Supply-Chain Research Opportunities with the Poor as Suppliers or Distributors in Developing Countries

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Abstract: Many social enterprises and some companies have developed supply chains with the poor as suppliers or distributors to alleviate poverty and to create revenues for themselves. Such supply chains have created new research opportunities because they raise issues fundamentally different from those examined in the existing operations management literature. We report this phenomenon of supply chains with the poor as suppliers or distributors in developing countries and identify OM research opportunities. We also provide some stylized models to serve as potential seeds for modeling-based research in this area.

Keywords: Socially responsible operations; value creation; micro-entrepreneurs; social enterprise; social business; supply chain management; supply chain surplus.

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1. Introduction

How can supply chain design alleviate poverty? This is the central question that this article seeks to raise while providing a starting point for research. Supply chains can source from the poor as upstream suppliers of products or services or use them as downstream distributors of finished goods. One challenge would be the large number of small transactions and therefore the huge transaction costs these suppliers or distributors would require given the vast numbers of the poor that form the "base of the pyramid" in any country. Therefore such supply chains would require the use of information and communication technology (ICT) to manage transactions and bring down transaction costs. Another challenge would be ensuring the poor as suppliers or distributors get an equitable share of the supply chain surplus because they lack market power. Meeting this challenge would require building supply chains around 'social' business models that seek both profits and poverty alleviation. Increasingly, many supply chains are being built with the poor as suppliers or distributors to overcome these challenges. This article seeks to report this phenomenon and to identify research opportunities for operations management (OM).

Enterprises built solely around social business models are called 'social enterprises' (Seelos and Mair 2005), while like-minded efforts of established companies are termed 'social business' (London et al 2010). The poor that are the focus of such efforts, at least in developing countries, are the working poor typified by *micro-entrepreneurs*, who make less than US $5/day in countries like India (Sodhi and Tang 2011). They comprise over 90% of the total workforce in India selling products or services in the so-called *informal sector* not subject to any taxes or even minimum-wage restrictions. Many social enterprises and some companies seek to create value by entailing these micro-entrepreneurs as suppliers or as distributors in their supply chains. The resulting supply chains offer new research opportunities because they raise operational issues that are quite different from those

examined in the traditional supply chain management literature, in part due to the two challenges mentioned above.

It is helpful to separate *upstream* supply-chain operations with the "poor as suppliers" of products or services from *downstream* ones with the "poor as distributors" of finished goods because the related research opportunities are quite different for these two contexts. Another useful thing is to separate the challenges in *developing* countries, which are primarily economic, from those of *developed* countries, while are primarily social, e.g., the rehabilitation of ex-convicts or drug addicts even though both sets of issues are present in both type of countries.

In this paper, we focus on developing countries and use the term "poor" to micro-entrepreneurs in the informal sector. We report on the phenomenon of such supply chains in developing countries and list research opportunities first with the poor as suppliers (upstream) and then with the poor as distributors (downstream). We also provide illustrative models to serve as seeds for further modeling research, given that most extant research is in the form of case studies. Finally, we discuss working capital lending that is necessary for enabling the poor to serve as suppliers or distributors: *supply chain microfinance* specifically presents opportunities for OM research, building on the work in the development economics literature on microfinance.

We contribute to the OM literature on the emerging area of *socially responsible operations* in three ways: First, we identify research opportunities in this nascent area. Although sustainable development has been studied extensively in the development economics literature (Ray 1998; Lal 2000; Hayami 2005), *operational* issues in this context have not been explored much yet. Second, we provide some stylized models that can serve as seeds for analytical research in this area. Most of the research, as of this writing, is exploratory and is

in the form of case studies (cf. Vachani and Smith 2008; London et al. 2010; and Haksoz et al. 2012), although Chen et al. (2012), Devalkar et al. (2011) and McCoy (2012) provide welcome first steps towards modeling of specific situations. Finally, corporate social responsibility (CSR) remains an untapped research area of operations management (Tang and Zhou 2012) and our work can provide a starting point for research into companies interested in supply chains with the poor aiding the creation of supply chain surplus in their supply chains.

The paper is organized as follows: Section 2 reviews supply chains with the poor as suppliers, identifies research opportunities, and provides some analytical models to serve as seeds for future modeling-based research. Section 3 does the same with the poor as distributors of finished goods. In Section 4, we discuss microfinance and identify research opportunities for possible applications to working capital funding for the poor as suppliers or distributors before concluding in Section 5.

2. The Poor as Suppliers

When micro-entrepreneurs serve as upstream suppliers in a supply chain, the business opportunity for them is to access a new market or to get better prices for their output in existing markets; the opportunity for the enterprise is to buy goods more cheaply that they could otherwise and, at the same time, be seen as contributing towards poverty alleviation. In developing countries, social enterprises can help the poor as suppliers by using three basic models:

1) **Reducing intermediate echelons to obtain higher selling prices**: Micro-entrepreneurs in developing countries typically sell their output through layers of middlemen and get low prices for their product. This creates an opportunity for social enterprises or companies to help the poor by purchasing their output directly. For example, Coconut

World purchases coconut sugar made by small farmers in the Philippines directly, and then sells directly to consumers through its online store and to other retailers in the US (Cameranesi et al. 2010). Walmart purchases the crops directly from farmers in China: farmers can obtain a higher price and Walmart can reduce its procurement cost and have fresher produce (An et al. 2012). Another example is that of the social enterprise Arzu, which purchases wool rugs directly from Afghan women and sells these in the US.

2) **Reducing search cost:** Perishable goods such as fresh produce, fish, or even labor hours require balancing the loss of such goods against spending time searching for a customer offering a higher price than others. The poor do not have easy way to search for customers for their products or services. In South Africa, Men-on-the-Side-of-the-Road (MSR) developed an online portal as a marketplace for day laborers (micro-entrepreneurs) and homeowners, which helps laborers and potential customers find each other (Sodhi and Tang 2011). The same applies to transportation: given that truck owners are typically micro-entrepreneurs with a single vehicle, private enterprises have created websites offering to match loads from shippers with trucks to help reduce the problem of trucks heading back home without a load after delivery, e.g., LoadJunction.com in India or 123LoadBoard in South Africa. Chipchase (2006) reports that customer demand information available on the mobile phones has helped taxi drivers to increase their earnings in Pakistan and Thailand. The same has been reported for fishermen in Kerala seeking markets for fish, a perishable product because of the fishermen's lack of access to cold chain facilities (Jensen 2007).

3) **Improving productivity**: The poor, especially small farmers, often lack relevant information to improve productivity and to increase selling opportunities. In India, IFFCO disseminates information about weather forecasts and crop advisory information (what to cultivate, when to harvest, and how to improve yield and quality) to farmers via

mobile phones so that they can plan their farming activities accordingly. In 2012, IFFCO's recommendation to cultivate sorghum that requires less water to subscribed farmers based on its forecasts of deficient rains helped some farmers in India to avoid big losses (Ghosal and Parbat, 2012). Also, Reuters Market Light (RML) tracks the prices of 50 commodities over 1000 markets and the weather conditions of 2000 locations and disseminates crop- and location-specific information to subscribed farmers in India using SMS text messages so that farmers can sell their products at a higher price (Preethi 2009).

Some business models offer all three benefits by exploiting both supply chain structure and information technology. Consider Indian consumer-goods giant ITC's e-Choupal initiative: ITC provides farmers the historical selling prices of different crops at different locations on its web portal, and ITC pre-announces its own price for purchasing the crops directly from the farmers before the market opens the next day. These farmers, who typically till small lots of land, can decide whether to sell their produce to the company or at least be aware of a floor price when bringing their produce to a commodity marketplace (Anupindi and Sivakumar 2006; 2007). From a poverty alleviation perspective, ITC's efforts help reduce price dispersion and possible higher prices for the farmer: Goyal (2010) reports that the market price information provided by the internet kiosks as part of the ITC e-Choupal initiative helped farmers obtain higher selling price for their soybeans in Central India.

2.1 Research Opportunities

It would be useful to examine different ways for social enterprises or companies to create supply chains with micro-entrepreneurs who would otherwise lack market access, market information, and selling opportunities. As such, one research opportunity is studying the different types of supply contracts (e.g., wholesale price, revenue sharing, or profit sharing) or how the transaction is carried out and to examine poverty alleviation as well as profits for

the enterprise. These contracts would include supporting the micro-entrepreneurs' need for capital, say, farmers having to buy equipment, seed or fertilizer.

Another research opportunity would be to further the understanding the value of information in increasing revenues for the micro-entrepreneur supplier via such supply chains. Providing timely and relevant information to the poor is beneficial by way of reduced search cost and improved selling opportunities by way of ICT alone (cf. Jensen 2007), but the evidence on income is not so clear. For instance, although Mittal et al. (2010) report that the farmers they interviewed reported 'positive benefits' by way of higher income because of their RML subscriptions, Fafchamps and Minten (2012) did not find any significant differences in price received by RML subscribed farmers and regular farmers (i.e., the control group). Indeed, when the same price information is available to all buyers and sellers, it may reduce price dispersion but in the short time window of the information being provided, say one day, it could result in price instability by attracting sellers to and buyers away from locations reported as having had high prices, and vice versa for locations that reported low prices the previous day.

On the other hand, combining ICT with supply chain restructuring, as we discussed earlier with the example of ITC's e-Choupal initiative, may have a beneficial impact. After all, e-commerce success depended not only on use of web technology but also on supply chains to carry out the physical part of the transactions. The role of the wholesale auction markets in India called *mandis* also needs to be better understood: the auctioneers share information with their regular suppliers, i.e., farmers, and their regular buyers using mobile phones in the day or days prior to auctions, and the auctioneers can be buyers themselves as middlemen.

Finally, researchers could explore the implications of crop advisory information regarding what to cultivate and when to harvest. It is of interest to examine how to present this

information to prevent the "herd effect" (Bikhchandani et al. 1998) of all farmers being enticed to grow the same crop and harvest at the same time that could result in much lower prices.

Next, we provide some illustrative models to serve as potential seeds for further research.

2.2 Modeling the value of direct purchase and direct market access

Consider a farmer who produces and sells a product through a serial supply chain with $n \geq 0$ layers of middlemen.[1] The middlemen are indexed as follows: middleman n buys from the farmer at unit wholesale price w_n and sells to middleman (n-1) at the unit wholesale price w_{n-1}, who in turn sells to middleman (n-2) at wholesale price w_{n-2}, and so on. Eventually, middleman 1 buys the product from middleman 2 at unit wholesale price w_1 and sells it at retail price p.[2] For any p, the market demand $q=a-bp$, where a, $b>0$. Here, the farmer sets the wholesale price w_n for middleman n, who sets the wholesale price w_{n-1} for middleman (n-1), and eventually, middleman 1 sets the retail price p. Coughlan and Lal (1992) examine a more general model with retail competition showing the recursive computation of the retail price in equilibrium. However, we obtain closed-form expressions for the retail price in equilibrium without considering retail competition, to obtain the benefits to the farmers and the direct distributors explicitly.

To obtain the optimal pricing we start with middleman 1: First, for any given wholesale price w_1, middleman 1 solves: $\pi_1^*(w_1) = \max_p (p - w_1)(a - bp)$, and the optimal retail price p^* and the corresponding selling quantity $q^*(w_1)$ to the market satisfy: $p^*(w_1) = \frac{a + bw_1}{2b}$. and $q^*(w_1) = a - bp^*(w_1)$. Next, for any given w_k, $k = 2, \cdots, n$, middleman k solves

$\pi^*(w_k) = \max_{w_{(k-1)}} (w_{(k-1)} - w_k) q^*_{(k-1)}(w_{(k-1)})$, where $q^*_{(k-1)}(w_{(k-1)})$ is the selling quantity of middleman $(k-1)$. The optimal wholesale price $w^*_{(k-1)}(w_k)$ is then $w^*_{(k-1)}(w_k) = \frac{a + bw_k}{2b}$.

The corresponding quantity is given by

$$q^*_{(k-1)}(w_k) = a - bp^*(w_1^*(w_2^*(....(w^*_{(k-1)}(w_k))))).$$

Finally, consider the farmer's problem: $\pi^* = \max_{w_n} (w_n - c) q^*_n(w_n)$, where $q^*_n(w_n)$ is the selling quantity of middleman *n*. The optimal wholesale price w_n^* selected by the farmer and the corresponding selling quantity $q_n^*(w_n)$ are: $w_n^* = \frac{a+bc}{2b}$ and

$$q_n^*(w_n) = a - bp^*(w_1^*\left(w_2^*\left(\ldots\left(w^*_{(n-1)}(w_n^*)\right)\right)\right)).$$

By using the optimal w_n^* and the "nested" relationship, we obtain:

Proposition 1. *In a serial supply chain with n middlemen, the optimal retail price p^* and the farmer's optimal profit π^* satisfy*:

$$p^* = \frac{(2^{(n+1)} - 1)a + bc}{2^n b}, \text{and } \pi^* = (w_n^* - c) q_n^*(w_n^*) = \frac{(a - bc)^2}{4b} \cdot \frac{1}{2^n}. \quad (1)$$

When the farmer sells direct (i.e., $n = 0$), the optimal price equals $\frac{a+bc}{2b}$ and the optimal profit equals $\frac{(a-bc)^2}{4b}$. However, Proposition 1 shows that in our model, each additional echelon of an existing supply chain would result in double marginalization: the farmer suffers from a lower profit due to lower price and the final customers (e.g., retailers) end up paying a higher price. Therefore, unless each layer adds value by way of (1) increasing the market size a, (2) helping reducing the price sensitivity b by improving quality, or (3) reducing the farmer's

production cost c, getting rid of intermediate layers creates value for the farmers and final customers. Thus, Coconut World has created a profitable distribution model for itself through direct purchase from farmers and through direct sales to consumers.

However, a caveat to the above reasoning is that the role of middlemen can be much more complex than what we assume above. The economics literature has discussed different roles of middlemen by way of holding inventory or helping customers distinguish quality. Also, the allocation of fixed costs may also benefit the farmer owing to the way fixed costs are allocated to different entities in the supply chain. We also note that in India, the mandi system was created by the state governments to help farmers get better prices than they were getting prior to the creation of these places of auction, and the auctioneers can also be middlemen.

2.3. Modeling the value of search cost reduction

To illustrate how market information can enable day laborers, farmers, fishermen, and other such micro-entrepreneurs to improve their earnings, consider a risk-neutral micro-entrepreneur who needs to search for a customer (or a market) to sell one unit of his service/product. For ease of exposition, consider the case when there are infinitely many potential customers (or markets) with the *i*'th customer willing to buy the service/product at price X_i; $i=1,2,\ldots..$ While the micro-entrepreneur knows that X_i has a probability distribution $F(.)$, he does not know the value of X_i *ex-ante*. However, to reveal the offer of each customer, the micro-entrepreneur incurs a search cost $c > 0$ tied to travel or referrals.

After incurring this search cost, the micro-entrepreneur receives an offer x from a new customer. Should he accept this offer or should he continue to seek a better offer? Consider the following stopping rule: the micro-entrepreneur will accept an offer x if and only if $x \geq c + z$, where $z(\geq 0)$ is a decision variable and $(c + z)$ is the "reservation price" (Lippman and

McCall 1976). In other words, the micro-entrepreneur will stop searching the *first time* he receives an offer A that exceeds his reservation price.

To show that the micro-entrepreneur will increase his earnings if he can leverage information technology to reduce his search cost, let us compute his expected profit. Let p be the probability that he will receive an offer that exceeds the reservation price (c+z) during any search so that $p = 1 - F(c+z)$, where p is decreasing in c and z. Also, observe that the accepted offer $A = (X| X \geq c + z)$, where $E(A) = E(X| X \geq c+z)$ is decreasing in c and z. Therefore, the micro-entrepreneur's expected profit is:

$$\Pi(c) = MAX_{z\geq 0}\Pi(c,z)$$

$$= MAX_{z\geq 0}\sum_{k=1}^{\infty}(1-p)^{k-1}p[-kc + E(A)] = MAX_{z\geq 0}\,[-\frac{c}{p} + E(A)] \qquad (2)$$

The above expression captures two observations: (a) the micro-entrepreneur will accept the k^{th} offer when all previous (k-1) offers were below the threshold (c+z) with probability $(1-p)^{k-1}$ and the k^{th} offer exceeds the threshold and (b) when accepting the k^{th} offer, the expected payoff is $-kc + E(A)$, the result of k searches and the expected accepted offer. For any given search cost c, we can use the fact that p and $E(A)$ are decreasing in z to show that the expected earning $\Pi(c, z)$ given in (2) is also decreasing in z. Hence, the optimal $z^* = 0$. In other words, it is optimal for the micro-entrepreneur to accept an offer $x \geq c$.[3] By substituting $z^* = 0$ into (2) and using the fact that p and $E(A)$ are decreasing in c, we can show that the resulting $\Pi(c)$is also decreasing in c. In other words, if the search cost is reduced, the micro-entrepreneur's expected earnings will increase.

2.4. Modeling the Impact of Price Information and an Alternative Channel

We now present a model to illustrate the value of price information. At any mandi in India, the farmers engage commission agents to display their produce, and the buyers engage their commission agents to bid on their behalf at certain pre-specified maximum bids. While the open auction mechanism appears to be fair, the farmers can face four major *challenges* (Anupindi and Sivakumar 2006; 2007): (C1) they lack advance information about the market price; (C2) they are under pressure to sell because they have already incurred the sunk cost for transporting the produce to the mandis; (C3) they may get treated unfairly because of unreliable assessments of quality and quantity of the produce especially when the commission agents are buyers themselves; and (C4) they may not get full payment immediately from the commission agents. State governments usually attempt to mitigate these challenges but they remain nonetheless.

2.4.1. Market Price Information. To examine the benefit of overcoming challenge (C1), consider the case when a risk-averse farmer has a maximum of K units of soybeans to sell. The farmer estimates that the trading price at a mandi on the next day p is uncertain, where $p \sim N(\mu, \sigma^2)$. To model risk aversion associated with any amount of money z, assume the farmer has a utility function $U(z) = 1 - e^{-rz}$, where $r > 0$ represents the coefficient of constant absolute risk aversion (e.g., Pratt 1964). Faced with uncertain price p, the farmer has to decide on the quantity $q \leq K$ to be sold. To model challenges (C3) and (C4) as stated above as well as to incorporate the agent's commission, assume that the "effective unit selling price" is αp, ($\alpha < 1$) and the "effective quantity" measured by the agent at the mandi is βq, $\beta \leq 1$. To eliminate the trivial case that the farmer is better off not selling at all, it suffices to consider only the situation where $\alpha\beta\mu$ exceeds c, the sunk cost for transporting each unit of produce. Accounting for the transportation cost and the effective payment, the

farmer's net profit $\pi(q) = \alpha p \cdot \beta q - cq$. Hence, the farmer's problem is $U^* = max_{q \le K} E_p\{1 - e^{-r \cdot \pi(q)}\} = max_{q \le K} E_p\{1 - e^{-r \cdot (\alpha p \cdot \beta q - cq)}\}$. Because $p \sim N(\mu, \sigma^2)$, $E_p(e^{sp}) = e^{s\mu + (s\sigma)^2/2}$ for any parameter s so that the farmer's problem becomes:

$$U^* = max_{q \le K} \{1 - e^{-r((\alpha\beta\mu - c)q - r/2 \cdot (\alpha\beta\sigma q)^2}\}.$$

Proposition 2. *When the selling price $p \sim N(\mu, \sigma^2)$, the optimal selling quantity q^* and the optimal expected utility U^* are decreasing in the price uncertainty σ, where*:

$$q^* = \min\{\frac{\alpha\beta\mu - c}{r(\alpha\beta\sigma)^2}, K\}, \text{and } U^* = 1 - e^{-r\{(\alpha\beta\mu - c)q^* - r/2 \cdot (\alpha\beta\sigma q^*)^2\}}. \quad (3)$$

Proof of Proposition 2: By considering the bound K and the first order condition of the objective function, we obtain q^* and U^* as stated in (3), where q^* is decreasing in σ. When $\frac{\alpha\beta\mu - c}{r(ha\beta\sigma)^2} \ge K$, $q^* = K$ and $U^* = 1 - e^{-r\{(\alpha\beta\mu - c)K - r/2 \cdot (\alpha\beta\sigma K)^2\}}$, where U^* is decreasing in σ. When $\frac{\alpha\beta\mu - c}{r(\alpha\beta\sigma)^2} < K$, $q^* = \frac{\alpha\beta\mu - c}{r(\alpha\beta\sigma)^2}$ and $U^* = 1 - e^{-\frac{(\alpha\beta\mu - c)^2}{2(pha\beta\sigma)^2}}$, where U^* is decreasing in σ. ■

Proposition 2 implies that with decreasing σ, the farmer will increase his selling quantity q^* and will earn a higher profit, getting higher utility $U^*(\sigma)$. Therefore, if RML can provide farmers with more accurate market price information via mobile phones so that the effective σ is lower -- Jensen (2007) among others investigates price dispersion in a similar context -- then farmers can earn more by subscribing and RML can get revenues from these subscriptions.

2.4.2. Market Price Information and Alternative Channel. In addition to market price information, we now examine the value of ITC's e-Choupal initiative as an alternative sales channel. To overcome challenge (C1) for the farmer, ITC provides the commodity prices

traded at various mandis at different locations in the previous day on its web portal (via a kiosk located at the village).[4] As an alternative sales channel for farmers, ITC announces its "direct" purchasing unit price x. To "isolate" the effect of this alternative sales channel, we assume that ITC estimates that the trading price at a mandi on the next day p is uncertain, where $p \sim N(\mu,\sigma^2)$, so that price uncertainty remains the same as before. Therefore, the farmer has two options: (a) sell at the mandi at an uncertain market price p, or (b) sell to ITC at the announced unit price x.

Suppose the farmer accepts ITC's announced price x, where x is determined by ITC. Then the farmer will receive full payment without having to pay any commission or suffer any loss in the measurement of the quantity sold so that $\alpha = \beta = 1$ (Anupindi and Sivakumar 2006; 2007). Accounting for the transportation cost, the farmer's net profit is equal to $\hat{\pi}(q) = (x-c)q$. Hence, for any price x, the farmer aims to maximize his utility by solving $\hat{U}^*(x) = max_{q \le K}\,[1-e^{-r\cdot((x-c)q)}]$. Note that the objective function is increasing in q so the optimal selling quantity $\hat{q}^* = K$ and the farmer's optimal utility $\hat{U}^*(x) = [1-e^{-r\cdot((x-c)K)}]$. By comparing the optimal utility when selling through the mandi U^* given in Proposition 2 and the optimal utility when selling directly to ITC $\hat{U}^*(x)$, we get:

Corollary 3. *$\hat{U}^*(x) > U^*$ if and only if x satisfies the following conditions*: (1) $x > \alpha\beta\mu - \frac{r}{2}K(\alpha\beta\sigma)^2$ when $\frac{\alpha\beta\mu - c}{r(\alpha\beta\sigma)^2} > K$; and (2) $x > c + \frac{(\alpha\beta\mu - c)^2}{2r(\alpha\beta\sigma)^2 K}$ when $\frac{\alpha\beta\mu - c}{r(\alpha\beta\sigma)^2} \le K$.

Proof of Corollary 3: First, when $\frac{\alpha\beta\mu - c}{r(\alpha\beta\sigma)^2} > K$, equation (3) implies that $q^* = K$ and $U^* = 1 - e^{-r\{(\alpha\beta\mu - c)K - r/2\cdot(\alpha\beta\sigma K)^2\}}$. We obtain condition (1) by comparing U^* and $\hat{U}^*(x)$. When $\frac{\alpha\beta\mu - c}{r(\alpha\beta\sigma)^2} \le K$, $q^* = \frac{alpha\beta\mu - c}{r(\alpha\beta\sigma)^2}$ and $U^* = 1 - e^{-\frac{(\alpha\beta\mu - c)^2}{2(\alpha\beta\sigma)^2}}$. We obtain condition (2) by comparison. ■

Corollary 3 has two implications: First, when the farmer's capacity K is small, we can use the fact that $\alpha < 1$ and $\beta \leq 1$ as well as condition (1) to show that a risk-averse farmer prefers to sell his crop to ITC even when ITC offers x that is below the expected price μ.

Second, when the farmer's capacity $\frac{\alpha\beta\mu - c}{r(\alpha\beta\sigma)^2} \leq K$, condition (2) implies that $c + \frac{(ha\beta\mu - c)^2}{2r(\alpha\beta\sigma)^2 K} \leq c + \frac{(\alpha\beta\mu - c)}{2} \leq \alpha\beta\mu$ based on our starting assumption that $\alpha\beta\mu > c$. So to entice the farmer to sell his crop to ITC directly, ITC needs to offer $x \geq \alpha\beta\mu$. Because $\alpha\beta < 1$, Corollary 3 reveals that, by providing market price information and by offering an alternative sales channel to the farmer can lead to a win-win situation: ITC can buy the crop at a price below the expected market price μ, and the farmer can obtain a higher profit by selling directly to ITC.

3. The Poor as Distributors

In developing countries, the distribution infrastructure is inadequate and formal distribution channels do not reach most consumers unlike in developed countries with large retailers and their supply chains. As such, a social enterprise or a company can use micro-entrepreneurs to distribute finished goods in order to overcome the high cost of 'last mile' distribution. Developing distribution strategies that entail micro-entrepreneurs are essential for poverty alleviation (Prahalad 2005). Also, there are research opportunities because the OM literature on distributing products or services in rural areas of developing countries is rather scant (Tang and Zhou, 2012).

A social enterprise or a company can help reducing distribution cost by using micro-entrepreneurs as distributors. For example, Mozambique-based VidaGas uses micro-entrepreneurs to sell propane gas to food-stall owners, fishermen, health clinics, etc. (Watson

and Kraiselburd, 2009). Vision Spring sells affordable reading glasses to low-income individuals through a network of micro-entrepreneurs in various developing countries (Bhattacharya et al. 2010). In East Africa, Coca-Cola bottlers deliver over $500 million worth of product to 1,800 “manual” distribution centers operated by 7,500 micro-entrepreneurs. There micro-entrepreneurs use push carts or even bicycles to distribute the product to small retailers (who are also micro-entrepreneurs) in congested areas, making frequent but small deliveries to these cash-strapped micro-retailers (Cummings 2012;Yadav et al. 2011). In 2000, Hindustan Unilever, a subsidiary of Unilever in India, started Project Shakti in 50 villages with woman-entrepreneurs receiving training and stocks of consumer-packaged goods from Unilever’s rural distributor to sell the goods to consumers and micro-retailers in 6-10 villages (Rangan and Rajan, 2007). Social enterprises like Living Goods and Solar Sisters, both operating in Uganda, also use women micro-entrepreneurs to do last-mile distribution of household necessities and solar lamps respectively thus emulating the model of the famed Avon Ladies (Economist 2012).

The basic distribution strategy entailing the poor as distributors is a **hub-and spoke** strategy. An enterprise can set up a center in a larger village as a “hub” from which micro-entrepreneurs (or employees) can travel to the more remote rural areas as “spokes” to sell goods or provide services. Coca Cola's distribution in East Africa is an example with each manual distribution center 'hub' itself being operated by a local entrepreneur and these hubs being supplied in turn from a bottling plant as a hub-of-hubs.

Such a distribution network can further benefit from (a) using existing commercial/non-commercial networks for moving goods to the micro-entrepreneurs or (b) providing additional services at the hub or sell more products or services to create more supply chain surplus. This is called a **piggy-back** strategy. In Africa, Cola Life, an independent UK

charity, hopes to bring "social goods" such as oral dehydration salts, high dose Vitamin A and water purification tablets to rural villages using a wedge-shaped container called an AidPod that fits between the Coca Cola bottles in their crates, thus reducing distribution costs (Yadav 2011). Gramin Suvidha Kendra, a private-public partnership between MCX and Indian Post Office established in 2006, distributes seeds, fertilizers, water purifiers, micronutrients and solar lanterns to farmers via the ubiquitous post offices in India (Vachani and Smith, 2008).

3.1. Research Opportunities

OM researchers have examined last-mile logistics in time-sensitive contexts arising from humanitarian disaster reliefs or health care service (Tomasini and Van Wassenhove, 2009). For example, Stapleton et al. (2009) examine the trade-offs between agility, adaptability and alignment to propose improved performance of the last-mile vehicle supply chain for the humanitarian logistics efforts of for the International Federation of the Red Cross and Red Crescent Societies (IFRC). McCoy (2012) has proposed an optimization model for "Riders for Health" in Africa to reduce the downtime of its current fleet of motorcycles owing to unavailability of spare parts. Apte (2009), McCoy (2012), and Pedraza and Van Wassenhove (2011) provide details about the challenges arising from humanitarian logistics – some of these challenges apply to distribution and may interest researchers of social business models pertaining to the poor as distributors.

However, efficient distribution strategies for enabling micro-entrepreneurs in developing countries to buy, distribute, and sell products have not been studied much. Moreover, for *piggy-back distribution*, it is not clear how the value created should be shared between the network owner and the enterprise or micro-entrepreneurs. For example, how much should

Coca Cola charge Cola Life for distributing its AidPods? How much should India Post charge Gramin Suvidha Kendra?

For *hub-and-spoke distribution*, inventory issues arising from a hub-and-spoke system with many micro-entrepreneurs as spokes provide interesting research opportunities. For example, a hub-based inventory at a centralized warehouse reduces the inventory due to the "pooling" effect, but makes it costly for the micro-entrepreneurs to replenish their inventories especially if they have to do so frequently owing to limited purchasing power. For example, NE Green Power (India) distributes and sells solar lamps and related products using a centralized warehouse that the micro-entrepreneur distributors find inconvenient (Jue 2011). On the other hand, the total inventory at the spokes would be much greater than it would be if it were only at the hub, raising the question of who should own this inventory. In general, involving local entrepreneurs as informal sales force in developing countries creates new research opportunities to extend the existing marketing and the OM literature in the area of sales force planning, sales territory design, and incentive design (Lilien et al. 1992).

3.2. Modeling the Hub-and-Spoke Distribution Strategy with PiggyBacking

We now present an illustrative model that captures the hub-and-spoke distribution strategy with piggybacking as adopted by Vision Spring (VS). VS sells *reading glasses* using micro-entrepreneurs as spokes in a hub-and-spoke model. Moreover, VS uses piggybacking to leverage the spokes to send customers needing specialized services to the hub to sell them *prescription glasses*. To keep the inventory cost low (for itself and the micro-entrepreneurs), VS sources only three strengths of reading glasses from China, and sells them through micro-entrepreneurs as "spokes" by providing them with $75 worth of eye charts, brochures, and a stock of the three basic strengths of glasses (Sodhi and Tang 2011). Because it is too costly to send optometrists to the field as spokes, VS opened optical shops at the hub level with

optometrists to sell prescription glasses. This way, the micro-entrepreneurs can sell basic reading glasses, and refer customers with more specialized optical needs to the hubs with optical shops.

Vision Spring's distribution strategies can be modelled as a distribution network comprising one optical shop (i.e., central warehouse or hub) and *n* local entrepreneurs (i.e., retailers or spokes). The demand occurred at each retailer i during any given time period D_i is normally distributed with mean μ and standard deviation σ. By assuming that the demand is independent across different time periods and across different retailers, the total demand experienced at the central warehouse during any given time period $D = \sum_{i=1}^{n} D_i$ is normally distributed with mean $n\mu$ and standard deviation $\sigma\sqrt{n}$.

3.2.1. The spoke distribution for reading glasses. We follow Lee and Tang (1997) for tractable analysis in using the assumption that the central warehouse and the retailers hold inventories, in our case of reading glasses, so that the distribution system can be "decomposed" into $n+1$ subsystems.[5] Let T be the replenishment lead-time of the central warehouse from the factory and let t be the replenishment lead-time of each retailer i from the warehouse. By assuming that the warehouse and each retailer replenish their inventory according to an "order up-to level" policy, the *expected total inventory* (in-transit and on-hand) I in any time period satisfies:

$$I = (T + t + \frac{1}{2})n\mu + z\sigma(\sqrt{n(T+1)} + n\sqrt{t+1}), \quad (4)$$

where z is safety factor (Peterson and Silver 1979). For each time period, let K be the fixed operating cost of the central warehouse, k be the fixed operating cost of each retailer, c be

the unit production cost, and *h* be the unit inventory holding cost. Hence, the total system cost of the entire distribution for each time period can be written as:

$$S^* = K + nk + cn\mu + h\{(T + t + \frac{1}{2})n\mu + z\sigma(\sqrt{n(T+1)} + n\sqrt{t+1})\}. \quad (5)$$

3.2.2. Piggybacking for prescription glasses at the hub. The micro-entrepreneurs do not hold inventory of prescription glasses, which are prepared only at hubs under the care of an optometrist. Piggybacking on the spokes, VS pays micro-entrepreneurs an incentive r for "referring" a customer to the optical shop at the "hub" for prescription glasses. Here, the warehouse has to satisfy the total demand referred by all n retailers. By using the same approach as before, the expected total inventory (in-transit and on-hand) $\hat{I}$ in any time period can be expressed as (Peterson and Silver 1979):

$$\hat{I} = (T + \frac{1}{2})n\mu + z\sigma\sqrt{n(T+1)}.$$

Accounting for the referral cost, the total system cost for this case satisfies:

$$\hat{S}^* = K + nk + rn\mu + cn\mu + h\{(T + \frac{1}{2})n\mu + z\sigma\sqrt{n(T+1)}\}. \quad (6)$$

To examine whether the distribution strategy selected by VS for distributing reading glasses prescription glasses is effective, we compare the system costs S^* and $\hat{S}^*$ given in (5) and (6) and obtain:

Proposition 3. $\hat{S}^* < S^*$ if and only if $\frac{r}{h} < t + z\sqrt{t+1} \cdot \frac{\sigma}{\mu}$.

Proposition 3 implies that the piggybacking on the spokes for distributing at the hub is more cost effective when the product demand is highly uncertain (i.e., when $\frac{\sigma}{\mu}$ is large) or when the retailer's replenishment lead time t is high. These two conditions fit the characteristics of

demand of *prescription* glasses so the distribution model is quite suitable, which is not the case for *reading* glasses.

4. Working Capital Lending for the Poor as Suppliers or Distributors

Micro-entrepreneurs have little access to credit from traditional banks not only because of lack of credit history or collateral but also because of the small amounts of money involved relative to the transaction cost for the bank for screening and collection. Therefore, social enterprises and companies must also find ways to finance the working capital if they are to engage the poor as suppliers or distributors. For example, as already noted, Vision Spring provides each micro-entrepreneur in its supply chain with $75 worth of eye charts, brochures, and a stock of reading glasses.

In general, there are different types of microfinance models for micro-entrepreneurs to obtain micro-loans:

1) Self-help groups (SHG)/ Rotating Savings and Credits Associations (ROSCAs). A community of the poor can form self-help groups, where all members bring savings to weekly (or monthly) meetings, and one of the members receives the weekly savings from other members as a loan (Ardener 1995, Snow 1999). Clearly, this approach will be difficult to use for working capital funding although it might be useful for a micro-entrepreneur to purchase capital goods like a bicycle.

2) Community banks. These banks seek to stimulate economic development (in terms of business and job creation) for their communities. Grameen Bank uses "group lending" to reduce its screening, monitoring and collection costs: all members in a group are responsible to provide the repayment when one of the members is behind (Foroohar 2010). Group

lending for working capital funding may be particularly beneficial if all members of the group are suppliers or distributors in the same supply chain and both materials and cash flows can be aggregated at the group level.

3) Peer-to-Peer Networks. Kiva is a person-to-person online lending organization that enables people in developed countries to provide micro-loans (Flannery 2007). So this could be used for funding micro-entrepreneurs wishing to be suppliers or distributors, but more for investment in capital goods rather than working capital.

4) Commercial MFIs: SKS is a for-profit, publicly traded microfinance organization in India that uses capital markets to scale up its operations quickly and uses information technology to reduce operating cost (Akula, 2008). Such a system could also be useful for working capital funding if micro-entrepreneurs can keep rotating balances.

Microfinance can be particularly compelling if lending is limited to working capital for the poor as suppliers or distributors over repeated transactions in supply chains. We can call this specialization **supply chain microfinance**. The fact that lending is limited to pre-paying for supplies from the poor or providing goods on terms to them for distribution limits the risk of the lender. Collection costs are also reduced because collection can piggyback on the transfer of goods. Repeated transactions increase trust, allowing for increased lending. Transaction costs and therefore interest rates are greatly reduced if we tie micro-lending to the actual transaction. Moreover, aggregation of suppliers or distributors can fit the group lending model well as we already noted.

For instance, if instead of a company selling to the micro-entrepreneurs on a cash basis could provide them the inventory on credit till the end of the day would limit the lender's risk to the value of one day's inventory (Sodhi and Tang 2013). Similarly, ITC could lend to farmers

before the sowing season and then gets its money back by receiving the produce when the farmer brings produce to ITC directly or receiving cash when he sells his produce on the mandi. Indeed, the social enterprise Arzu goes further into capital lending by renting out equipment and letting the women buy it over time through their role as suppliers of rugs. To our knowledge, this type of lending is rather limited in practice, with Vision Spring being more of an exception than a rule, and even Unilever sells its products to the women-micro-entrepreneurs on a cash basis.

4.1 Research Opportunities

Economists have studied microfinance since the early 1990s. Research topics include: (a) the value of microfinance (Armedáriz and Morduch 2007); (b) the effectiveness of those four microfinance models mentioned above (Komera 2008); (c) the impact of lending to women versus men (Pitt and Khandker 1998 and Kevane and Wydick 2001); (d) the determination of optimal interest-rate for lenders to charge for those micro-loans (Conning 1999); and (e) the impact of group lending versus individual lending especially when group lending enables group members to *screen*, *monitor*, and *enforce* each other's loans for reducing default risk (Karlan 2003; 2007).

Based on the economics literature on microfinance, the following are OM research opportunities in general and for working capital funding in particular: One opportunity with micro-lending in general is related to group lending and the group size. There are different economic theories on group lending– see Ghatak and Guinnane (1999) and Brau and Woller (2004) for comprehensive reviews. While Besley and Coate (1995) show that the group default risk is lower when the "social collateral" induced by the group is sufficiently high; however, Sadoulet (2000) argues that "social collateral" induced by group lending is not sufficient to reduce group default risk, albeit in a different setting. Therefore, there is an

opportunity for empirical research to test the assumption of risk reduction in group lending. The same could be applied to micro-entrepreneurs as distributors when provided with goods on inventory on a credit basis.

Another research opportunity deals with loan repayment. It would be of interest to determine the optimal loan repayment schedule that incorporates the following trade-offs: frequent repayment schedule reduces the amount of defaulted loans but it increases the lenders' cost of collection. If companies or social enterprises buying from or selling to the micro-entrepreneurs were to additionally offer micro-loans as working capital to these micro-entrepreneurs, the loan and its repayment could be tied to their performance as suppliers or distributors in terms of productivity or quality. For farmers particularly, it could be interesting if companies like ITC could arrange loans to procure seeds and other inputs, and then take the payment over time as the farmers bring the product to market.

A third research opportunity is screening micro-entrepreneurs for lending. To reduce the cost associated with default loans, there is a need to develop more effective ways to screen potential borrowers. Van Gool et al. (2012) find that traditional credit scoring adopted by retail banks is not yet ready to replace the human-intensive screening process conducted by MFIs. However, there are research opportunities about effective way to develop new credit scoring methods by analyzing the data captured by the financial transactions (remittances, loan repayments, payments) conducted over the mobile phones (Lee and Tang, 2012). Doing so makes even more sense if the enterprise buying from or selling to the micro-entrepreneur can share information on the financial transactions with the lender (if the lender is a third party). Indeed, researchers have used Kiva's online portal to examine how this information would affect lending behaviour among online lenders (Hartley 2010). This can be specialized to screening for distributors especially when the goods are being provided on credit.

However, the amount of goods being small in quantity, and the lending being limited to a single replenishment cycle, means that the risk is low so the screening need not be as intensive as lending in general.

5. Conclusion

We reviewed examples of supply-chain operations with the poor as suppliers of goods or services and those with the poor as distributors of finished goods. Moreover, we listed opportunities for OM research and provided some illustrative models as potential seeds for further analytical research. Finally, we discussed supply chain microfinance as a specialization of microfinance and have listed research opportunities tied to working capital lending for the poor as suppliers or distributors.

OM researchers may find that research in this area can inform supply chains for multinationals companies, given the external pressures from governments and consumer-advocacy groups as well as internal pressures from top executives. At the same time, these companies are interested in seeking "the next billion [consumers]" in developing countries (Vlad et al. 2011). However, because the existing supply chains are built solely to maximize profits, engaging the "poor as suppliers or distributors" would require re-building supply chains that are both profitable for the company and socially responsible (Lee 2010). We hope our paper will motivate OM researchers to explore the impact of engaging the poor as suppliers or distributors in distributors, helping enterprises make profits while also alleviating poverty.

Besides the research opportunities listed in Sections 2 through 4, there are other avenues for future research. These include:(1) exploring other business models in practice and in theory; (2) quantifying the value created by different social business models; (3) dividing this value

between the enterprise with market power and an individual micro-entrepreneur who has none; (4) exploring the similarities and differences between social business models in *developing* countries with poverty and *developed* countries; (5) seeking to explain the failures of less successful social businesses and enterprises via supply-chain design or transaction costs, and (6) studying the characteristics of supply chain structures that we call *thistle-shaped* to depict the highly arborescent networks with the poor as suppliers or distributors.

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Notes

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[1]Disintermediation is beneficial to the farmer because it reduces vertical competition. In addition to this benefit, disintermediation can mitigate the "bullwhip effect" as well. This is because, by reducing the number of layers, it is easier for the supply chain partners to communicate and coordinate their planning activities (Lee et al. 1997), and (Sodhi and Tang 2011)).

[2]For simplicity, we assume these middlemen do not add any value except handling the transaction. Also, to simplify our exposition, we assume the unit processing cost of each middleman is zero.

[3]We wish to thank an anonymous referee for suggesting us to explore this idea.

[4] Here, we do not model the auction mechanism at the mandis explicitly. Instead, we assume that ITC can use historical trading prices to forecast the future trading prices at the mandi.

[5]We can obtain similar structural result when either the warehouse or the retailers canhold inventories but not both. For example, when the warehouse does not hold inventory, one can use the approach as described in Garg and Tang (1997), Erkip et al. (1990), and Eppen and Schrage (1981) to determine the expression for the expected inventory level in the system. Then by using the same approach, we can identify the conditions under which it is more effective for the retailers to refer their customers to collect their product at the warehouse. To avoid repetition, we omit the analysis of this setting.