether they have been ground down or carefully designed not to be intrusive.

Ethics

The OED (2018) defines *ethics* as "a system or set of moral principles; (in weaker sense) a set of social or personal values." This section refers to corporate ethics that may or may not be advertised to consumers; I discuss ethical branding in the section above on Comparative Advantage.

Are ethical considerations relevant for a particular component or product? The answer may be no; in the absence of legal or social pressure, ethical considerations could be low on the priority list. In the case of clear cost-benefit tradeoffs such as employee pay, a firm (and/or its shareholders) may be more concerned about getting their product out into the world than worrying about ethical considerations. If paying a "fair" wage or setting up an environmentally sustainable production line results in a much more expensive product, firms have to ensure that their customers are willing to pay the price. These considerations could also change over

time as a firm scales up and shifts directions. Patagonia, for example, starts out by finding the best possible suppliers for their particular products, and then works with these suppliers to ensure that every component meets Patagonia's strict standards for social and environmental ethics.

A traditional liberal economist like Friedman (1962) would argue that the entire premise of "ethical" jobs is redundant; in an ideal free market economy, all workers should have the freedom to choose whether or not to accept jobs. Anyone who feels exploited can quit and move to another company, thus helping to regulate the market and ensuring that exploitative firms change their ways. Companies that fail to provide decent jobs will go bankrupt for lack of workers.

Yet today's markets are neither ideal nor completely free (by a liberal economist's standards), and many eligible workers around the world are consistently unable to find decent, full-time employment. According to the UN (2018), 204 million people are unemployed worldwide, and we will need to create 30 million new jobs every year between now and 2030 (and prepare people for those jobs) to keep up with the growth of the working age population. In addition, 780 million workers are unable to lift themselves out of extreme poverty. Worst of all, the United Nations and ILO (quoted in Free the Slaves 2018) estimate that over 40 million people are literally enslaved worldwide– more than at any other point in history– and their forced labor generates $150 billion every year in illegal profits for human traffickers.

The lack of decent opportunities to earn a living is likely to get worse; automation and other new technologies are making many traditional middle-class manufacturing and service jobs obsolete, and exacerbating education inequalities. The World Bank Development Report (2016) estimates that 57% of jobs in OECD countries and considerably more jobs in emerging markets are at risk of automation. Research is inconclusive on whether the creation of new jobs will outpace the rate at which current jobs are disappearing. To make matters worse, yesterday's workers are not trained for today's high-tech jobs: millions of manufacturing positions in the United States are currently unfilled (Bonvillian and Singer 2017), and employers around the world are disturbed by the lack of workers capable of adapting to today's rapidly-shifting environments. In regions where the job market is driven by employers rather than qualified job-seekers, Friedman's liberal arguments become less applicable. In this case, what incentive does a purely profit-maximizing company have to behave ethically?

Ruggie (2013) defines two different types of "licenses" required for operating a business in a given location: the legal requirements of satisfying the requisite local and international laws, and the "social license" of whether the local community will allow a business to continue its operations. In many cases, legal requirements may be dangerously lax, or perhaps decent laws may exist on paper but in practice are rarely enforced due to a lack of resources and/or political will. Ruggie cites a case in which Ogoni locals in Ogoniland, Nigeria eventually forced out the oil company Shell through popular protests, which turned toward sabotage after Shell's continual disregard. Shell had failed to provide the local employment it had promised, and the company continued polluting the environment with oil spills and gas flares for decades after Ogoni chiefs and environmentalists had peacefully complained about the degradation. Even though Shell retained a valid legal license, it effectively lost its "social license" to operate in the

1990s. (Nonetheless, Nigeria's leader at the time launched a massive and violent crackdown against the Ogoni to support Shell's operations.) While a company's legal license depends upon policy and the degree to which laws are locally enforced, its "social license" depends upon acceptance from the local community.

A social license can also be granted by a business's customers. Nike's stock, for example, lost over 15% of its value from 2000-2001, due in part to a widely-popularized worker exploitation scandal. As a comparison, rival shoemaker Rebook's shares increased by around 370% over the same period (Dukcevich, 2001). Nike did not regain its customers' trust again until the company launched a major campaign to both reform its own labor practices and advertise this improvement to its customers.

A company may be able to comply with the bare minimum of legal and social requirements and still remain profitable– but this does not mean that the company's behavior would be considered "ethical" by workers or customers. For this framework, I consider "ethics" as the moral considerations of production that go *beyond* mere licensing.

I will not go into the tragic details of forced labor, which is explicitly illegal everywhere in the world. Likewise, I have not looked into considerations of dishonesty, financial manipulation, or other unethical business practices that are similarly illegal. This discussion of tradeoffs mostly concerns cases in which companies have a *legitimate choice*, from a business and legal standpoint, to be more or less ethical in making production decisions.

Note: are ethics actually a tradeoff?

It is noteworthy that many researchers and practitioners today do not consider ethical concerns to be a tradeoff, but rather an essential criteria for running an effective business. This is a far cry from the early days of large-scale manufacturing, from the "naked, shameless, direct, brutal exploitation" of factory workers decried by Karl Marx (1883). Frederick Taylor, a key pioneer of "scientific management" and assembly-line manufacturing, was clear about his priorities for efficient production: "in the past the man has been first; in the future the system must be first" (Taylor 1914). In order to minimize variability and maximize production efficiency, Taylor emphasized that humans must be subordinate to their systems and machines.

Yet Ton (2014) argues, through several case studies, that companies tend to be more profitable when they invest in their employees and treat human labor as an asset rather than just a cost that must be minimized as a part of some larger mechanical system. Ton's "good jobs strategy" can lead to more productive employees and happier customers. As evidenced by General Motor's partnership with Toyota on its NUMMI manufacturing plant in Fremont, California, a more ethical management strategy allowed the same workforce and the same union to increase their productivity from 48.5 hours/unit to 19.6 hours/unit, while reducing worker absenteeism by a factor of ten (Adler 1992). When American automobile manufacturers first attempted to implement the Toyota production system several decades ago, they adopted only the organizational and engineering aspects of the system and neglected the social components– leading to only minor factory improvements, and occasionally even becoming detrimental (Gershwin 2016). NUMMI's unique transformation came about through a transition from GM's adversarial manager-factory worker dynamics into Toyota's more egalitarian and

human-centric lean production system, in addition to a renovation of the manufacturing processes themselves (Adler 1992 and Langfitt 2010).

Ton (2014) details four steps that retail businesses should take in order to provide excellent jobs for their employees– which bear many similarities to Toyota's manufacturing line strategies that transformed the NUMMI plant:

1. Offer less to customers
2. Standardize and empower people
3. Cross-train employees
4. Operate with slack, allowing all employees to be part of system and providing them with the flexibility they need to respond to unexpected changes

Mackey and Sisodia (2014) also argue that "conscious capitalism" at a firm level results in more profitable companies overall, using the following definition (Conscious Capitalism 2018): "Conscious businesses… endeavor to create financial, intellectual, social, cultural, emotional, spiritual, physical and ecological wealth for all their stakeholders." Mackey and Sisodia (2014) present four principles behind "conscious" value-creation, with a focus on dynamics and interactions *within* the firm:

1. Purpose
2. Culture
3. Stakeholders
4. Leadership

Mackey describes how his company Whole Foods goes to great lengths to support its suppliers, retail workers, and customers– and how the firm functions better because of this commitment to ethical behavior. Mackey and Sisodia (2014) found that a selection of 28 firms that are top-performers along a series of "humanistic" criteria (sense of purpose, how much stakeholders love the company, company culture, and leadership) out-performed the S&P 500 index by a factor of 10.5 from 1996 to 2011. The authors also describe how companies on the Fortune 100 "best companies to work for" list boasted an average of 10.32% annualized stock market returns from 1997 to 2011, as opposed to 3.71% average returns from S&P 500 companies over the same period (Mackey and Sisodia 2014).

I propose the following ethical considerations for this production framework. Note that many firms would not consider all of these to be negotiable tradeoffs– and, indeed, certain ethical decisions may lead to a dramatic increase in profitability. My research indicates that there is little intrinsic ethical difference between Mass Producers and SME Producers; ethical considerations tend to be more correlated with the personal values of a firm's founders and/or upper management than a firm's production structure, although I note several exceptions below.

I will begin with ethical considerations related to worker wellbeing, as summarized in Table 3 below.

Table 3: Summary of ethical considerations related to worker wellbeing

Living Wages	Job Security	Personal Safety	Work-Life Balance
Equal Opportunities for Advancement	**Meaningfulness**	**Shared Value Creation**	**Autonomy and Empowerment**

Worker Wellbeing – Living Wage

The definition of a "living wage" differs from city to city, and is almost always higher than the legal minimum wage. In Glasmeier's (2018) Living Wage Calculator for the USA, she calculates the "minimum employment earnings necessary to meet a family's basic needs while also maintaining self-sufficiency." Many factories that employ large numbers of migrant workers– notably in China's industrial centers– pay their employees lower wages while providing dormitory-style accommodations and meals at no additional cost. The ethics of this sort of arrangement depends upon local norms and how the situation is managed; workers might be happier not worrying about anything outside of their job, or they may feel uncomfortable in their crowded dormitories and deprived of any work-life balance.

Worker Wellbeing – Job Security

Can workers depend upon the fact that they can keep their job for the long-term, or are positions more tenuous? If workers are hired on a contractual rather than full-time basis, do they have any form of job security– and can they reliably get contracts when they need them? For full-time employees, what are the chances of suddenly being let go if tasks shift or become automated?

Companies like Toyota create a culture of "continuous improvement," which includes training to upgrade employees' skills as technology improves and tasks shift. Modern auto-part factories in the southern USA, on the other hand, are notorious for hiring contract workers and then letting them go as factories change; some of this shift is due to the lack of union presence in these states. While workers tend to be hired for life in German and Japanese firms, American factory workers today typically have less loyalty towards their employers– thus dissuading firms from investing in their employees for the long-term (Hall and Soskice 2013). Contractual work is a feature of both Mass Producers and SME Producers, although SME owners, unlike factory workers, have the advantage of owning their own tools and factories even if their manufacturing contracts expire.

Informal sector jobs offer little in the way of job security, often forcing workers to take on a number of odd jobs and start new businesses in order to make ends meet. Simons's (2012) study across Africa revealed that the businesspeople they surveyed ran on average 6 businesses– and one waste utility entrepreneur had 66 different businesses! A tailor, for example, might run a small retail storefront and also repair clothes when business stagnates.

Due to the lack of record-keeping across these different businesses, craft workers may not be aware of which activities are the most profitable– leading to further inefficiencies as workers attempt to keep all of their enterprises afloat.

Worker Wellbeing – Personal safety

Although the United States and Europe have reasonable standards for job safety, government agencies such as the USA's Occupational Health and Safety Administration (OSHA) rely upon continual funding in order to go into factories and enforce their standards. In addition, agencies like OSHA must be legally empowered to stay up to date on new chemicals, materials, and technologies so they can issue new rules and regulations accordingly. However, many of these regulations are reactive rather than proactive; out of over 80,000 new chemicals produced in the USA, only a few percent have actually been tested for toxicity (Ashford and Caldart 2008).

Across the global informal SME sector, there are fewer safety standards and even fewer government agents who can enforce them. Even if countries adopt national worker safety regulations, how would informal artisans– who are often illiterate or under-educated– even find out about them? Since most informal firms fail to register as businesses, the government has no means of contacting them; on-the-job safety then falls to SME workers' collectives, which often have antagonistic relationships with government agencies. Informal clusters also suffer from improper disposal of flammable materials such as oil barrels, and artisans may run the risk of losing their shops to fires or other disasters.

In the Suame Magazine informal industrial cluster of Kumasi, Ghana, hazards to informal artisans included the inhalation of toxic fumes while spray-painting vehicles without proper masks, and the lack of eye-protection during welding. Kumah, Cobbina, and Duodu (2011) surveyed 470 welders and 450 non-welders in Suame Magazine, and found that 84% of welders (compared to under 10% of non-welders) had damaged conjunctivas as a result of the extended exposure to radiation during their work.

Worker Wellbeing – Work-life balance

Do workers have to be constantly available to go to work at a moment's notice, or can they plan their lives in advance around set routines? Do they have time for rest and leisure, and the ability to have a life outside of the workplace? What is the average stress level among workers, and is all this stress necessary in order to get the job done? Ton (2016) cites examples from the retail industry, which is notorious for scheduling workers' shifts so unpredictably that workers are unable to take on second jobs or make any other plans for their lives.

Janoski and Lepadatu (2014) note that Silicon Valley firms and Japanese firms such as Toyota, despite ranking highly on many other "ethical workplace" criteria, tend to rate poorly in this category since jobs become all-consuming. A number of Silicon Valley firms boast "campuses" with dorms for occasional use, laundry services, showers, and three meals a day– encouraging employees to embrace work as a lifestyle.

Since many SMEs are literally cottage industries, SME workers may suffer from this lack of work-life balance. Nonetheless, a number of SME workers actually prefer to work from

home, where they can take care of their children and work on their own schedules.

Worker Wellbeing – Equal opportunities for advancement

Are all workers treated respectfully regardless of their ethnicity, race, class, gender, sexual preferences, or other relevant criteria? Even if workers are protected from discrimination under the law, they might fear retribution from employers if they speak up. In many countries, local laws are insufficient to protect certain workers from harassment– meaning that the firm itself must create a respectful culture in order to protect its staff. These practices may be easier to follow in a centralized Mass Production facility. Still, well-run SMEs may have the advantage of being smaller, so managers are better able to personally take good care of their workers. In addition, are workers free to collectivize and demand better treatment when necessary? Workers from distributed SME networks have a distinct disadvantage in attempting to organize, as compared to large factory workers– unless an agglomerating firm decides to help workers connect to one another.

Is there an equal opportunity for advancement within the firm? Advancement may involve more favorable tasks, more flexibility, more respect, or better/fewer working hours. Increased compensation is also important, though a firm can provide benefits to loyal workers in other ways as well.

More broadly, does the job provide an opportunity for workers to improve their lot in life, or at least to improve the lives of their children? A job that does not provide any opportunities for advancement can still be an ethical one, but the idea of social stagnation is antithetical to what many workers believe to be a core promise of the free market society. Schumpeter (1942) claims that this opportunity for advancement is the key to the justifying "morality" behind capitalism, which has encouraged the strong support of free market enterprise throughout much of the world.

The question of whether a job allows workers to improve their own life conditions, or to at least create a better life for their children, is different from the question of whether the job pays a living wage. The living wage question is one of immediate sustenance and independence from loans or government support, while the advancement question is one of long-term social mobility.

Worker Wellbeing – Meaningfulness

Mackey and Sisodia (2014) emphasize the importance of cultivating a "higher purpose" in the workplace; at Whole Foods, the company's mission is to make customers happier and healthier while improving the planet. Whole Foods staff are a critical part of this mission, and they can all share their own ideas for helping their company become an even better place. Toyota follows similar practices in encouraging factory workers to see themselves as critical players in their company's success.

Successfully cultivating a higher purpose is surprisingly rare in industry. JUST's survey (2017) found that 62% of Americans said they "distrust" corporations. On a 2015 survey of working British adults, 37% of people said their job "is not making a meaningful contribution to the world" and only 63% found their job "personally fulfilling" (Dahlgreen 2015).

Worker Wellbeing – Shared value creation

Do workers have any stake in the value created? Do they feel as though their contributions are respected by the firm and their superiors? In 2017, 80% of USA respondents surveyed said that companies "don't share enough of their success with employees" (JUST 2017). Shared ownership could involve a cooperative ownership model in which workers literally own the company, such as the Ace Hardware franchise in the USA or the Mondragon federation of worker cooperatives in the Basque Country. Workers could own company shares on a smaller scale, such as the stock packages that Silicon Valley firms routinely given to their software developers.

Alternatively, companies can foster a sense of ownership through purely cultural practices like celebrating loyal workers, or by relying upon workers to help determine the direction of the company. Toyota is famous for instilling a sense of loyalty and co-ownership among its staff (Janoski and Lepadatu 2014). On the other hand, more traditionally Taylorist factories tend to separate production into tasks that are so minute that assembly-line workers have no sense of pride in having helped to create the final product (Davis 1967).

Worker Wellbeing – Autonomy and empowerment

Do workers have any sort of creative freedom? Software developers, designers, and other creative professionals may have an easy time feeling empowered within their jobs, while a clothing factory likely wants its workers to perform tasks that are as standardized as possible. Nonetheless, do workers feel empowered to make important decisions and plan their own tasks– even if they have no freedom over the final product?

Across a variety of factories, Davis (1967) finds that "a reward system that supports responsible autonomy was shown to provide gains beyond those of simple increases in task output." The job shop organization of SMEs tends to support the "whole man approach" of complete product creation better than the piecemeal work of assembly-line mass production (1967), although Davis indicates that mass producers can likely find ways to introduce autonomy into their factories.

Ton (2014) points out that retail businesses that can standardize tasks and then empower employees to take over whichever tasks need doing can become more efficient overall– especially compared to firms that require all workers to perform a regimented series of tasks regardless of urgency.

Customer Wellbeing

Are customers satisfied by this product over its entire lifetime? Does the product provide personal and economic value? For addictive products like tobacco that negatively impact the health of consumers, customers may be satisfied in the short-term but suffer consequences in the long-term. In regions where there are few legal protections for consumers, or when the chemicals used in a product have not yet been tested for safety, the ethical burden of consumer wellbeing may play into a firm's production decisions.

Sometimes customers are unable to find products that suit their needs, and must

purchase things that do not satisfy their requirements for various reasons. For example, Waldman (1993) describes how certain producers face socially nonoptimal incentives to introduce planned obsolescence into their products, so they can sell products to the same customers more regularly. Yet why do customers continue to buy short-lived products? Perhaps customers cannot afford anything else, or they are seduced by advertising into buying more fashionable products, or maybe there are no decent products on the market that are designed for longevity.

Community Ethics

Is the firm in question a "good corporate citizen," and does it create value for its community at large? This value can be cultural, such as preserving crafts or traditions, or more tangible in the sense of boosting the regional economy. Firms may also invest in local corporate social responsibility activities like supporting non-profits and sponsoring educational events.

Responsible Sourcing

Responsible sourcing (also referred to as "supply chain transparency") often involves shortening the supply line and eliminating middlemen, so producers are aware of the entire mine-to-market chain. Some jewelry producers will take their vendors directly to their metal or gemstone mines to prove the ethics of their labor and environmental practices. In the United States, retailers are legally required to buy from reputable sources all down the chain in order to comply with laws such as California's Transparency and Supply Chain Act; this Act requires know-your-customer forms to ensure that suppliers are not indenturing workers, hiring children, or abusing workers (through inadequate safety standards, lack of access to healthcare, poor conditions, etc.).

In addition, is the firm honest and forthright in its interactions with other people and firms? This might involve honesty in marketing, and whether a firm chooses to share relevant information with stakeholders such as employees, shareholders, and customers. Even if they can avoid any legal responsibility, some firms may take a strong stance against corruption by refusing to pay bribes to local officials. This sets a precedent for honesty in future interactions, though it may harm firms in the short-term if they are unable to get government support while their competitors have fewer qualms about bribery.

Transparency poses a particular challenge for distributed Networked SME Producers; informal workers are often disorganized and undereducated, and thus subject to illegally low wages and even forced labor. Due to a history of exploited homeworkers in the fashion industry, many less vertically-integrated companies attempt to avoid homeworkers altogether (NEST 2017). While a vertically-integrated company like Fabindia can freely post photos of its thousands of homeworking artisans and discuss their life stories on the front page of the firm's website (Fabindia 2018), a contract manufacturer like H&M must discuss its homeworkers in more guarded terms. On a back page of the Sustainability section of H&M's website, the company states: "There are a number of concerns related to home working, but it can be beneficial in some production countries because it is often carried out by women and can be an important contributor to a family's income" (H&M 2018).

Environmental Sustainability

Environmental ethics may be closely related to social ethics, such as the danger of allowing hazardous chemicals to pollute a communal water source. They can also act as opposing forces, such as when chemical companies replaced the ozone-depleting refrigerant CFCs with the more environmentally-friend HCFCs, which happen to be far more hazardous to factory workers (Ashford and Caldart 2008).

Relevant questions around environmental ethics include the following:

- **Pollution mitigation**: Are there environmental hazards in the production process, and can those be effectively mitigated? What sort of pollution will be generated, and can this be contained? What is the chance of a toxic spill? Could toxic materials be replaced with safer options? Could the overall carbon footprint be lowered in some way?
- **Resource efficiency**: Can energy or resource use be minimized through cleaner production strategies? Is the extraction of requisite raw materials sustainable?
- **Lifecycle considerations**: What happens to each component at the end of a product's lifecycle? Is this component reusable/recyclable, or could disposal pose an issue? Is there a way to make manufacturing and use of this product a more "circular" process, so waste can be efficiently reused in future products?

Debate continues over whether decentralized and distributed production models are more or less environmentally sustainable than centralized Mass Production (Kohtala 2014; Fox and Alptekin 2017). Mass Production has historically been more resource-efficient, and the centralization and economies of scale tend to facilitate toxic waste management. Even the carbon emissions that come from shipping products around the world might not make up for the waste created by inefficient though localized SME Production.

The Circular Economy concept (Webster 2017) argues that those companies which consider material recyclability and disposal from their initial design phases will be more successful in the long-term; if not, a company risks using up of its resources and/or becoming dependent upon fluctuating raw material costs as those resources become scarce. One of the most promising Circular Economy models is that of the product-to-service economy— in which a large firm maintains perpetual ownership over its products, and leases to consumers rather than selling. That firm then has an incentive to keep its products in service as long as possible, in contrast to the notion of planned obsolescence currently popular among consumer electronics and fast fashion firms. As the concept of a widespread service economy is relatively recent, it is unclear whether companies in a Circular Economy would in fact employ *local* re-manufacture and repair—or if it makes more sense to follow a Mass Producer model of shipping used/damaged products back to the OEM for refurbishment. Nonetheless, a more localized SME Production model could potentially collect and redistribute used products more easily.

Chapter 4. Soko's Virtual Factory

Now that I have outlined a loose set of value tradeoffs involved in manufacturing decisions, I will provide an overview of the jewelry industry and explore the jewelry company Soko through an in-depth and comparative case study. My advisor Campbell Flatter first suggested Soko following our discussion around networked craft production, and I became fascinated by the firm's production model after attending a talk by co-founder Ella Peinovich.

As first mentioned on page 18, Soko employs decentralized, Networked SME Production with the deliberate aim of supporting artisan-owned microfactories. Like Fabindia, Soko provides both professional and financial support for its network of craft artisans to grow their own businesses while contracting with Soko. Soko refers to its own model as a "virtual factory," and combines the manual labor of low-tech informal microfactories (similar to the putting out or homeworker model) with advanced algorithms and mobile technology for distributing physical production (in the vein of the Smart Microfactory model). Soko's combination of high-tech connectivity with traditional handmade techniques is highly unusual in the fashion industry, where brands tend to keep their high-tech factories– such as Au Enterprises, described on page 48– wholly separate from their low-tech craftspeople– such as those employed by H&M and Fabindia. Thus, Soko presents an intriguing hybrid of Intermediate Technology and Germany's *Industrie 4.0*.

By the sociology definition mentioned in Chapter 2, Soko's model would not fully qualify as a (re)distributed production system; Soko's artisans do not design their own products, none of the production is open-source, and most of Soko's products are sold overseas rather than to local markets. Soko initially started with artisan-created designs ("Etsy for Africa") but realized that its artisans lacked the knowledge of international fashion trends that would be required for industrial-scale sales; this may be a cautionary tale for those who hope to fully distribute design while competing on a global scale. Nonetheless, I believe Soko's case still holds useful lessons for, at the very least, those interested in the "manufacture local" component of (re)distributed production systems, and the tension between economies of scope and economies of scale.

As stated in Chapter 1, my thesis is that **Networked SME Production systems such as Soko's can present an effective and ethical model for manufacturing**. I will consider Soko to be "effective" if its production model proves to be scalable and globally competitive with established jewelry manufacturers, like Au or Fossil's outsourced factories. Though "ethical" production is a tricky and multivariate concept, I will follow my definition of social and environmental ethics from Chapter 3– with a particular focus on Soko's stated goal of helping artisans help themselves out of poverty.

Jewelry Industry Overview

Jewelry production began with independent artisans designing (or copying popular designers) and manufacturing their own wares, and gradually became more industrialized as major producers/designers started creating their own brands and building their own factories. By the 1980s, New York and Rhode Island were major hubs for global jewelry manufacturing, with factories employing 500-1000 people. With its wealth of skilled craftspeople, Italy was also

a significant jewelry producer, although much of Europe's jewelry production tended towards small-batch designer products made by SMEs rather than Fordist factories. Raw materials came from all over the world, with India in particular supplying many of the world's diamonds.

The market did not become substantially globalized until the mid-1990s, as leading brands in most markets were primarily national companies. In the mid-1990s, smaller factories began developing across emerging markets. Indian entrepreneurs realized that they should start *manufacturing* diamond jewelry instead of just selling the raw diamonds, which led to a major growth spurt across the country. Thailand emerged as a major source of designer jewelry due to strong traditions of fine craftsmanship and low labor costs, and China also became a major manufacturer due to low labor costs and factory-friendly policies. It took Chinese jewelry manufacturers some time to master quality control, so it was not until more recently that they became a competitor for high-tier jewelry production.

Even though jewelry production today is highly automated, it still requires considerable handiwork– from loading machines, to manually tweaking fabrication equipment, to inspecting and finishing final products. Smaller producers employ skilled technicians that can competently complete multiple production steps, while mass producers tend to utilize an assembly line of lower-skilled operators who each perform one step at a time.

Jewelry that is not made from precious metals and gemstones, considered mid-tier, "costume" or "fashion" jewelry, is still mostly made in China, especially Qingdao and Yiwu. Vietnam, Cambodia, and Laos are becoming bigger manufacturers of mid-tier jewelry. Brass in particular is often produced in Qingdao. Hsu et al. (2014) attest that Chinese jewelry producers are investing "heavily" in machining equipment and upskilling staff. To keep up with trends toward customization and improved quality control, China has begun transitioning away from low-cost production model towards skilled workforce development and high-tech equipment such as laser diamond-sawing, robotic gemstone cutting, and other computer numeric controlled (CNC) equipment (Hsu et al. 2014).

Major Trends

Supply chain consultant John Croston identifies responsible sourcing as an emerging trend among jewelry firms, given the trend among middle and upper-class Millennial shoppers in the USA and Europe of preferring socially and environmentally ethical brands. Emerging technologies such as smartphones and the blockchain (a shared and distributed ledger) could enable a more streamlined data collection and verification process, ensuring the increased transparency of complex, global supply chains. Through social, political, and/or economic pressure, vendors may increasingly have to become certified in order to sell their wares– and reputation scores will be publicly recorded for prospective customers to see. One of the major problems is that purchasers today have little incentive to investigate their suppliers; Croston says "it's a non-issue." If a shared ledger like the blockchain can facilitate more detailed records and transparency throughout supply chains, then purchasers will be obliged to investigate their suppliers, who may in turn investigate their own contractors and subcontractors to ensure compliance with relevant laws and best-practices. For example, California's recent fair trade laws have forced jewelry companies to ensure reasonable labor practices when selling

anywhere in the United States; since many producers do not know where retailers will ultimately sell their wares, they are legally obligated to comply with the laws of the most stringent state (i.e., California).

McKinsey & Co. (2014) identify five major trends shaping the industry: "internationalization and consolidation, the growth of branded products, a reconfigured [sales] channel landscape, 'hybrid' consumption, and fast fashion." The ten biggest jewelry-producing firms controlled only 12% of the global market in 2014; the market is still predominantly local, with a long tail of small producers and boutique cottage industries. Though a mere 20% of today's overall market consists of branded products, McKinsey & Co. (2014) anticipate this sector doubling over the next decade– potentially to the detriment of small producers, if they are unable to establish their own brands or partner with existing brands. Branding requires a substantial marketing investment, though it becomes worthwhile when loyal and/or fashion-conscious customers are willing to pay extra for branded jewelry. In light of this shift, new sales channels such as mono-brand stores and ecommerce are on the rise– while department store jewelry sales have remained relatively constant. "Hybrid" consumption refers to the growing trend of brands looking to diversify their customer base by creating jewelry lines that are considerably more or less expensive than their typical product line– sometimes by employing new materials (silver rather than gold, for example) or contracting with new factories.

The rise of "fast fashion" in the mid-1990s– typified by brands such as Zara and H&M that introduce new apparel and accessories on the order of weeks rather than months– has led many fashion companies towards a strategy of small-batch production runs. The flexibility of online platforms and the ease of virtual shopping have helped drive this trend, particularly among the Millennial generation. In the UK, fast fashion accounted for 25% of apparel sales in 2014, and the number of Zara stores in China grew 60% annually between 2007 and 2012 (McKinsey & Co., 2014). Fast fashion companies encourage consumers to purchase new clothes as soon as styles fall out of fashion, and pressure their suppliers to provide an ever-changing diversity of goods at very low prices– often leading to stressful labor conditions and low wages for workers, and a high wastage of resources as consumers discard lightly-worn garments in favor of more fashionable wares. Due to the small profit margins of fast fashion, there is considerable churn throughout the sector; suppliers and brands are quickly forced out of the market if they cannot compete on speed, cost, and responsiveness.

Prior to fast fashion, stores like Macy's used to purchase thousands of identical jewelry items per order, and were happy to wait for months before receiving the next shipment of goods. Fordist mass production in China or India usually takes 6-8 months to move from design to storefront. When a new "season" of jewelry arrives, retail stores must sell off any unsold goods at price or below to make room for their new wares. As fashion has become faster, many major retailers have shifted to buying only hundreds of units at a time, so they are more likely to sell out and therefore capture the full market value of their line. Since batch size is shrinking, SMEs and smaller mass producers can now directly compete with jewelry brands that own mega-factories, since everyone will end up producing jewelry in small batches.

As Chinese labor costs increase and gold duties become more expensive in the United States, some American gold jewelry producers have started bringing production back to

American cottage industries. To avoid competing with today's large-scale and high-quality Chinese manufacturers, longstanding American producers such as Detroit-based Au Enterprises focus on highly-customized batches of 10s-100s of units at a time. Au can even profitably produce a single customized item; one-off production is in high demand for wedding rings and samples for fashion designers. Au's 31-year-old factory is 8000 square feet and employs 15 people, including moderately-skilled CAD modelers and technicians who use 3D printing techniques to achieve quick turnarounds on unique items of jewelry.

Vertical Integration

The degree of vertical integration in the jewelry industry is complicated. Some firms like Zara employ their own designers, build (most of) their own factories, and sell their own branded products, while other firms may only be involved in one or two steps along the production chain. Some known brands like Tiffany have their own in-house designers, while other firms employ trusted independent designers or offer white-label manufacturing services. The jewelry industry is very trust-oriented and retailers tend to be risk-averse, so firms will typically go with known designers and manufacturers over new entrants.

Some retailers have started to place orders directly with factories, since middlemen have become expensive and companies are moving toward more vertical integration. Purchasing teams at stores like Nordstrom or Niemans might buy jewelry from established brands that they know, and these brands will hire or contract with their own trusted factories.

Given the wide variability within the jewelry industry, there are varying degrees of vertical integration among jewelry manufacturers:

Table 4: Stages of jewelry production (margin estimates from Croston and Drogs)

Production Stage (% of margin captured)	**Description**	**Traditional Handmade**	**Modern Handmade**	**Mass-Produced**
Initial Design (~10% of margin)	Designing items and coherent suites of products for the season's trends	Artisan	Smaller fashion brand designers, or custom-made for individuals	Larger fashion brand designers, or off-brand manufacturers
Design for Manufacturing	Turning models or design sketches into manufacturable products	Artisan (minimal effort)	Factory creates CAD models for digital fabrication, sometimes with designer	Brand working with factory on production molds, machining workflow, QC, etc.

Manufacturing (~20% of margin)	Physical production of goods from processed materials, and/or assembly of pre-manufactured components (chains, beads, etc.)	Artisanal microfactory (~3-10 people)	SME factory (~10-200 people)	Large factory, rarely owned by brand (~200+ people)
Finishing	Polishing, painting, buffering, etc.	Same as manufacturer	Same as manufacturer	May be different facility
Sales (~70% of margin)	Sales of final product, wholesale and/or retail	Boutique or fair trade labels at retail outlets	Boutique or major retail outlets	Major retail outlets
Batch size	*How many identical items per batch?*	*10s-100s*	*10s-1000s*	*1000s-millions*

Manufacturing

Manufacturing systems vary widely among factories, from family-run SMEs that operate as job shops (i.e., disorganized rather than assembly-line production), to larger scale Taylorist factories. Much of jewelry production is distributed in the manner of Specialized and Flexible SMEs, with one vendor requiring several independent factories to produce a completed product, through several small batches of distinct and/or identical product components. Some producers run their own factories, while others contract out to independent suppliers. Depending on a firm's decisions, the cost of manufacturing might go up by a factor of 10 or more for equivalent materials and processes. Ideally, manufacturing costs for jewelry should be about 10-20% of the overall retail costs; manufacturing costs are higher at the higher-tier, and lower for mid- and lower-tier.

A high-tech, specialized SME like Au serves two different customer segments: their B2B segment consists of retailers and/or designers who manufacture small to medium batches of 100s to 1000s of pieces at a time, while Au's consumer segment mostly buys customized one-offs. One-off products are typically 3D printed and then cast; these consists of customized items and small runs for high-end jewelry designers who want to limit their overall batch size, or cannot afford to produce large numbers of product until they first test out the market.

Au produces small and medium batches at scale by digitally designing an item, then making that pattern into a mold and setting up a coherent workflow to manufacture in bulk. Au's factory workflow is more organized than a job shop, but the variable times required for producing different types of items likely preclude the company from delegating micro-tasks in the highly-structured form of an assembly line factory. Research mentioned earlier from Davis (1967) and Adler (1992) would indicate that Au's workers are probably happier with the

variability and completeness of their tasks, as compared to assembly-line workers in a Taylorist mass production facility.

Most jewelry today is the product of casting or die-striking, and is produced in medium to large batches. Customized, higher-tier products such as wedding rings or high fashion items might be made in a one-off fashion in a factory like Au. Generally speaking, there are three different types of jewelry production:

1. Traditional handmade: an individual artisan at a bench fabricates items one at a time, entirely by hand. Drogs describes this as the "arts and crafts section" of the jewelry industry rather than the commercial side. A traditional American artisan might make a piece of jewelry that retails for $30 and takes an hour to produce, and the artisan would take home about $12 per item. Traditional artisans in the United States can rarely make ends meet; without modern technologies and techniques, Drogs estimates that handcrafted jewelry in the USA have overall production costs that are 30-50% higher than similar items that are partially or wholly made by machine.
2. Modern handmade: Croston (2018) describes hand-carved jewelry as a "dying art," with the exception of particular items that require high definition unachievable through automated equipment, such as higher-tier jewelry produced by skilled artisans in India and Thailand. Much of the "handmade" jewelry sold today is designed digitally and then 3D printed in wax for lost-wax casting– although most of the steps involved in both the wax and final finishing touches still require moderately-skilled, manual handiwork.
3. Machine-made: Lower-tier jewelry and components of mid-and higher-tier jewelry such as tubes and chains use a continuous, automated casting process. Some costume jewelry is made from start-to-finish in a single vertically-integrated factory. Nonetheless, even these items require continuous handiwork and human involvement throughout the process.

For example, a necklace consisting of a pendant handing from a chain might be made in a variety of ways. The chain was likely machine-made in bulk in a Chinese factory. A mid-tier pendant might also be mass-produced in China or India by machine and/or by hand. A similar pendant purchased from a higher-tier store might be more customized and produced in smaller-batches in the United States, Italy, Southeast Asia, or elsewhere.

Retail

Sales typically account for 70% of the revenue margin of an individual item of jewelry. Wholesalers will take about 30% of the revenue margin, while retail captures another 40%. There are five general types of jewelry retailers:

1. Direct-to-consumer: Individual craftspeople and Craft SMEs (such as Soko's artisanal suppliers described in the next section) can rarely produce enough jewelry in bulk to get retail contracts. They typically design their own wares and sell through local craft markets and boutiques.
2. eCommerce: Tech-savvy Crafts SMEs have started selling direct to consumers through online storefronts like Etsy. Many designers and brands have also benefitted from the high margins and low operating costs involved in ecommerce.

3. Small retail: Cottage retailers run by sole proprietors typically start with ~100 square ft of retail space, and will purchase jewelry in bulk. Some second-generation stores may buy up to a few thousand square feet of retail space.
4. Medium retail: Regional operators might own 2-15 different stores, and purchase jewelry either through wholesalers or direct from the designers.
5. Large retail: Larger multi-chain operations own outlets on a national and multinational scale, and many of these larger firms are hybrids that own several different jewelry brands (i.e., a cheaper jewelry brand and a high-fashion brand). Large retailers may also buy from other jewelry companies at wholesale rates.

Soko Case Study

Founding Story

Founded by architect Ella Peinovich, industrial designer Gwendolyn Floyd, and software engineer Catherine Mahugu, the Kenyan company Soko designs and produces brass, horn, and bone jewelry for mid-tier customers worldwide under its own brand name. In June 2017, Soko had around $3.5M in revenue, 75 full-time employees, and 2500 artisans in and around Nairobi that manufacture jewelry on a contract basis. Peinovich is especially proud of the fact that Soko's artisans retain 22-25% of Soko's overall revenue (23% in 2017), as compared to the industry standard of only 8-10%, or 3-5% among low-skilled, mass production factory workers. After a bumpy first few years, Soko's co-founders finally found a profitable business model and reached a stage of consistent growth: the company's revenue has consistently doubled year-over-year since 2014. Soko's customers include tens of thousands of ethical fashion-conscious consumers across 35 countries, as well as major fashion retailers such as Nordstrom, Anthropologie, QVC, and others.

Soko's full-time artisanal suppliers (around 30% of Soko's overall network) received around a 5x increase in annual income after becoming contractors for Soko. "They've gone from a handful of products by the side of the road every day," said Peinovich, "to now hundreds of products in retail shops around the world." Most importantly, Peinovich explained how Soko was also contributing to social mobility:

> *We see a number of people moving out of the slums. They are paying their dowries for the first time, they're paying the school fees for their boys and their girl children, and now putting three meals on the table every day. This is a huge point of pride, because we at Soko really believe that we are helping artisans to lift* themselves *out of poverty.*

Soko V1: Etsy for Africa

Soko began as a simple platform for informal jewelry artisans to sell their own products on the international marketplace. It started out as an Etsy.com for Kenyan jewelry artisans, with additional marketing support for the less technically-savvy informal sector. While Peinovich and Mahugu built a mobile-to-web marketing platform to connect artisans with the international market, Floyd curated a high-quality selection of jewelry sourced from artisans around Nairobi.

This platform became a virtual marketplace for informal artisans to sell their goods directly to international consumers, so artisans wouldn't have to rely upon locals, tourists, and middlemen.

Unexpectedly, Soko's team found themselves unable to consistently grow sales for their products after 6 months— and, as with many marketplace solutions, Peinovich struggled to properly manage everyone's expectations. None of the co-founders had run a retail business before, and Soko's early days involved many challenges. The team knew how to find and market excellent products, but they lacked a sustainable business solution to reach profitability. Soko's co-founders realized that they were solving the wrong problem: connecting Kenyan artisans to international markets would never be enough, since the key challenge for artisans was the fact that they didn't know what international customers wanted to buy.

After exhausting their market of friends and family, Soko's team had to come to terms with the fact that sales had stagnated. They initially expected that wealthy North Americans and Europeans would be willing to pay far more than Kenya's local market for handicrafts, but Soko's estimated price of its handmade goods and the actual price that customers were willing to pay (given the proliferation of similar machine-made goods) were, in Peinovich's words, "completely misaligned." As she discovered through this failed Etsy model, it was very difficult to sell large volumes of diverse products— especially when the artisans creating these products had little exposure to international trends, no concept of foreign customer preferences, and no experience with quality control standards. Every item in Soko's online store turned out differently, and traditional Kenyan designs were not always attractive to young, fashion-conscious consumers.

In other words, Soko's Etsy-for-Africa would never amount to a profitable business. Peinovich, Mahugu, and Floyd applied their design thinking expertise to the problem and, after several harrowing brainstorming sessions, the team pivoted towards developing their own fashion brand rather than relying upon local artisans as designers. Peinovich explained, "There's a spectrum: at the far end you have art, one of a kind individual pieces [Soko V1]. Soko [V2] is somewhere between art and small-scale manufactured products… Can we meet the volumes that we're seeing in retailers?"

Soko V2: Creating a fashion brand

Soko's team never set out to develop a revolutionary production model, but they were not going to waste the opportunity. **"**It's not just simply product being sold out to customer," said Peinovich, "but there's an entire value chain, an entire ecosystem that frankly we had to develop in order to make Soko successful. But we did not start there."

Soko's co-founders always knew that their ultimate goal was large-scale distribution and competition with major fashion brands; they did not intend to limit themselves to local craft markets or niche Fair Trade companies, but they were unsure of how to stay competitive while employing informal artisans. Peinovich's passion for problem-solving eventually led Soko's team to adopt the pre-industrial model of putting out or homeworking, with the addition of modern networking technology and smart algorithms to select the right artisans for the right jobs.

Soko's final business model matched talented artisans with both an international marketplace *and* highly-competitive jewelry designs. Since Soko began with a strong commitment to supporting existing brass artisans, the co-founders wanted to leverage their existing ecosystem of skilled jewelry artisans rather than build their own infrastructure or train unskilled workers. This also allowed them to save on capital costs by contracting out to existing microfactories rather than building their own factory. Nonetheless, as befits a new production model, Soko had to invent its own manufacturing system. Peinovich said, "we're building the next generation supply chain: more distributed, more agile, and it is more ethical. I see this as a necessary step in revolutionizing retail and the fashion space as we see it today."

Many fashion manufacturers viewed homeworking as a potential liability in their supply chains, due to a long history of factories outsourcing handicraft production (especially beadwork and embroidery) to informal sector subcontractors at exploitative rates (Nest 2017). Peinovich, however, saw these informal cottage industries as a potential asset; Soko eliminated middlemen through vertical integration and direct interactions with suppliers, and further trained artisans so they were able to earn above-market wages by manufacturing jewelry for a discerning global audience. Soko's business model turned semi-skilled, informal artisans into highly-skilled SMEs, providing artisans with the skills and resources to compete with the formal sector on their own terms. "Formalization," said Peinovich, "is not the answer. Rather, networked infrastructure will bring progress." Indeed, Soko's virtual factory model of Networked SME Production combined the scale, efficiency, and collective intelligence of high-volume manufacture with the benefit to local economies provided by small, artisanal businesses. Peinovich explained:

> *With the way that the retail sector is going and consumption is leading us down this fast fashion path, the way that artisans are really marginalized due to access, not talent, we asked ourselves: what if fashion and consumerism could work for the poor rather than against it? And at Soko we believe that we can enable human capital through use of technology. And this is in contrast to mass manufacturing, where technology is automating people out of the supply chain.*

The technical innovation behind Soko's operations– and its key piece of intellectual property– was its mobile-to-web enterprise resource planning (ERP) system, which allowed for the coordination of its distributed supply chain with minimum variability:

Figure 17: Diagram of Soko's ERP system or "virtual factory" from Peinovich (2017)

This system allowed Soko's craft production model to compete (and sometimes even out-compete) larger SMEs and mass-producers. Soko designed its jewelry in-house, sent these designs out via mobile app to the most suitable artisanal microfactories for any given product, provided in-person training and support for artisans making new products, and finally collected all final items at its central office in Nairobi for finishing, quality control, packaging, and distribution.

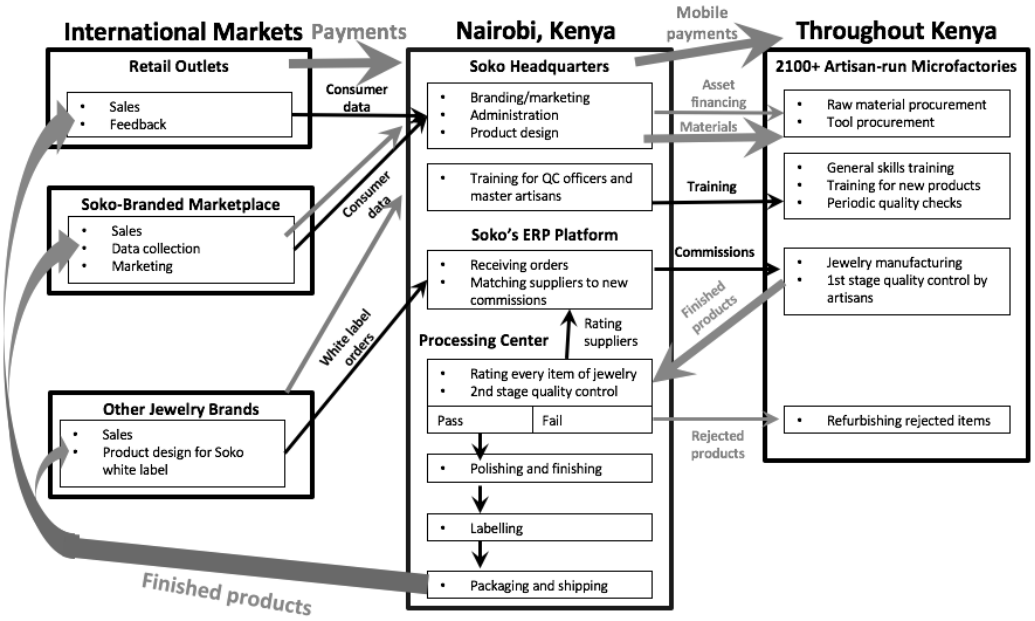

Figure 18: Diagram of Soko's business model (inspired by McKague et al. 2013, who presented a similar diagram to depict Networked Craft Producer Hathay Bunano)

Since all orders and payments were digitized, Soko was able to continually improve which artisans are selected for which jobs, based upon machine learning algorithms. Soko also

kept up-to-date on trends of which particular skills were in rising demand based on market shifts, so the company could train artisans in new skills when necessary and thus keep all its suppliers employed for the long-term. Peinovich explained:

> *We have constant data about every single artisan group that we work with, and so we can actually tailor every engagement to them. We know for each individual artisan what is your production rate, what is your speed of delivering, what is your history of the product that you've produced, what's the categorization of those products? Difficulty level, motifs required, families of products– that's all automated.*

Every item of jewelry was digitized and tracked via Soko's custom-built platform. This allowed the company's quality control officers to rate each item and connect product metrics back to individual artisans—who were graded according to quality, timeliness, responsiveness to communication, production capacity per time, and availability. Soko's wares were cost-competitive with mass-produced jewelry of comparable quality. Soko's professional design team in San Francisco, California generally came up with new product lines every six months or fewer, and Soko's suppliers manufactured these designs in bulk across their network of SMEs. When dainty pendant necklaces came into fashion in mid-2017, for example, Soko's design team was quick to roll out a series of fashionable pendants inspired by Maasai shapes:

Figure 19: Soko necklaces (ShopSoko.com 2017)

Here is a timeline of the major pivots in Soko's business model, from Etsy-for-Africa to developing new quality control mechanisms to the firm's new foray into white-label manufacturing:

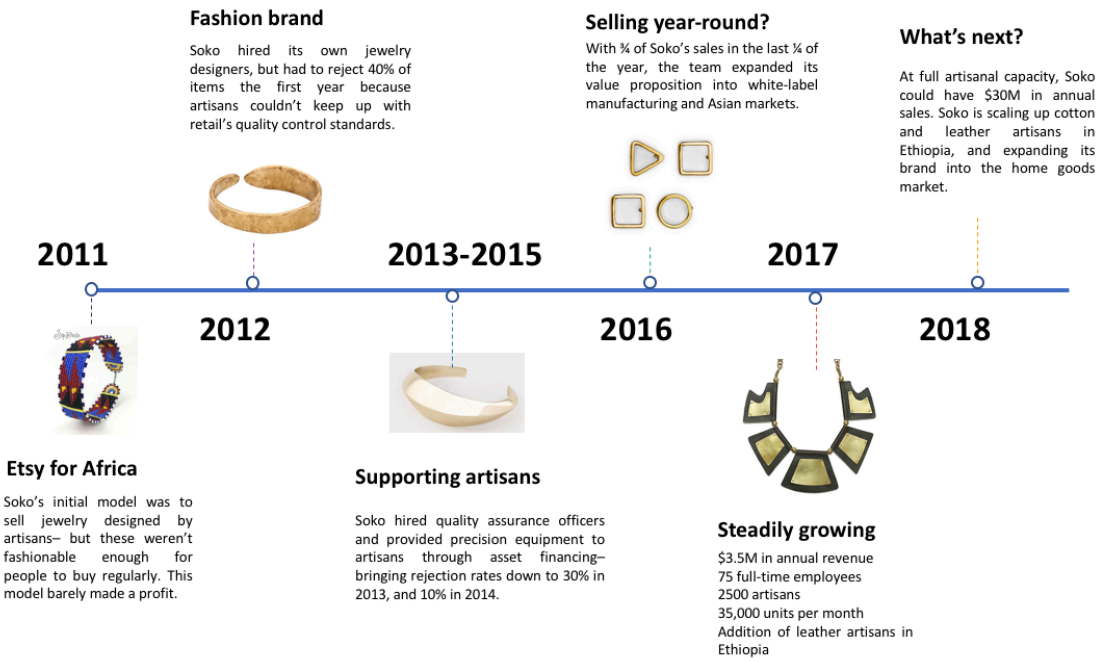

Figure 20: Soko timeline (left to right images from Sip Dada, Accompany US, and Soko)

Core Value Proposition

Soko consists of a jewelry design firm and a vertically-integrated, high-tech supply chain that turned a disparate network of artisans into an ethical manufacturing company. Soko caters to two key sets of stakeholders: artisanal jewelry suppliers, and the fashion-conscious customers who buy its wares:

Table 5: Soko's two-sided market

Craft SME Suppliers: *Mostly lower-class jewelry artisans*	**Jewelry Consumers:** *Mostly middle-class, professional women*
- Stable long-term business partnership - Competitive wages - Flexible hours and location - Training in new skills, quality control - Asset-financing for new tools - Prestige of international sales	- Beautiful design - High quality artisanship - Competitive prices ($50-$150) - Trendy, fashion-conscious wares - Availability (online or local retailers) - Ethical sourcing

Value to Customers

Customers can purchase Soko jewelry indirectly through retail stores and other fashion brands, or directly through the website shopsoko.com and from Soko's own storefront in San Francisco, California. Peinovich and her co-founders were always set on catering to mainstream fashion consumers, although this also required them to compete on price. 82% of Soko's 2017 sales were direct to businesses such as department and specialty stores, and the other 18% of

sales took place through Soko's curated channels. Only a fraction of Soko's direct-to-business sales were marketed to customers through fair trade or ethical production messaging; Peinovich said that most customers in 2017 bought Soko's jewelry "based on price and aesthetics only."

Value to SME Suppliers

For its SME suppliers, Soko provides relatively stable work at decent wages– and helps semi-skilled artisans increase their skills and build up their microfactory capabilities. Soko supports its artisans in growing their businesses through skills training and asset-financing. Most of Soko's suppliers tend to contract their work to multiple companies– from other informal microfactories to jewelry companies to home goods manufacturers–in addition to producing their own jewelry for local markets. Even though Soko might not pay as well per item as some fair trade companies, Soko issues contracts on a much more regular basis. Peinovich described how jewelry customers tended to view costly fair trade items as "guilt-ridden purchases" to be bought on occasion, while Soko's items were trendy and more affordable, so fashion-conscious customers always had an excuse to shop at Soko. One fair trade company even purchased jewelry from some of the same microfactories as Soko, but sold its necklaces for $300 rather than Soko's price of $65 for the equivalent item. Yet, by launching a fashionable new product line every 6 months, Soko could provide more stable employment for its artisans– by encouraging Soko's loyal customers to come back every season.

Informally, Peinovich identified three different types of motivations among Soko's artisans. This distinction helped inform Soko's decisions on which artisans to contract for what purposes:

- Enterprising: 50-70% of artisans had a long-term plan for scaling up operations, and wanted to invest in better precision tools. Soko provided these artisans with new equipment through asset-financing. This category had considerable "stickiness"; enterprising artisans cared about increasing their production capacity and proving themselves as trustworthy, and thus provided the best long-term return on investment for Soko.
- Artistic: about 20% of artisans had very high quality standards and were proud to sell their work, but they were not usually as timely.
- Money-driven: 10-30% of artisans worked primarily for immediate profit. Soko hired them when the company needed to ramp up production, but this group could not be relied upon for attention to detail or long-term microfactory growth.

Analyzing Soko's Effectiveness

Did Peinovich achieve her goal of becoming competitive with mass production? The simple answer is probably: Soko's production model can theoretically yield a profit margin of 65% at scale, although the firm itself suffered a net loss of $2M in 2017.

As Soko solidifies its wholesale relationships (which required a major marketing cost in 2017) and expands into retail, Peinovich is confident that Soko's demand will increase and the company will soon become profitable. This assumption is supported by the fact that Soko

brought on a new CEO with decades of experience in the retail industry who was the former senior manager for the Americas at Fossil; a manager with this level of experience would have likely conducted her own assessment of Soko's potential before joining the team. Peinovich stepped down from her position at Soko in December 2017 to develop a new organization in collaboration with Ikea, which will employ a similar virtual factory to hire refugees for craft production.

To better compare Soko to other jewelry companies, I asked Drogs and Croston about the cost buckets for a brass pendant necklace that might be sold at Nordstrom for $100; Soko and Fossil both sell their branded jewelry at Nordstrom stores, and Au regularly manufacturers for jewelry brands that sell to Nordstrom. It is notable that a consumer purchasing a necklace from any one of these companies would have to pay particular attention to a small tag in order to know how and where that necklace was made. Soko's necklaces in Nordstrom in 2017 might have carried a small tag saying "handmade in Kenya" or "100% good 100% beautiful," but did not otherwise advertise its "ethical" or "fair trade" production. Au-produced jewelry might say "made in the USA" and Fossil's might read "made in China."

Table 6: Estimated cost buckets for necklace production (estimates from Drogs, Peinovich, and Croston)

	Au Enterprises (Flexible SME)	**Soko (vertically-integrated Networked Craft SME)**	**Fossil + outsourced Chinese factories (Mass/Specialized SME)**
Staff	15 skilled and semi-skilled full-time staff; lots of 3D printers	75 full-time staff; outsourced SMEs with 1000s of skilled and semi-skilled artisans	10,000+ full-time staff; outsourced factories with 1000s of semi-skilled and unskilled staff
Average batch size	10s-1000s	100s-1,000s	1,000s-100,000s
Overall margin captured by manufacturer	$20 (manufacturing only)	$30 (vertically-integrated)	$20 (manufacturing only)
Worker margin	$8 *(full-time staff paid $25-35/hr)*	$7 overall revenue; $3.50 as profit	~$0.60 (+ food/lodging)
Material and equipment costs	*$4*	*$3.50 (paid by artisans)*	$5
Shipping costs	*negligible*	$2.40	$0.10s
Overhead cost of sales and labor	*~$4*	*$3*	$4
How long does a piece sit in inventory?	*Hours to days*	*Days*	Weeks
Time to roll out entirely new pendant and chain product	5 days	~4 weeks	2-3 months; or up to 6 months for major retooling

Internal cost of rolling out new product line	$70-140 (CAD designers already hired full-time)	$250	$1-2K overall $100-500 cost to Fossil because vendors eat cost
Overall annual revenue in 2017	*$2.5-5M*	*$2.5M*	*$2.8B*
Profit margin in 2017	*20% overall profit margin*	*Soko had 65% gross profit margin; firm overall suffered a loss (artisans have 50% profit margins)*	*Fossil had 50% gross profit margin; firm overall suffered a loss*
Minimum batch size for profitability	*1-2 units*	*30 units*	*~1000s of units*
Age of company	*31 years*	*5 years*	*33 years*
Average revenue growth 2015-2017	*20%*	*53%*	*12%*

Application of Production Tradeoffs Framework

Leveraging our production tradeoffs framework depicted in Table 2 (on page 23, how does Soko maintain competitiveness? With 2500 artisans to coordinate in 2017, Soko was doubly disadvantaged as both a distributed network and a traditional handmade producer. The combination of increased logistics costs, higher-paid workers, and low-tech production methods makes an average unit of Soko jewelry up to 50% more expensive to manufacture than typical mid-tier products, and shipping costs from Kenya can be an order of magnitude higher than shipping from well-established exporters in Asia or the Americas. Yet, the retail price of Soko's jewelry is cost-competitive with mid-tier market prices, and even cheaper than many top-tier jewelry brands of similar quality.

Despite the complex logistics required for distributed quality control in an underdeveloped market, Soko's overall production agility, lack of physical assets, and level of vertical integration provide an advantage over Specialized SME and Mass Producers. Since large amounts of inventory are a liability in a quickly-changing market, Soko's distributed production-on-demand model has helped it to stay competitive. Most of Soko's artisans check their mobile apps every day to receive their instructions for that day's jewelry production. This is more similar to Au's on-demand model or Zara's fast fashion model than typical Mass Production, where tasks tend to be fixed weeks or months in advance rather than introduced daily.

Scalability

In early 2018, Soko was on track to achieve a 50% growth in gross profits. Soko has grown consistently since 2014:

Table 7: Soko's growth (from company data)

Year	**Soko's Growth (Gross Profits)**
2014-2015	210%
2015-2016	53%
2016-2017	53%
2017-2018	50% (anticipated)

Yet Soko's growth in revenue in 2017 was in large part due to increased prices and better organization rather than an increase in sales volume; Soko's demand has not kept pace with Soko's increasing potential for production, and Soko's artisans only worked at an average of 20-30% capacity outside of the holiday season. If these suppliers had consistently spent half of their production capacity working for Soko throughout the year, the company would have made $15M in sales. Most of Soko's artisans would prefer to work consistently at 50% capacity rather than vary their production rates throughout the year, and those who are unable or unwilling to meet this demand can adjust their availability and capacity through Soko's app.

On the other hand, if Soko succeeded in maxing out its current brass, horn, and bone artisans, would there be a large enough pool of skilled artisans around Nairobi for Soko to hire? To avert the potential for stalling growth due to a lack of suppliers, Soko's team decided to expand into new artisanal markets with its current platform, bringing leather-working artisans from Ethiopia into the network. To both maximize its underutilized production capacity and capture more revenue for artisans, Soko shifted into several new customer segments and new verticals at the same time in late 2017:

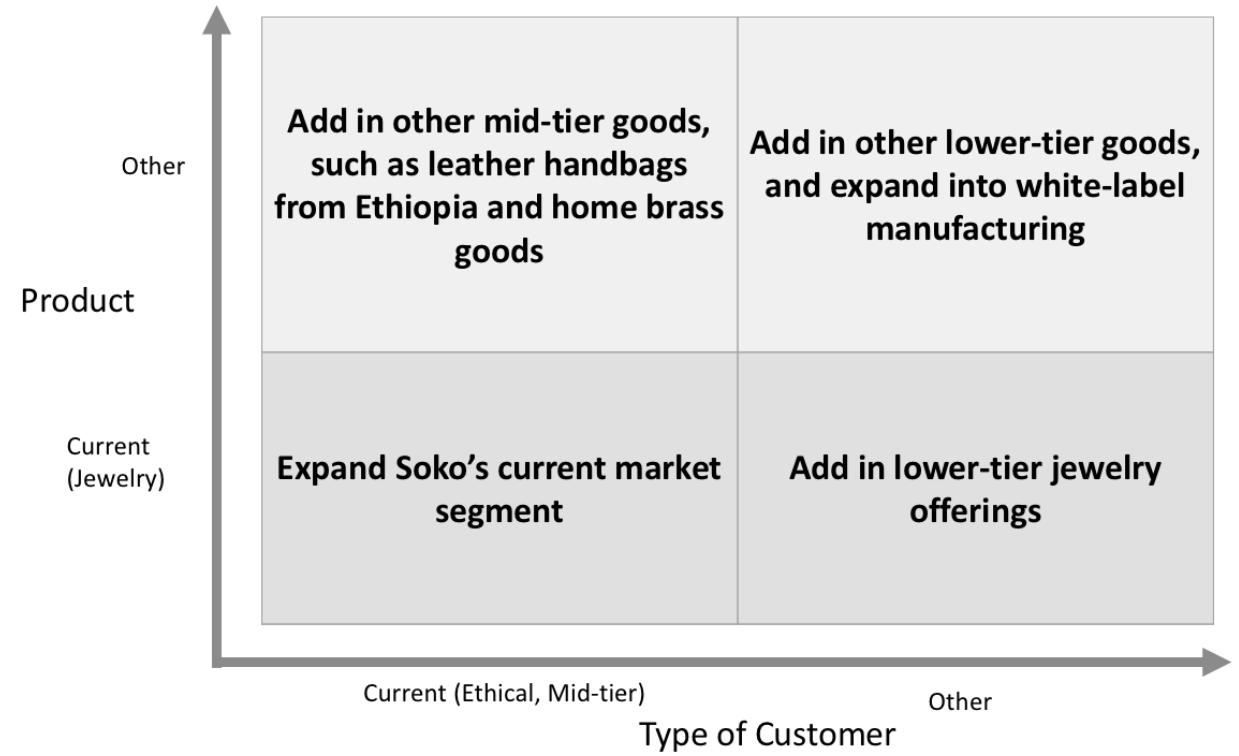

Figure 21: Soko's customer and product diversification strategy

Keeping in mind their key mission of breadth and "disruptive scale," Peinovich's team focused on introducing new artisans with new skillsets and product diversity– yet they also took care to maintain their current depth of engagement with their core artisan group. Soko began leveraging the Asian market to increase demand outside of the American and European holiday season; Chinese New Year became a particular season of interest. Peinovich acknowledged that Soko was willing to sell at lower margins outside of the Christmas season, because then artisans would be more primed for high production volumes throughout the year.

The company diversified beyond women's jewelry into a variety of what Peinovich categorized as "high margin, small package goods" that could be made within Soko's artisanal factories. Breaking into the apparel industry with purses and scarves, Soko also built up a small pilot project with leather and cotton textile artisans in Ethiopia.

Finally, Soko built up a white label manufacturing arm and added an option on its website for jewelry designers to get in touch about customized manufacturing– so Soko's artisans would not have to be limited to producing goods under the Soko fashion brand. This fit in well with the co-founders' mission of Soko as an on-demand platform for the global marketplace to utilize the craftsmanship of thousands of skilled artisans across Kenya, Ethiopia, and perhaps even more locations as Soko prepared to scale up in 2018.

As Soko scales up, its key scalability question is related to the firm's mission of providing the tools for artisans to bring themselves out of poverty. If Soko succeeds in this mission with its core artisans, will the firm then be obliged to start finding new artisans? What should Soko's balance be between bringing on new, impoverished artisans and supporting its current supplier

base– especially given recent difficulties in growing overall customer demand for brass products?

Results from Soko's impact analysis in 2017 indicated that the number of new artisans Soko brought onboard in 2016, along with their overall share of Soko's revenue, had decreased from 2014 to 2016 as increasing overhead costs of sales (CoS), marketing, and other key business expenses cut into the artisans' overall percentage of revenue:

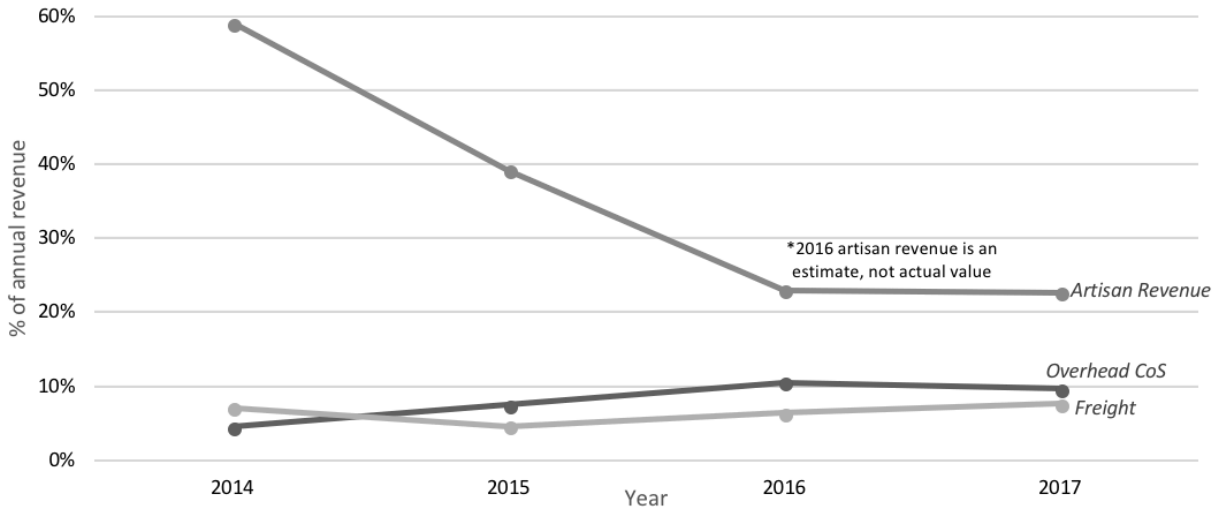

Figure 22: Soko's cost of goods as a % of revenue (from Pawa and company data)

Can Soko keep providing its artisans with a decent share of revenue, or will it have to shift its business model in order to actually become profitable? From Peinovich's point of view, a shift away from supporting artisans would decrease Soko's overall effectiveness as an ethical producer– but this might be the only way for Soko to compete with modern technologies and assembly-line factories.

Level of Service

Throughput agility

Despite the rise in fast fashion, most jewelry manufacturers use Manufacturing Resource Planning (MRP) production systems rather than "Lean Manufacturing" or Just-In-Time (JIT); this means that they plan their manufacturing in advance based on historical trends instead of adopting a more flexible production schedule with lower inventory requirements. Both Soko and Au Enterprises are exceptions, employing JIT instead. (Soko's proprietary enterprise resource planning software would be considered a JIT system.) Most companies use their own MRP software system, since there is no accepted standard in the jewelry industry; these systems vary widely, and can be found in many different languages depending on the region. The lack of an established, modern MRP system in the jewelry industry has made it easy for a technologically literate company like Soko to out-compete established firms by both using algorithms to determine production volumes for various types of items, and setting up a viable JIT system to integrate with the mobile phones of its artisanal suppliers.

Since fashion product lines shift every season, greater product differentiation and demand volatility have led economies of timing to take precedence over economies of scale (Aoki quoted in Lazerson, 1995). This enables Soko to practice JIT production; if a certain product line is selling well, Soko can reach out to hundreds of artisans instantaneously through its mobile platform, and tell them all to scale up production. Soko can also notify these artisans directly about minor improvements to designs and production methods.

JIT apparel manufacturer Zara is among the world's most valuable brands, and a pioneer in the fast fashion industry. According to a case study by SCM Globe (2016), while most brands bet on yearly fashion trends and manufacture 80-90% of their products in advance, Zara only manufactures 50-60% in advance. To facilitate its rapid on-demand production model, Zara voluntarily keeps up to 85% of its factories idle at any given time so it can quickly scale up manufacturing as needed. Zara manufactures 50% of its wares in Spain within 11 factories, all within a 16 km radius of its headquarters. The company even has 200 km of high-speed monorails to quickly transport cut fabric to factories for dying and sewing. Zara can thus distinguish itself through highly contemporary fashion design and trustworthy brand names rather than extensive marketing budgets; in fact, the company is routinely criticized for stealing ideas from high-fashion designers directly off the runway.

A seasonal production run in jewelry involves a coherent suite of products: rings, bracelets, necklaces, leather and chain products, etc. Traditional jewelry producers do not considerably change their wares much from one season to the next; a major fashion shift might be moving from green to purple gemstones, while the rest of the product would remain the same. Since MRP-based companies typically have trouble forecasting demand for new fashions, a manufacturer might over-order green gemstones and then be caught off-guard when customers all demand purple instead. This could lead to considerable inventory costs, and manufacturers may suffer losses if they need to sell off their green wares at discounted prices.

Like Au Enterprises, Soko's distributed and modular contracted suppliers are far more flexible in scaling production up or down and dramatically changing products from one season to the next than factories following antiquated Mass Production models. Since Soko's suppliers are paid by the piece, each SME is free to set its own working hours. Typically, an individual SMEs will produce a batch of 10s-100s of items with a staff of 3-5 people, over a period of about two weeks. Soko's larger SMEs employ up to 10 full and/or part-time workers.

Peinovich explains that within Soko's community there are "reverse economies of scale"; Soko's artisans declined in productivity when they were aggregated into larger factories during Soko's brief experiment into Mass Production. As Davis (1967) found, Soko's smaller factories allowed artisans to see the direct benefit of their work– leading to artisans taking better care of equipment, becoming more efficient, and producing higher quality goods. Depending on the cost of labor and resources, Soko occasionally needs to renegotiate its prices with artisans after its initial order– which can all be facilitated through its constant virtual communication with suppliers.

Soko's ERP system and wealth of data help it to keep track of the maximum production capacity of each one of its SMEs. Soko's team knows exactly when and where extra skills and

capacity will be available, allowing it to distribute production accordingly during seasons of high demand. This is particularly useful in a sector with such lumpy sales during the holiday season:

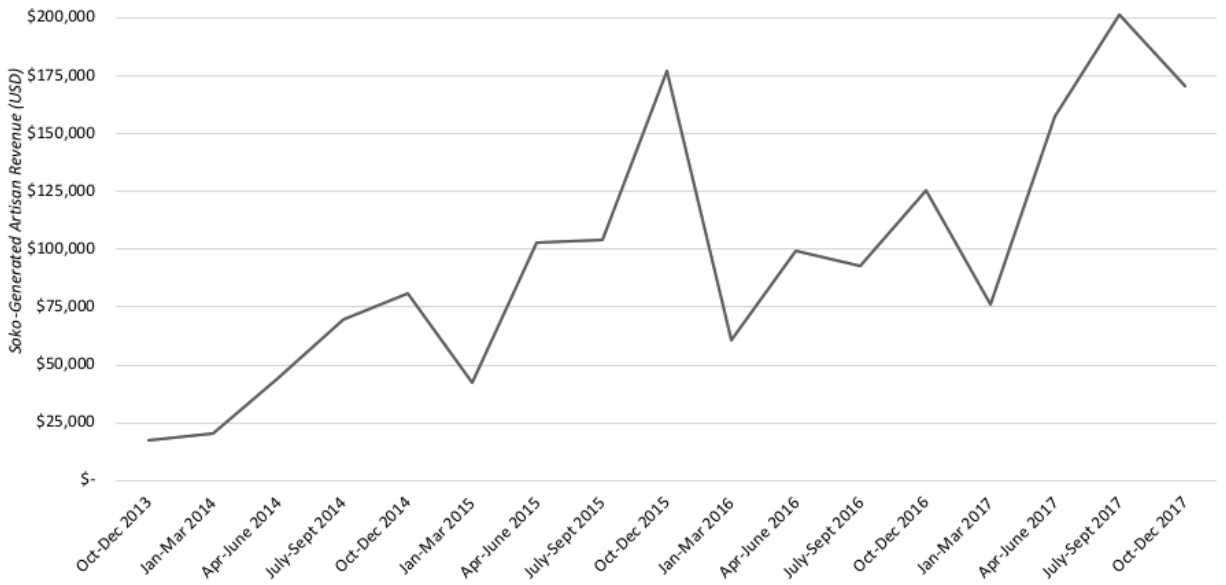

Figure 23: Soko-Generated Artisan Revenue per Quarter (company data)

For example, over the spring of 2016, Soko's suppliers doubled their Soko production for 2-3 months, then kept up a constant rate during the summer. Soko sold nearly ¾ of its entire annual sales during the last quarter of the year for the holidays, during which time it increased production up to 300% of capacity for a few months by pre-producing some products, extending out timelines, and encouraging certain suppliers to ramp up production by investing in additional equipment and bringing in casual labor for low-skilled tasks. This variable demand has forced many of Soko's artisans to train new casual workers and prioritize timely production, which may negatively impacts the overall job quality of part-time workers since they cannot plan in advance or rely upon a steady income. This job variability is discussed below in the section *Ethics: Worker Wellbeing*.

Level of Service: Product Line Agility

A key benefit of handmade jewelry production– whether traditional or modern– is that manufacturers can roll out a new product line in as little as a few weeks. Retooling a complex machine, on the other hand, might take 3-6 months depending on the degree of change required. Even without retooling, large-scale factories usually require 3-6 weeks to produce just the samples, plus an additional 4-6 weeks for production after the samples get approved. Soko can turn a brand new jewelry design on paper to an item in the store within 5-6 weeks, or make minor design changes in a matter of days. Soko's production cycle is only 4 weeks:

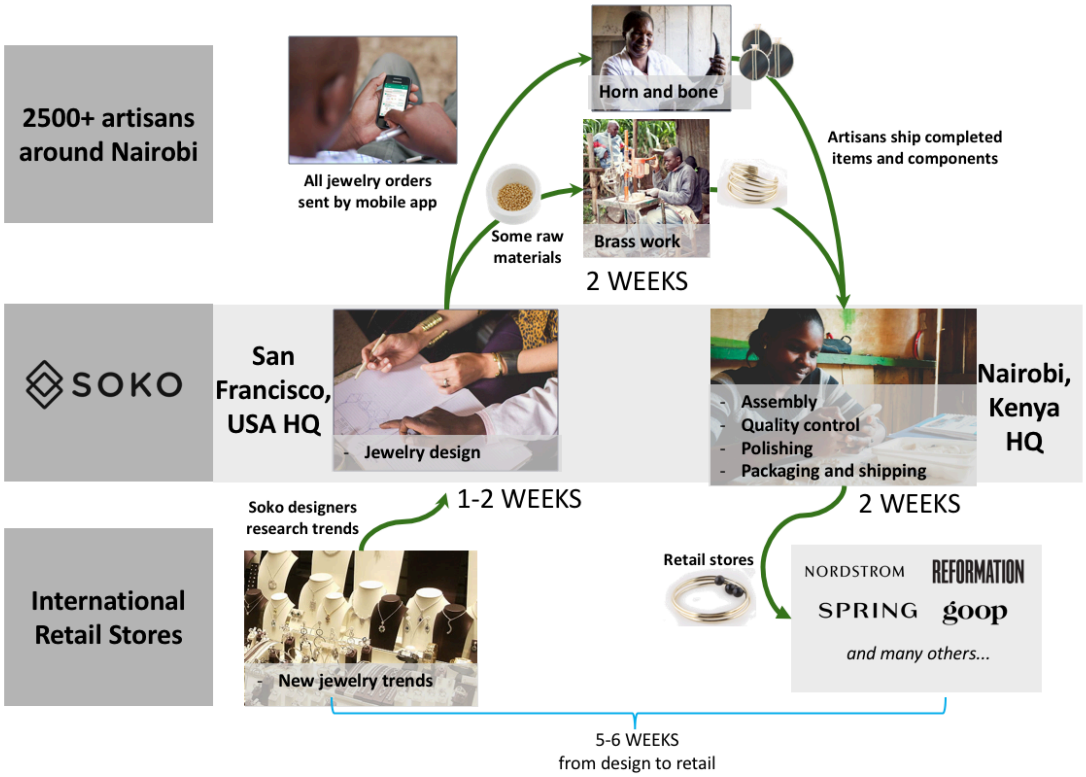

Figure 24: Soko's production timeline (images from ShopSoko.com and Peinovich 2017)

Handmade jewelry is typically economical at around 20 units, and the cost of a new design might be $1000-2000, plus 20-30% to hire a decent designer (unless the firm is borrowing ideas from an existing design). At a very large scale, vendors can afford to eat the bulk of this cost and only charge producers $100-500. Soko's designers work full-time so design is an internal cost, and Soko's single-batch minimum (in order to break even) is 30 units. Soko requires around a $250 investment to develop and introduce an entirely new design; Soko first must validate product demand for this new design, and then build up infrastructure and train artisans in the case of new production techniques. When doing white-label production, Soko charges its producer the full investment cost and requires a minimum of 50 units.

Since Au Enterprises uses 3D printers to make its initial molds, and all operations are centralized, the company can deliver a batch of jewelry in 5-10 days after the design is approved. Au produces about 100 one-off pieces in a given week. Au can produce up to 800 identical pieces in one week with only 3 full-workers.

Mass Production jewelry manufacturers used to require minimum orders of 10,000-100,000 units in order to begin production. After the price of gold dropped and department stores were stuck with expensive unsold inventory, many manufacturers scaled back their minimum sizes to as low as 2000 units. For machine-made products, the first 20-30 units might be discarded as part of the burn-in cycle– so a minimum batch size might have to be ~1000 in order to make a profit.

Competitive Advantages

Retail is a highly-competitive sector where fashion brands compete on price, quality, and overall design.

Competitive Advantage: Vertical Integration

Much of Soko's competitive advantage comes not from the company's manufacturing decisions, but rather from its decision to become a vertically-integrated fashion brand, from design through manufacturing through some direct sales to consumers. This level of vertical integration was not part of the initial mission of the company, but rather a decision that emerged from the co-founders' mission of maximizing profits for local artisans.

Au typically works with a jewelry designer from the retailer who is formally trained, though this designer does not always have the requisite engineering background to turn a design on paper into a digital model suitable for 3D printing. Au's CAD experts must interpret that design into a product that can be manufactured at the retailer's targeted price-point. Mass-manufacturing companies such as Fossil generally work in collaboration with staff at their outsourced factories to design products for manufacturing. Since Soko employs skilled artisans for traditional handmade production, Soko's design-for-manufacturing stage is faster and easier than that of a more modern factory– leading to Soko's ability to do rapid design iterations without the need for CAD or design-for-manufacturing experts. For a $100 brass pendant necklace sold at a department store like Nordstrom (see images of Soko's necklaces above), here is how Soko's brand and off-brand production compares to Au and Fossil, with shaded boxes representing vertical integration:

Table 8: Comparative vertical integration (Fossil data from eMarketer 2018)

Production Stage (% of margin captured)	**Au Enterprises** (Flexible SME)	**Soko branded products** (Networked SME and jewelry brand)	**Soko white-label products** (Networked SME only)	**Fossil** (Brand only)
Initial Design (~10% of margin)	Customer	Soko's in-house designers	Customer	Fossil's designers
Design for Manufacturing	Au's in-house CAD experts	Soko's in-house expert artisans	Soko's in-house expert artisans	Fossil working with Chinese factory
Manufacturing (~20% of margin)	Au's in-house factory workers	Contracted out to Soko's 2500+ artisanal suppliers	Contracted out to Soko's 2500+ artisanal suppliers	Outsourced to Chinese factory
Finishing	Au's in-house factory workers	Soko's in-house factory workers	Soko's in-house factory workers	Mostly outsourced to Chinese factory
Packaging and Shipping	Au ships to customer	Soko's in-house factory workers	Soko ships to customer; customer packages and ships to retail/wholesale	Fossil's production warehouse

Wholesaler/ Distributor (~30% of margin)	Some customers sell to wholesalers	82% of Soko's sales	Some customers sell to wholesalers	75% of Fossil's sales
Retail (~40% of margin)	Some customers sell to retail	18% of Soko's sales (2% retail; 16% ecommerce)	Some customers sell to retail	25% of Fossil's sales (21% retail; 4% ecommerce)

By bringing design, manufacturing, wholesale/distribution, and even some retail sales in-house, Soko can theoretically capture more of the overall sales margin than a manufacturer like Au Enterprises or an outsourcing brand like Fossil. Indeed, Soko's overall sales margins (not including marketing) were 65% in 2017. However, this increase in vertical integration also requires considerably more diverse expertise; Soko must hire its own designers and brand experts, do its own research and development to support its under-educated supplier network, and maintain a significant marketing team. Soko gets the best margins on e-commerce and bulk retail sale through partners (like the United Nation Trust Fund to End Violence Against Women), since Soko can then sell directly at retail prices without having to pay any retail overhead costs.

In 2017, Au Enterprises had overall profit margins of 20% and Fossil had profit margins of 50%, while Soko's business overall suffered a loss of $2M (with revenue of $2.5M). Here is a breakdown of Soko's operating expenditures in 2017:

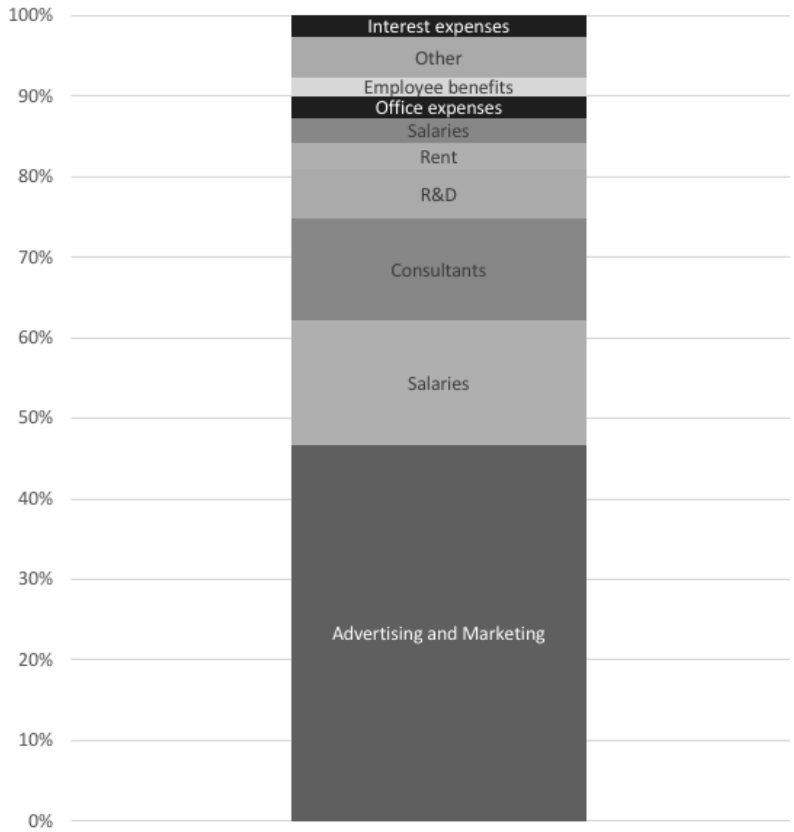

Figure 25: Soko's 2017 operating expenditures (from Pawa and company data)

How long will it take for Soko to become profitable, and was complete vertical integration the right decision for profitability? If Soko successfully doubles its revenues again in 2018 without a corresponding increase in overhead, the firm is likely to finally break even.

Competitive Advantage: Ethical Branding

Peinovich insists that Soko can sell products at a higher cost when the brand could tell stories about how Soko's artisans are earning their way out of poverty. Soko had no control over this ethical branding when producing white-label manufacturing, and minimal control over branding within department stores and other wholesale customers. In 2017, most Soko-branded products, including those purchased from department stores or via other channels like QVC, came with a small label reading "handmade in Kenya." On the back, the same label reads "100% good 100% beautiful"— which implies but does not necessarily indicate ethical production. When purchasing Soko jewelry online through third-party shops, some websites I visited in mid-2018 highlighted Soko's production model through blogposts (Reformation), others used phrases such as "supports independent artisan entrepreneurs in the developing world" in small print (Nordstrom), and still others (Urban Outfitters and QVC) said nothing about the manufacturing strategy or even the fact that Soko's products were made in Kenya. Soko has the most control around storytelling for the company's direct-to-consumer sales, where the company can highlight individual artisan's stories as well as details about the firm's mission of sharing revenue with artisans.

In 2017, Soko focused on expanding its own online store and partnerships with other ethical fashion brands, and developing additional messaging around ethical production that could be featured on all Soko-manufactured products (including those designed by other brands through white-label production). The challenge is, establishing a retail brand requires considerable and continuous marketing expenditures, while wholesale can bring ongoing sales with minimal effort as long as retail partners remain satisfied with Soko's production. It is too early to tell whether this shift towards more "ethical" branding has increased Soko's sales, but Peinovich was optimistic about the results in early 2018.

Both Soko and Au have also taken advantage of an increasing trend among retail stores to source more ethically, whether or not this information is conveyed to final customers. "Retail is really jumping at this opportunity to work with ethical fast fashion," Peinovich said. "They see it as a great alternative. We are able to meet their style and price requirements without compromising on our values." Especially in the wake of fashion factory disasters like the 2013 Rana Plaza collapse in Bangladesh, retailers are keen to purchase from manufacturers that can guarantee ethical production.

Competitive Advantage: Production Location

Due to the efficiency and sheer volume of shipments from China to the United States and Europe, Chinese manufacturers benefit from negligible shipping costs– while a full 10% of Soko's revenue went to shipping its wares from Kenya. Southeast Asian manufacturers also have moderately higher shipping costs, but these do not compare to Soko's exorbitant fees– and customs fees and tariffs are likewise cheaper due to a legacy of exports. Soko's 10% fees

only includes Soko's internalized costs, and Soko's SMEs must pay for additional logistics to send their finished goods to Soko's headquarters– or, more often, to send junior artisans to deliver goods in person. Some clusters of Soko microfactories can collaborate and send in their wares together, but there are likely dozens of artisans who end up transporting finished goods to Soko *in person* every few weeks. The travel-time required to bring these goods to headquarters is likewise excluded from Soko's calculations.

Still, Soko has benefitted from the USA's African Growth and Opportunity Act. This Act reduces the taxes of selected imported products from certain African countries by 25%, and eliminates some taxes altogether. These tax cuts have helped Soko considerably in offsetting shipping costs and reaching the American market.

Peinovich acknowledges the overall difficulty of working in Kenya and starting production in Ethiopia rather than working with artisans in better-established export markets:

> *Choosing to work in Africa doesn't feel like a cost to me, because that's the choice that we made… and it's a huge differentiator in a lot of ways as well. Still, we've chosen a very difficult market. If I was purely profit-driven, I would've gone and produced in China. I would start a brand that's purely focused on consumers, and I wouldn't frankly have really chosen this context.*

Local policy incentives for manufacturing and small business development can also play a significant role in supporting– or discouraging– artisanal production. The more businesses begin to see value in informal-sector firms, the more local policy-makers may pay attention to the possibilities. The government of Kenya has several legal structures in place to support small businesses, but their current "small and medium enterprise" category requires a minimum of 15 full-time employees– so Soko did not initially qualify. Peinovich admits that growth-oriented Kenyan SMEs prefer "to remain under the radar" for as long as possible, and it is practically impossible for a Kenyan startup to get its paperwork correct the first time around. Indeed, Peinovich had to hire a tax attorney to deal with the bureaucracy of Kenya's accounting scheme for locally-manufactured products—and then she needed to navigate import/export regulatory systems both in Kenya and in Soko's countries of import.

Competitive Advantage: Handicraft as a Design Choice

According to the USA Federal Trade Commission, the *handmade* or *handcrafted* label means that "the entire shaping and forming of such product from raw materials and its finishing and decoration were accomplished by hand labor and manually-controlled methods which permit the maker to control and vary the construction, shape, design, and finish of each part of each individual product" (US Government Publishing Office 2015). This is the primary legal definition of handmade within the USA. Nonetheless, both Drogs and Peinovich say that this definition is vague enough to allow many types of jewelry that are made with 3D printing or other digital fabrication techniques to still qualify as "handmade."

A decent segment of jewelry customers place additional value on "handmade" items. Fuchs et al. (2015) found a statistically significant preference towards purchasing handmade objects as gifts in their survey of 487 Austrian consumers (using a three-way ANOVA, M_{hand} = 4.11 and $M_{machine}$ = 3.81 on an increasing scale from 1 to 7). The same researchers conducted a study of 302 consumers in the USA purchasing soap as a Mother's Day present, and found a

significantly higher willingness to pay for soaps described as “handmade” versus “machine-made” (M_{hand} = \$6.56, $M_{machine}$ = \$5.63, $p < .05$). Based on survey results of consumers and related literature, Fuchs et al. attribute the increase in the desirability of handmade products to the perceived existence of *love*, defined as “the love that originates with a producer and that has the product and its production process as its object rather than another person”– especially in contrast to Marx’s concept of human alienation from the machines of production. Fuchs et al. found the handmade effect to be particularly strong when people are buying gifts for their loved ones; judging by Soko’s dramatic increase in sales around Christmastime, many of Soko’s customers are indeed purchasing their wares as gifts for others.

Peinovich knows that a combination of hybrid 3D printing and handicraft (in the style of Au) would be more cost-effective than Soko’s purely handcrafted production process for high volumes of wares. For very high volumes, mass-production using dies would out-compete hybrid 3D-printing of metal jewelry.

Thus, the market niche for handcrafted jewelry relies upon marketing the *handmade* quality, providing companies like Soko with a competitive advantage. The amount of manual labor required for an individual item of jewelry may be obvious to a layperson due to irregularities or other unique, individual qualities. Or, its “handmade” qualities may be stated explicitly in information presented about the product. As Peinovich says, “we at Soko believe that humans are our best asset!”

The label on all Soko-branded products uses the term “handmade”; this is also common among other Fair Trade jewelry products. Soko’s in-house designers strategically develop designs that are difficult to produce through 3D printing. This leads to what Peinovich describes as a “chunky, bold aesthetic,” such as this *Double Dash Choker Necklace* which is a perennial Soko bestseller:

Figure 26: Soko's choker necklace (ShopSoko.com 2018)

The lack of fine detail on this choker and the sheer volume of brass required make it particularly difficult to 3D-print out of brass, and it would also be time-consuming to 3D print hundreds of these as wax molds for hand-casting. Instead, it is easier and cheaper for skilled Soko artisans to hand-carve several wax positives out of wax, and then pour molten brass into

the molds. Artisans do some sanding and polishing, but most of the finishing touches like electroplating and final polishing are performed at Soko headquarters in downtown Nairobi.

Soko's designers also strive to highlight the uniqueness of artisanal handiwork, as opposed to the sameness of machine-produced items. Peinovich says that a "certain level of irregularity is welcomed." For example, the description of Soko's *Daya Statement Drop Earring* on the Soko website advertises the item's "distinctive hand-cast statement silhouette":

Figure 27: Soko's earrings (ShopSoko.com 2018)

The fact that every earring looks slightly different is thus highlighted as a feature, and becomes part of Soko's "hand-cast" charm.

Costs

Difficulty in Calculating Expenses

It is difficult to determine Soko's exact capital and operating costs because the firm does not own its means of production– so Soko is able to outsource many of its production costs around equipment maintenance, inventory, land and factory construction, energy and other utilities, and waste. As discussed later, estimating artisans' overall take-home profits is obstructed by the lack of record-keeping among informal artisans, and by the fact that most artisans only work part-time for Soko. A well-run, large-scale factory may have less overall inventory than Soko, even though Soko's inventory is distributed across hundreds of microfactories at any given time. Peinovich points out that Soko's artisans tend to take much better care of their own machines than equipment that does not belong to them, which may provide savings on capital and maintenance costs across the entire supply chain.

Soko's coordination of asset-financing for its artisans to purchase new equipment also complicates this calculation. Soko takes on minimal liability since most of these loans are provided by outside institutions; the artisans' debt, however, is part of the overall Soko production ecosystem and could conceivably play a role in calculating overall capital expenses.

Costs: Operating Expenses

Unlike most jewelry manufacturers, Soko's virtual factory model involves rapid turn-around with very minimal inventory and capital costs; suppliers stock their completed jewelry at their own microfactories, until they are ready to deliver an order in bulk to Soko

headquarters in Nairobi within one to two weeks of an order. Since most suppliers are based in or around Nairobi, transportation has not been an issue and many artisans carry their wares to Soko headquarters in person. In contrast, traditional mass-manufacturers tend to keep significant inventory, and are thus more concerned about selling off their current wares (before they become obsolete) rather than designing and setting new fashion trends.

Soko's quality control costs and onboarding costs, however, are very high relative to more centralized jewelry manufacturers– or compared to other firms that hire homeworkers without taking on the responsibility of improving their suppliers' microfactories.

Soko benefits from the low daily wages in Kenya, since the company can employ and train highly-skilled workers for a lower cost than similarly-skilled workers in China or Thailand. Nairobi's minimum hourly wage for skilled machinists starts around $7/day, while Thailand (popular among handmade jewelry manufacturers for skilled metal-workers) just raised its nationwide minimum wage to $9.70/day. The unskilled minimum hourly wage in Nairobi is around $5/day; the average rate that senior Soko artisans paid their employees was $5/day for new microfactories, and $7/day for microfactories that had been with Soko for more than 6 months.

These low wages also contribute to Soko's production agility; paying for a CAD designer to develop a 3D model and then print out a prototype might take 2-3 hours at $35/hour, whereas a skilled Soko artisan can hand-mold or hand-cut a new item of jewelry based on a sketch in the same amount of time for a few dollars. It may take more time overall to hand-make a large batch of brass jewelry vs 3D-printing, so Nairobi's relatively low wages and cost of living are key reasons why Soko can profit off of handmade production can be profitable for Soko.

Zara makes a similar tradeoff to Soko, electing to pay higher costs in order to keep its factories more responsive. While Soko's higher manufacturing costs are in quality control and logistics rather than labor, Zara pays higher than global market rates for labor in order to run half of its factories in Spain. In 2016, Zara paid an average of $9.60 per hour to its low-skilled Spanish workers, as compared to the industry average of $0.50 per hour for low-skilled Asian workers. Roughly a quarter of Zara's products are manufactured by outsourced factories with cheaper labor in Asia, North Africa, and Latin America (where one of Zara's outsourced plants in Brazil was, according to Forbes (2011), accused of "slave-like" conditions). The last quarter of Zara's goods are manufactured in Europe. Zara make up for its increased production costs by selling most of its wares at the highest possible price point; while the clothing industry sells an average of only 60% of its wares at full price, Zara sells a record 85% (SCM Globe 2016).

Costs: Capital Expenses

Since Soko does not own its own factories, the co-founders essentially traded very low capital expenditures for higher operating expenses– which is the essential tradeoff between Mass Production and SME Production. Peinovich and her team would never have gotten the initial resources to build their own factory while Soko was starting up. Instead, Soko had to rely upon its network of pre-existing microfactories. Soko's primary capital expenses were the

development of its ERP software and mobile platform, and building a centralized office/warehouse with an electroplating and polishing facility after a few years.

Assembly-line production tends to be overall more efficient than the job-shop systems employed by artisanal microfactories, even for purely handmade jewelry. In a Taylorist system, workers can improve and perfect individual tasks to better streamline the manufacturing process. Some of Soko's larger microfactories likely employ more organized production systems, but most microfactories lack enough staff to properly divide up the steps of production. Given how much production is done by hand, artisans' energy costs will overall be lower than more automated factories.

Quality

The costs of training, distributed quality control, and coordinating asset-financing are all built into Soko's financial model, and Soko's agile production methods make up for the added burden. Nonetheless, since all new artisans must be trained personally by Soko staff, the quality standards required to compete with international jewelry manufacturers have been a significant impediment to introducing new artisans into Soko's supply chain.

In 2017, Soko's quality control officers rated every individual item of jewelry as AA, A, or B-grade. Since one of Soko's quality factors was consistency, a number of overall high-quality items ended up with a B-grade if they did not have an exact resemblance to other items of the same batch. These items might include pieces of horn with a naturally different color, or jewelry featuring a hammered finish that happened to have a slightly different stipple from everything else but otherwise met all quality criteria. The high-quality, B-grade products that looked like their sales photos could be sold online; ecommerce customers only saw one product at a time, unlike customers looking at a sales rack in a department store who might expect everything to look identical.

When Soko first started hiring artisans, most artisans used poor-quality drill bits and lacked the skills and tools for precision craftsmanship, and Soko was their first client to demand consistent quality. Soko had to reject almost half of its suppliers' jewelry in its early production runs, angering artisans by demanding that they refurbish completed wares. Soko's team quickly realized that if it wanted to become a globally respected jewelry company, it would have to both upgrade their suppliers' equipment *and* invent a robust method for distributed quality control across hundreds of microfactories.

Soko's dedicated efforts brought its rejection rate for sub-par products down from 40% in its first year to 30% in its second year and 10% in its third year. Initially, only a select few of Soko's microfactories (compared to more than a dozen in 2017) knew how to solder, and all of them used large and imprecise torches. Most of Soko's artisans originally learned brass-work through apprenticeships to master-craftsmen, and thus used decades-old tools and methods. Thus, Soko started offering asset-financing for precision tools to increase product quality and precision– including small soldering torches and electric drills and bits. Artisans were accustomed to using old rulers with faded markings, so Soko also had to provide better measuring equipment such as new rulers and calipers before they could fairly demand higher

quality. In addition to new tools, Soko needed to individually train all its lead artisans (in micro-factories staffed by more than one artisan, lead artisans can train their subordinates).

At first, Soko's artisans were annoyed by such strict standards. They were used to Fair Trade companies who charitably preferred to employ more artisans rather than ensure high-quality wares, and were surprised when Soko rejected their low-quality products. Soko, on the other hand, prioritized long-term growth, and eventually convinced almost all its suppliers to adapt to its high standards. Other artisans would self-select out of orders from Soko rather than adhere to improved quality accordingly. Now that Soko's artisans have figured out how to manage quality control, they have started to complain about Soko's short time frames for delivery. Peinovich believes that Soko's artisans will adjust and grow capacity to meet this new challenge just as they adjusted to the quality requirements.

By 2015, Soko's artisans could reach a millimeter-level precision that was unprecedented for the informal craft sector. Soko hires field workers to teach its artisans additional skills: these include improved metalworking techniques, as well as training metal-workers how to work with horn and bone to expand their repertoire. The company has nine full-time staff members who travel around their microfactories on a regional basis to perform routine quality control checks and train artisans. Building upon the success of these regional staff, Soko has also begun training some of its more qualified artisans to become part-time quality assurance officers and help onboard new artisans.

In 2017, despite a rapid onboarding of new artisans, Soko's internal rejection rate was only 11%; this is the percentage of all wares sent back to artisans for re-work after quality inspection at Soko's Nairobi headquarters. This is slightly higher than rejection rates of mass-manufactured jewelry, and much higher than Au's internal rejection rate of 3% and external rejection rate of 4-6% after shipping to clients. Still, Soko's rate is probably comparable to the rejection rates of other traditional handmade items.

Ethics

Many unethical practices in the jewelry industry violate legal and/or social licenses in both the countries of origin and the countries of end consumers: notably slave labor and indentured servitude, child labor, payment under minimum wage for full-time jobs, the purchasing of "conflict minerals," and gross environmental negligence. Nonetheless, laws in certain regions are often difficult to enforce, and there is a large legal grey area for dubiously-ethical practices. Due to a widespread practice of contracting and subcontracting among retail manufacturers, it may be difficult for brands to determine responsibility– especially among subcontracted homeworkers. Thus, the question of ethics in the jewelry industry often becomes a question of transparency, brand protection, and corporate values.

In Soko's internal 2017 impact report, the authors state that Soko is "anchored on ethical and sustainable production - a core element of which is impact. Impact is the reportable, quantifiable difference, or potential difference, that a project or program is making in real people's lives." In light of this, the company is making a dedicated effort to use its existing artisan mobile app to gather data more regularly. Soko aims to make the following differences in the lives of its artisans:

- **Economic impact**: revenue earned by artisans through Soko, ability to get out of poverty, and ability to upgrade microfactory equipment and/or build new microfactories
- **Gender equity**: percentage of female artisans in Soko's network, growth of women-led microfactories, and performance of female vs male artisans
- **Skill development and training**: number of artisans that have taken Soko's workshops, number of artisans using new materials, and lead artisans training their junior artisans
- **Social wellbeing**: impact upon families and broader community (closely tied to economic impact)

Soko's 2017 report outlines a "continuum of impact," which begins with gathering knowledge around how Soko's network currently operates, and concludes with the imperative to "build systems to ensure equitable and sustainable impact."

Consumer Wellbeing

Prior to Soko, many of Nairobi's brass artisans were unaware that their raw materials contained lead. Brass was a popular material around Kenya for many purposes, so many artisans liked to save money by collecting brass scraps from the landfills of old homes. This posed a problem when Soko's team realized that some older types of brass contain lead, and all Soko's jewelry must comply with the strictest global lead standards because Soko had little control over the final location of product sales. Soko thus had to insure that its artisans used entirely unleaded raw material. For larger orders, Soko headquarters started sourcing its own recycled brass which was tested for lead, melted down, and sold to artisans in the form of bricks. This made it easy for Soko to test out lead levels before large batches of jewelry were manufactured. Thanks to careful quality assurance and frequent testing, all of Soko's jewelry– whether produced from locally-sourced brass or Soko's bricks– was devoid of any detectable lead.

Worker Wellbeing – Living Wage

Wages in the jewelry industry depend considerably upon location, country, and skill level of work. In 2017, Au's medium-skilled workers earned about $25/hour in Detroit, Michigan. New Yorker jewelry-makers earned closer to $35/hour. Unskilled Chinese jewelry workers earned about $1.50-3 per day in 2017, on top of room and board in a dormitory provided by the company; these were reasonable living wages, which allowed mostly-rural workers to save some money for their family. In Mexico, jewelry factory workers earned around $3/hour without room and board (estimates from Croston, 2018).

Soko pays competitive wages to its full-time staff in both Nairobi and San Francisco. The company is also devoted to paying its contracted artisans a living wage; in 2017, Soko's lead artisans paid their full-time employees, on average, the Nairobi minimum wage of US$5/day– but this was skewed toward new microfactories with lower earnings. After partnering with Soko for six months on average, lead artisans made an average of $7/day.

Worker Wellbeing – Opportunities for advancement

Within months of joining Soko, artisans' incomes increased by a factor of 4 on average in 2016 (Floyd 2016; Peinovich 2017). Soko's 2016 impact survey reported that working for Soko for three months halved an artisan's risk of poverty; since many of Soko's artisans started out below the Nairobi poverty line, this marks a considerable improvement upon their prior employment possibilities.

Soko artisan Veronicah Rachiedo said: "Soko saved my life. Before Soko, I barely had enough to eat. Now with Soko I have started my own business, even hired my first employees, and can provide for my family without fear" (Rachiedo quoted in Peinoivch 2017). Through Soko, Rachiedo received training and asset-financing to upgrade her shop's equipment, and the added revenue enabled her to move her family out of a corrugated shack and into a proper house. By 2017, Rachiedo was managing eight employees across two factories, and was one of few female artisans who had men working under her supervision. During the holiday season in 2013, Rachiedo's work with Soko increased her earnings by factor of 5 as compared to her previous artisanal job.

In 2014, Soko artisan Kennedy (no surname provided) reported in 2014 that his income had increased by a factor of 9 (from $250/month to $2480/month) after working for Soko for six months, enabling him to increase his full-time microfactory staff from 3 to 5 people (including 3 women) and qualifying him for a loan to upgrade his machinery. With the revenue from Soko, Kennedy was able to build up his family's house in his home village from a small mud and grass-thatched house to a 3-room brick house. He also managed to pay his siblings' school fees and send money home to his widowed mother.

Soko's 2017 survey detailed how artisans had spent their Soko-generated income: these funds were used for business and personal development, as well as reinvestment into the community. Artisans' total Soko-generated revenue in 2017 was $586k, with an estimated take-home profit margin of 50% (Mwangangi 2018). Across the entire network, artisans spent 75% of their revenue on income-generating investments:

Table 9: Soko artisans' investments in 2017 (2017 Impact Report)

Investment	**Number of Artisans Investing**	**Percentage of Soko-generated revenue**
Land (worth at least $3000)	43	34%
New Equipped Microfactory (worth at least $1045)	15	12%
Livestock (valued at $1000)	32	26%
Other investments	4	2%
Revenue not invested	--	25%

The 15 new microfactories were all built by junior artisans who had been employed in other shops; they had earned enough to finally rent or purchase their own microfactories, where they could become lead artisans and eventually hire their own staff.

The 2017 impact report writers admit that Soko's piece-workers in outsourced microfactories have been left out of this survey, and acknowledge that they would like to include these artisans in future surveys and future skills training workshops.

Worker Wellbeing – Opportunities for Advancement through Learning New Skills

Since Soko's artisans all own their own microfactories and tools, any efforts that increase the skills and capacities of local artisans can also help them to become more competitive for other contractor jobs. This could theoretically be a disadvantage for Soko; indeed, many manufacturing firms are reluctant to pay for training their staff for fear of staff finding better employment opportunities elsewhere. However, since Soko hires artisans at very competitive rates and has an excellent reputation as an employer, Soko's team does not have any particular cause to worry about their hard-trained artisans going elsewhere. Thus, Soko's training and asset-financing has a multiplier effect in helping artisans improve their own direct-to-retail production, and get better contract manufacturing gigs from other employers.

Soko coordinates asset-financing for artisans to purchase new microfactory equipment on loan such as grinding wheels and electrical upgrades, through collaborations with microfinance institutions such as Kiva and local banks. By helping artisans to collectivize, Soko enables microfactory owners to participate in Savings and Credit Cooperatives so they can be more competitive loan applicants. Most of the artisans who received this support would never have been able to access funds without Soko's support in networking groups of artisans and connecting talented microfactory owners with banking institutions.

In 2016, Soko launched a skills transfer program with the aim of "supporting artisans to expand their production skillsets to keep pace with the materials and quality demanded by the global jewelry market." Through this program, Soko's artisan management team supported artisans in the following ways:

- Engaging partners to offer business and financial literacy training
- Training in business development and introducing financial management/accounting tools
- Networking together groups of Soko artisans to share skills and best practices
- Training artisans in new quality control techniques
- Introducing artisans to new skills

In 2017, Soko partnered with some of its lead artisans to train 386 new artisans. Soko also surveyed 125 of its active artisans (8% of Soko's active artisanal network) to ask about skills trainings. 80% of these artisans reported having picked up new skills through the Soko network from other Soko artisans, through trainings held at Soko headquarters, or from the necessity of having to pick up additional skills on-the-job. Soko's 2017 impact report details the new skills picked up by artisans:

Table 10: New skills learned by Soko artisans

		Number of Artisans	Percentage of Surveyed Network
New Skills Introduced			
Artisans Trained by Soko in the Period		84	67%
Total Number of Soko Lead Artisans that have Trained Others		100	80%
Popular Skills	Quality Control	100	80%
	Soldering	45	36%
New Materials Introduced			
New Material in Use By		44	35%
Popular Materials	Brass Sheet & Wire	34	27%
	Horn	21	17%

Worker Wellbeing – Job security

Although non-salaried work– especially in the informal sector– is less secure and often looked down upon in Kenya, Soko's artisans actually prefer to work as independent contractors. When Soko ran a trial factory, the firm was unable to retain workers– and those who stayed did not perform as well as they had in their own microfactories. Most of Soko's artisans (especially women with children) would rather have their own flexible hours in their own microfactories, especially since Soko pays them the equivalent of a decent salary regardless. Peinovich found that when artisans worked on a salary basis, morale dropped because they could not see how their hard work contributed to their personal bottom line.

While Soko provides most of its artisans with a drastic improvement in job security, Soko does not actually provide consistent earnings for the majority of its artisans. In Soko's focus group of 25 random artisans in 2015, they "nearly unanimously expressed a desire for more work with Soko"; Peinovich reported that this enthusiasm for more Soko contracts continued throughout 2016 and 2017. In 2016, a handful of Soko's artisans realized that they could earn a better income in farming, and they left the Soko network altogether– though they might return during less profitable farming seasons.

On the other hand, many of Soko's artisans reported that the skills they learned from Soko (including quality improvements, more modern jewelry designs, new materials/techniques for production) have helped increase their retail and wholesale sales through other channels, including local Massai markets. Judging by the tone of the impact reports, Soko's team has no problem with artisans borrowing Soko's design elements for artisans' own jewelry sales; to date, no one seems to have wholly copied Soko designs for off-brand production.

As Peinovich admits, the lack of full-time work for artisans is one of Soko's greatest challenges in increasing its overall positive impact. Across the 2500 artisans registered in Soko's network in 2017, Soko's 2017 end-of-year impact report only lists 1520 active artisans for that year. This marks a decrease from the 1805 active artisans reported in June 2016, despite Soko's gross profits doubling from 2016-2017.

Only a third of all active artisans worked full-time for Soko in 2017; the rest were part-time, or came from outsourced microfactories and provided labor only during times of high demand. The numbers from 2013-2015 below are estimates, and the 2016-2017 numbers were taken from a direct survey of artisans:

Table 11: Types of artisans by year (from Soko's impact reports 2014-2017)

<table>
<tr><th></th><th>Definition</th><th>2013 Total</th><th>2014 Total</th><th>2015 Total</th><th>2016 Total</th><th>2017 Total</th></tr>
<tr><td>Lead Artisans</td><td>Microfactory owners; full-time</td><td>20</td><td>25</td><td>50</td><td>72</td><td>125</td></tr>
<tr><td>Full-time employees</td><td>Employed on-site, and paid on a daily or monthly basis</td><td>150</td><td>230</td><td>110</td><td>631</td><td>358</td></tr>
<tr><td>Part-time (surge) employees</td><td>Employed on a casual basis during high seasons</td><td rowspan="2">20</td><td rowspan="2">85</td><td rowspan="2">Not measured</td><td rowspan="2">1102</td><td>290</td></tr>
<tr><td>Outsourced (surge) artisans</td><td>Other microfactories that provide piece-work high seasons</td><td>747</td></tr>
<tr><td>Percentage of active artisans per quarter</td><td>Artisans contracting with Soko during the year</td><td>~80%</td><td>~75%</td><td>Not measured</td><td>Not measured</td><td>60-80% depending on season</td></tr>
<tr><td>Total Artisans in Soko Community</td><td>All artisans registered in Soko's network</td><td>240</td><td>465</td><td>1190</td><td>1800+</td><td>2500+</td></tr>
</table>

Worker Wellbeing – Personal Safety

Soko takes its safety standards very seriously, which likely presents a major change for informal artisans first joining the network. In early 2016, Soko rolled out a Code of Artisan Conduct to define Soko's minimum "ethical production standards," which are in-line with international standards for microfactory safety and labor rights. These safety guidelines include the following:

- Fire extinguishers
- Coveralls
- Close-toed shoes
- Face masks for respiratory protection
- Goggles for eye protection when soldering and drilling

In 2016, Soko targeted a rate of 75% compliance across its network in oxyfuel welding and fire safety training, and provided certifications for microfactories that met compliance standards.

Despite Soko's reported success, it is worth nothing that the mere existence of a requirement for employees to wear personal protective equipment (PPE) does not always translate to employees actually practicing this rule. Several factory studies have found that, even when respirators, goggles, and other items of PPE are readily available, safety gear is often so cumbersome and uncomfortable that workers tend not to wear them unless a factory manager or safety officer comes around to ensure compliance (Chew 1988; Akbar-Khanzadeh et al. 1995). The best strategy is to engineer safety into the factory workflow itself, which is far easier to do with a centralized SME or Mass Producer rather than a network of craft producers. Soko's distributed network thus poses a unique challenge around worker safety, due to the lack of economies of scale and the relative disorganization of an artisanal workshop as compared to a large factory with dozens of workers and clear protocols. Centralized factory managers oversee thousands of workers at a time and can play a much stronger role in ensuring safety compliance, while Soko's 100+ lead artisans oversee an average of 1-5 workers depending on the season– so Soko's compliance team must work hard to educate these lead artisans on why safety is so important.

Worker Wellbeing – Equal Opportunities and Inclusivity

Brass and horn work has traditionally been a male-dominated sector in Kenya. Peinovich and her co-founders initially tried commissioning beadwork– a female-dominated craft– but it didn't sell as well as brass and horn in the international jewelry market. Soko's team of full-time staff (not including contracted artisans) is 70% female, and they are particularly dedicated to increasing their fraction of female artisans.

From 2016-2017, Soko focused on increasing the number of female artisans through workshops and incentives for female artisans, and informal education for male artisans. Soko launched its Women Initiative in 2017 to introduce more women into the network by partnering with all-female artisan groups, which Soko's 2017 Impact Report cites as a key reason for the increase in Soko's women-led microfactories from 2% to 16% in less than a year. In 2017, female artisans made up 26% of Soko's total active network, and 34% of part-time employees.

Soko's dedication towards ensuring equal opportunities for its female artisans has anecdotally helped its male artisans to create more welcoming job environments for their female colleagues; one male artisan started training programs to help local women gain new skills. In late 2017, Soko started planning to run trainings to specifically provide women with opportunities to try out new skills and machinery.

Worker Wellbeing – "Higher purpose"

From Soko's inception, the company's mission has always been to "help artisans help themselves" through connections to international markets. This mission extends from Soko's full-time staff in its San Francisco and Nairobi headquarters out to Soko's artisans, who mentioned during interviews (Soko 2016 and 2017) that they were proud to provide full-time employment to others. Soko's artisans are also proud of the fact that their wares are being sold in reputable retail stores around the world.

Since Soko is explicitly helping bring people out of poverty, Soko's employees may feel a more acute sense of purpose than a jewelry company which merely provides decent local employment. It is worth noting, however, that *bringing* a particular segment of people out of poverty is an inherently short-term mission: what will happen to Soko's primary mission after most of its artisans are no longer in danger of falling back into poverty? Will Soko expand into new craft sectors to work with other impoverished artisans, or take on a different "higher purpose"? Or will the firm be content to simply provide decent, stable employment for its artisans and their employees?

Worker Wellbeing – Share of Value Creation

Qualitatively, Soko's 2016 impact report author reports "all-around warmth" from an unspecified number of artisans during that year's interviews, likely indicating that artisans feel included in Soko's overall value creation.

Compared to a small firm like Au Enterprises, Soko's artisans capture a slightly lower percentage of overall company revenue from jewelry sales: workers receive about 11% in profits or 22% in revenue from a $30 Soko necklace, compared to Au's employees receiving around 35% of $20 per necklace. Soko's artisans have roughly a 50% profit margin on their revenue, though some of these costs go towards microfactory improvements that will help reap more contracts and profits in the long-term. Soko's smaller artisanal microfactories are unlikely to pay most of their taxes, whereas Au's formal-sector employees must diligently report their income and pay taxes as well as healthcare costs. Neither Au nor Soko provide healthcare to their workers. The artisans of both companies capture far more than the roughly 2-3% of revenue from mass production or homeworker production that typically goes to workers, although mass production workers may like in factory-provided housing.

As Soko fine-tunes its business model, there is some danger that Soko's artisans' share of revenue may fall. If Networked SME Production becomes more popular, it will be interesting to see whether producers like Soko ever decide to offer company shares or other employee benefits to their SME manufacturers.

Worker Wellbeing – Self-determination and empowerment

The fact that Soko's artisans own their means of production is fundamentally empowering; if Soko were to suddenly go bankrupt, most of the firm's artisans could find other contractors or sell their own wares, using the skills and equipment they have acquired through partnering with Soko.

On the other hand, Soko found that providing their artisans with artistic freedom (in their initial "Etsy for Kenya" model) could never compete on the level of international jewelry brands. Soko's suppliers can still capitalize upon their cultural traditions of brass handicrafts, although they must follow the designs provided by Soko's professional design team. This team is based in San Francisco and mostly American, but they are clearly inspired by traditional Kenyan styles and craftsmanship. Thus, Soko's co-founders had to sacrifice their initial goal of celebrating Kenyan designers in favor of creating a globally competitive brand; Fabindia seems to have made a similar tradeoff. Many Fair Trade companies that sell one-off products made the opposite choice, and have thus found themselves unable to compete with fast fashion.

Nonetheless, Soko's interviews with dozens of artisans indicated that the ability to sell their wares internationally has increased artisans' reported "self-esteem" and "pride" in their work. Artisans who still wish to design their own wares have the opportunity to do this on their own, since no one is required to work full-time for Soko. Soko may even provide particularly creative artisans with opportunities to join the firm's official design team and help suggest new products.

Worker Wellbeing – Work-Life Balance

By supporting cottage industries, Networked SME Production helps to keep the fabric of communities intact because parents– especially mothers– can work from home and take care of their children or elderly parents at the same time. Soko thus enables many of its workers to have a richer family life both outside and inside of the workplace– although, as with all cottage industries, some artisans may have trouble separating their work-life and home-life. Since most of Soko's artisans had been working in the informal craft sector before joining Soko, and few of them would have the skills to find formal employment, artisans cannot properly compare their Soko experiences to the prospect of formal sector manufacturing jobs.

Even though many of Soko's artisans would prefer full-time employment, they reported enjoying the freedom of being able to determine their own work schedules. Several of the artisans who took on full-time jobs at Soko's headquarters eventually went back to their own factories.

Community Ethics

Soko's 2017 impact report indicates that a total of 341 families of lead artisans have been "impacted positively": these families are all well-nourished, have access to healthcare, and children receive quality education. The overall impact upon families is likely greater, since junior and part-time artisans were not surveyed. Several artisans report that they have been introducing the new skills they learned through Soko's network to their own relatives and

community members– often in rural villages outside of Nairobi, where jewelry crafts are not well-known or widely practiced.

Again, it is difficult to compare Soko's success in this respect to other jewelry manufacturers, which may be able to report similar stories of improving the lives of their workers– although perhaps not in such a drastic fashion, if their workers did not start out in poverty.

Responsible Sourcing

Soko sources most of its raw materials from known brass recyclers and cow/sheep butchers, and follows up with all its artisans who source their own materials to ensure that they have been properly treated and all workers have been suitably compensated. Soko purchases some necklace chains, clasps, and other mass-produced components from China, and does due diligence to ensure that these are all ethically produced. Peinovich personally visited several Fossil factories during Soko's collaboration with Fossil in 2017.

As Soko's business grows, there may be issues about the price of brass increasing until other Kenyans can no longer afford it, and must turn to some lesser material for their crafts– but this has not yet posed an issue.

Environmental Ethics

The environmental impact is difficult to pin down for a Networked SME Producer, since every artisan must take account for their own waste products and ecological impact. Soko performs some of its most environmentally-hazardous tasks such as brass polishing at its central headquarters, so all the waste can be disposed of in one batch. As Soko moves into leather treatment and other processes with more toxic effluent, the firm may face challenges in enforcing environmental compliance across its networked factories. On the other hand, most of Soko's artisans have already been practicing their craft– so Soko may actually provide an environmental benefit by introducing safer techniques.

From an ecological standpoint, Soko could be considered a contributor to the devastating global trend of fast fashion– leading to overconsumption and a massive waste of resources as consumer feel obliged to purchase new clothing and jewelry every season in order to remain up-to-date. From 2000-2014, consumers bought 60% more garments of clothing– and kept each item for only half as long in 2014 as 2000 (McKinsey & Co 2016). As a mid-tier producer, Soko must produce new wares every season in order to remain competitive. Still, Soko's website boasts "timeless" pieces of art that need not be thrown away or donated at the end of the season. As Soko expands into other fashion products, the firm runs the risk of becoming an even greater contributor to disposable fashion– unless the company deliberately sticks with more timeless wares such as home goods products.

Chapter 5. Conclusions and Future Work

Summary of Frameworks

I created two frameworks to assist product developers in making production choices, and to illustrate these options to policy-makers. I also presented a set of ethical considerations for worker wellbeing, and several charts and a figure summarizing how Soko's Networked SME Production model operates. Here is a list of these key tables and charts:

- Framework illustrating the bounds of production systems: Table 12 on pg. 7
- Framework of production tradeoffs within firms: Table 13 on pg. 23
- Ethical considerations related to worker wellbeing: Table 14 on pg. 39
- Diagram of Soko's business model: Figure 28 on pg. 54
- Comparative cost buckets for necklace production: Table 15 on pg. 58

Effective and Ethical Production?

Returning to my original thesis, **does the case study of Soko prove that networks of informal-sector producers can provide an effective and ethical model for industrial production**? I conclude that the company *does* live up to its promise of ethical production, and it has the potential to become a profitable and competitive jewelry brand. Overall, Soko provides a role model for how global firms can effectively utilize craft SMEs for industrial-scale production.

Yet the *scalability* of Soko's current impact is still up for debate– will Soko be able to expand its impact by incorporating new artisans into its network and distributing the gains, or does Soko's model simply concentrate the gains among a handful of top Soko artisans, while lesser suppliers fall behind? Can Soko's overall network of artisans continue to capture such a large portion of overall revenue, or must Soko increase its overhead costs in order to stay in business? Will Soko's traditionally handcrafted jewelry remain competitive as modern technologies become more prevalent and easier to use? This case is complicated by the fact that much of Soko's success to date is tied up with the company's identity as a *fashion brand*; without Soko's strong branding and design aesthetic, Soko's production model may never have led to such an effective and ethical business.

In addition, Soko's distributed production model does not intrinsically lead to ethical production; a networked SME producer without Soko's clear mission of supporting Kenyan artisans might have made different value tradeoffs– perhaps leading to a more exploitative homeworker model.

While Soko's production model is clearly ethical (as discussed above), I cannot state definitively whether its production is intrinsically *more* ethical than a centralized production model that produces similar volumes of jewelry; a well-run mass producer likely provides more consistent employment to a larger number of less-educated workers, albeit perhaps with a lower overall level of worker wellbeing. It is also tricky to evaluate how Soko compares to a well-run American SME like Au Enterprises, which employs 1-2 orders of magnitude fewer full-workers in Detroit at competitive salaries. While Au provides an empowering working

environment, workers all rely upon Au's equipment and means of production. If Soko manages to scale up its number of full-time artisans, it may be able to provide more jobs overall than either of these other factories– but Soko may have to follow a different strategy for growth.

Still, one key takeaway from Soko is the firm's successful application of a high-tech, Networked SME Production model that harnesses the power of existing informal sector microfactories. Since most informal jewelry artisans come from underprivileged backgrounds, and Soko's team is dedicated to helping them succeed on an individual basis, Soko has almost certainly played a larger role than most manufacturers in bringing hundreds of families out of poverty. Furthermore, Soko's artisans receive skills training and support in purchasing and owning their own means of production– providing significant additional opportunities outside of artisans' contracts with Soko.

Critically, Soko allows craft SMEs to compete with industrial-scale producers. Soko provides a compelling example of the potential for harnessing networks of informal craftspeople across Kenya to manufacture jewelry for a discerning global audience. Soko's business model turns semi-skilled, informal artisans into highly-skilled manufacturers for the global jewelry market. Through training, asset-financing, and international market connections, Soko provides artisans with the skills and resources to compete with the formal sector on their own terms. This is particularly relevant in a country like Kenya, which does not yet have the infrastructure to build up a large number of industrial factories.

Role for Policy-Makers and Entrepreneurs

On a global scale, Soko's production model provides a potential path for policy-makers and entrepreneurs to engage with the two billion workers worldwide (ILO 2018) in the informal sector without necessarily forcing formalization. Many informal sector firms lack the business literacy and education required to formalize. Those who can register often have little incentive to do so; in the absence of coercion, why would a small business pay taxes if it would not result in any significant benefit? By supporting ethical aggregating firms such as Soko, policy-makers could engage directly with networks of informal enterprises to create a more friendly regulatory environment and help informal SMEs to become globally competitive. As evidenced by Appropriate Technology initiatives in Ghana throughout the 1980s-90s (Powell 1995; Waldman-Brown et al 2015) loosely-networked SME Production also has the potential to support small-scale experimentation with novel manufacturing techniques– but artisans will likely need governmental support for importing new equipment and materials. Policy-makers could also help to support new forms of worker organizations, such as artisan-owned cooperatives that are optimized for the high-tech world of Germany's *Industrie 4.0*.

The manufacturing model itself, however, can be just as easily turned toward exploitative practices, such as the majority of homeworking in the garment industry or the rising number of contract manufacturing jobs with no job security. Thus, policy-makers must play a stronger role in helping these artisans to either collectivize on their own or to find supportive networks such as Soko. Current industrialization policies tend to favor traditional mass production firms, so new policies will have to be created that are more open to informal

or semi-formal producers, and which encourage the creation of networks and/or brands like Soko that can agglomerate such firms.

Innovation-driven entrepreneurs can also play a major role in supporting informal sector development; in the absence of Soko's dedicated co-founders, Nairobi artisans would never have been able to collectivize on their own. Most entrepreneurs in the fashion industry view craft SMEs and homeworkers as an ethical problem to be eliminated and an inefficient means of production, rather than a vast, potential source of semi-skilled labor (Sommers 2018). Yet Soko proves that traditional handmade production can still be viable under certain circumstances, and that some types of goods can be designed to accentuate handmade qualities. Even if Soko only manages to impact a small number of full-time artisans, a series of like-minded aggregating companies across Kenya could collectively provide a large-scale benefit. By highlighting both the successes and challenges of network SME producers like Soko, we can help entrepreneurs to engage more effectively with the informal sector. Networked SME models may be particularly useful for entrepreneurs who lack the capital costs required to build their own factories, as well as those who place a particular value on throughput agility.

Future Work

Given the relative novelty of sensors, digital fabrication, and networking capabilities within factories (Germany's *Industrie 4.0*), and the lack of modern research around the informal sector, we identify several directions for future research:

- The role of systems-level entrepreneurs like Soko and the Kenyan sanitation company Sanergy in developing public infrastructure, especially when this infrastructure builds upon existing informal SMEs
- Technology platforms to increase supply chain transparency among homeworkers and informal SMEs
- Further comparative studies between networked SME production and factory jobs, focusing both on business competitiveness and worker wellbeing
- Comparing the competitiveness and job creation potential of handmade vs machine-made production
- Follow-up studies with Soko as its business model matures– perhaps tracking overall number of artisans impacted and the distribution of this impact, as well as how the impact might shift over time
- Exploring the overall effectiveness of networked SME production under different boundary conditions
- Evaluating alternatives to traditional models for industrialization, especially in the face of declining manufacturing jobs

A New Model for Sustainable Development?

The breadth of the global informal economy could provide a massive, untapped opportunity for the processing of raw materials, as well as the production of some finished goods, on both domestic and international scales. Despite a dearth of full-time employment

opportunities, formal jobs remain the ultimate goal for many informal workers across emerging markets; informal artisans lack social services and many other forms of support, and full-time jobs tend to be more socially prestigious. While networks of ramshackle firms will never substitute for large-scale infrastructure development, Soko's Networked SME Production proves that the informal craft sector may still be able to play a key role in sustainable industrialization. After all, the global manufacturing landscape has already shifted away from Fordism and toward networked specialized SMEs. Why should emerging markets be left out? Although craft SMEs may lack the financial incentives to upgrade on their own, an aggregating company like Soko can benefit from the collective improvement of all hundreds or thousands of these SMEs. Like most workers in the informal industrial sector, Kenya's jewelry artisans have lacked their own resources to innovate to meet the demands of international clients, and have relied heavily upon outside interventions like Soko to upgrade their skills and techniques. If Soko can provide the expertise, innovation, and organization needed to keep its suppliers globally competitive, thousands of artisans can reap these benefits. A well-connected cooperative of artisans could play a similar role, like Mondragon in the Basque region of Spain.

Similar to the practice of Putting Out observed throughout the 1990s in Italy, Networked SME Production maintains several advantages over traditional SMEs or mass production: minimal inventory, low up-front capital costs, the ability to utilize existing microfactories rather than build new facilities, the creation of local employment and expertise, increased throughput agility, and potential savings on transportation costs when producing for local consumption. Upholding traditional rural industries could also help to mitigate unsustainable urban migration by providing more jobs in disenfranchised regions– and some consumers are demonstrably willing to pay a premium for ethically produced and/or locally-made goods. Although Soko's artisans use only manual tools, Soko's production model bears similarities to the supposed promise of Smart Microfactories employing on-demand digital fabrication services.

Just as Bangladesh "leapfrogged" the developed world by skipping landline telecommunications networks and jumping straight to infrastructure-light mobile phones, some foresee a similar trend for manufacturing. Why would emerging markets—which already suffer from costly and convoluted supply chain logistics— burden themselves with the outdated infrastructure of large-batch manufacturing (whether formal SMEs or Mass Production) in sectors where distributing production across existing craft SMEs could be equally competitive? Soko's model offers a production model for sectors that don't benefit from traditional economies of scale: specialized components like airplane engines, customized or on-demand products such as medical devices and fast fashion, and labor-intensive handicrafts.

The company Soko, despite its shortcomings, is an exemplar of a "virtual factory" of Networked SME Production, effectively combining the scale, efficiency, and collective intelligence of high-volume manufacture with the benefit to local economies provided by craft SMEs. "Formalization," says Peinovich, "is not the answer. Rather, networked infrastructure will bring progress." Given our rising global levels of inequality and a perennial lack of decent formal-sector jobs, we must give careful consideration to how firms' production decisions and tradeoffs can shape society.

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