Financial Access or Price Premiums? A Nuanced View into Improving Farmer Welfare and Reducing Child Labor in Commodity Supply Chains

Andre P. Calmon, Andreas K. Gernert, Dan A. Iancu, and Luk N. Van Wassenhove

Abstract Millions of smallholder farming households engaged in the production of agricultural commodities grapple with poverty and resort to their children's labor to boost production and enhance their living conditions. In response, governments, commodity-buying firms, micro-finance institutions, and non-profits have initiated various interventions to improve household welfare and mitigate child labor, but the effectiveness of these interventions remains uncertain. Drawing inspiration from cocoa supply chains, we propose a model that captures a farming household's need to secure basic subsistence, alongside its decisions on borrowing, saving, consumption, and the reliance on child labor for farm production. With this model, we evaluate the effects of common financial interventions, including improved access to credit and savings and the implementation of price premiums, examining their impacts on household welfare, immediate consumption, and child labor usage. Our analysis reveals a complex landscape: improved access to credit can either decrease or inadvertently increase child labor, depending on whether households borrow for subsistence or discretionary expenses. Conversely, enhancing access to savings invariably curtails child labor but might simultaneously depress household consumption. Furthermore, price premiums can effectively diminish child labor usage only when they are significantly large; otherwise, they may inadvertently incentivize increased child labor. These results highlight the dual-edged nature of financial interventions and underscore the critical need for tailoring strategies to the specific operational dynamics of farming households, ensuring interventions do not inadvertently exacerbate the issues they aim to resolve.

Andre P. Calmon
Georgia Institute of Technology - Scheller College of Business, e-mail: andre.calmon@gatech.edu

Andreas K. Gernert
Kühne Logistics University - Department of Logistics, e-mail: andreas.gernert@klu.org

Dan A. Iancu
Stanford University - Stanford Graduate School of Business, e-mail: daniancu@stanford.edu

Luk N. Van Wassenhove
INSEAD - Technology and Operations Management Area, e-mail: luk.van-wassenhove@insead.edu

1 Introduction

Child labor is a profound challenge that continues to impact individuals and communities across many value chains. Over 80 million children in Sub-Saharan Africa are engaged in child labor, with a majority of them doing hazardous agricultural work.[1] Although child labor has decreased in most of the world, the proportion of children engaged in child labor in Sub-Saharan Africa has grown over the last few years and is expected to continue growing over the next decade [52]. Child labor is a particularly serious problem in the cocoa supply chains of Côte d'Ivoire and Ghana, where nearly 1.5 million children, or over 40% of children in cocoa-producing households, engage in hazardous child labor in cocoa farms [49]. Although the labor occurs primarily on family farms and contributes significantly to the household labor force [41, 47], its repercussions are profound, exposing children to dangerous working conditions, hampering their educational opportunities, and feeding a perpetual cycle of poverty and underdevelopment [10]. Moreover, the practice contradicts several international labor standards, raising ethical concerns in global trading networks [31].

The underlying causes of child labor in commodity supply chains are varied and complex. For example, cocoa-producing households often face food insecurity and scarcity of basic goods, which compels children to work to ensure basic subsistence [30]. Additionally, the lack of modern equipment and the limited availability of hired labor can perpetuate the practice even in households that are beyond basic subsistence, as they seek to improve their productivity and increase their cocoa income [40, 53, 23, 21]. Other factors like inadequate access to quality, affordable education or health facilities can exacerbate the situation by leaving children with few alternatives to farm labor [55].

In response, many interested parties have launched a range of interventions to address some of the underlying root causes of child labor while ensuring the economic prosperity of smallholder farmers. Two such examples, which we discuss more extensively in this chapter, include facilitating financial access (specifically, by offering loans with lower interest rates or savings accounts with higher interest rates) and paying a price premium for the smallholders' farm output. Facilitating financial access has been a priority for microfinance institutions, development banks, and governments in numerous developing economies, with many interventions specifically aimed at curbing child labor [26, 48]. Paying price premiums – particularly for responsibly produced goods – has long been advocated by NGOs and governmental agencies, and buyers of commodities like palm oil, coffee, or cocoa have been increasingly collaborating with certification bodies on their implementation [5, 25]. Our research is, in fact, motivated by collaborations with the International Cocoa Initiative (ICI, a non-profit organization) and Tony's Chocolonely (a chocolate manufacturer), which are spearheading many of the efforts to combat child labor and improve the livelihoods of cocoa farmers in Ghana and Ivory Coast [1, 51].

These interventions share a common goal – to alter the circumstances that farmers face, thereby reducing the incentives for and necessity of child labor – but their effectiveness remains in many cases inconclusive [47]. For example, improving farmers' access to credit might alleviate the financial burden, but it could also increase investments in agricultural activities and inadvertently increase child labor. Similarly, higher cocoa prices could raise the marginal value of each farm's output and incentivize more child labor during harvest seasons. As a result, practitioners, NGOs, and academics have emphasized the need for research that sheds light on the tradeoffs and the effectiveness of interventions that address child labor [42].

With this motivation, we develop a general model to examine the impact of financial access and price premiums on a smallholder household that produces and sells an agricultural commodity in a global value chain. The household faces immediate liquidity constraints and consumption constraints (related to meeting basic subsistence), as well as uncertainty of its future farm production. To meet its immediate consumption,

[1] This includes working with sharp tools, carrying heavy loads, or working with agrochemicals.

the household can borrow money at a predetermined interest rate, and it can also accrue interest on its savings, albeit at a potentially different interest rate. The household decides its immediate consumption, how much to borrow and save, and how much child labor to use on the farm. Child labor incurs a disutility but can improve the future farm output and, thus, the income generated by selling it. The household's objective is to maximize a combination of immediate utility (tied to its immediate consumption and its use of child labor) and expected end-of-season value (tied to its financial position after producing and selling its farm output and paying back its loans).

We use the model to examine three interventions and quantify their impact on the household. We consider two measures of financial access: improved access to credit (through a reduction in the interest rate for borrowing) and improved access to savings (through an increase in the interest rate accrued on savings). And we consider price premiums in the form of an increase in the per-unit price paid to the household for its farm output. We quantify three metrics of interest of the household, namely its total overall welfare, its immediate consumption, and its child labor use.

We find that improved access to credit increases the household's overall welfare and its immediate consumption, but its impact on child labor is subtle and critically depends on the purpose of the borrowed funds. For an extremely poor household that is forced to borrow to support basic subsistence, improved access to credit *lowers* the reliance on child labor by alleviating the household's substantial debt burden without increasing its incentives to consume. In contrast, a household that borrows to support discretionary spending consumes more when loans become cheaper, and its use of child labor *increases* to offset the added financial burden from the larger consumption.

Improved access to savings also increases welfare and never increases child labor use, but has a more complex impact on the household's immediate consumption. Because a higher interest rate on savings means that the household could save less and consume more without affecting its future financial status, we find that in some cases, the household will *increase* its immediate consumption. But a higher interest rate on savings could also constitute an attractive financial opportunity, so the household might prefer to *reduce* its immediate consumption and set more money aside. Importantly, improved access to savings would not help the poorest households, which borrow and cannot afford savings in the first place.

Lastly, earning a higher price for its output also increases the household's welfare and consumption, but the impact on child labor is again nuanced. When the premium is not very large, it creates a complementary effect by increasing the marginal value of labor and thus leads to *more* child labor on the farm. In contrast, a sufficiently large price premium leads to a reduction in child labor, irrespective of whether the household is borrowing or saving; but the premiums required can be very large (and, in some cases, infinite).

Our findings thus reveal a complex landscape where no single intervention is best, and all interventions have positive as well as negative aspects. This underscores the importance of detailed analyses to understand the impact of other interventions and the need to tailor interventions to each household's specific operational and financial context.

The remainder of the chapter is structured as follows: §2 positions our results in the context of related academic literature and industry white papers; §3 outlines our analytical model; §4 formalizes our results and discusses our findings; finally, §5 discusses managerial and policy implications, and outlines a few directions for future research.

2 Literature Review

Studies have shown that child labor in agriculture, particularly in demanding industries like cocoa farming, is associated with higher school dropout rates, lower educational attainment, and compromised physical and cognitive development (see Ibrahim et al. [29] for an extensive literature review). For instance, Beegle et al. [10] utilize data from Vietnam and an instrumental variables strategy to document significant negative impacts of child labor on school participation and educational attainment. Bhalotra and Heady [11] find that children tend to work more in households with more land due to market failures for labor, land, and financing.

There are decades of economics literature that examines policies to reduce child labor [9, 7]. Doepke and Zilibotti [20], Maffei et al. [38], and Dessy and Knowles [19] examine the effects of child labor bans, increased punishment of child labor, and mandatory schooling on a household's usage of child labor. In a model that captures savings for adults and bequests to children, Baland and Robinson [6] show that stricter child labor policies can lead to Pareto-Improvements. Basu et al. [8] show that establishing functioning labor markets can help to reduce child labor. While these papers focus on governmental policies or labor market interventions, we complement them by studying financial interventions and their effect on farming operations.

Several empirical studies focus on the effect of access to finance on child labor and price subsidies. Edmonds and Theoharides [22] and Hossain [28] used data from randomized control trials to analyze the effects of microcredits on child labor in Bangladesh and Vietnam, respectively. They find that such microcredits, which can be used for investments in various productivity-increasing purposes, lead to more child labor. The same is observed in Hazarika and Sarangi [27] who based their empirical study on the 1995 data drawn from the Malawi Financial Markets and Food Security Survey, in which hundreds of rural Malawian households were surveyed [27]. Similarly, Jacoby [32] finds in the 1994 Peruvian Living Standards Survey that child labor is more likely in households that borrow. Our work complements and provides nuance to these studies by showing that cheaper capital can decrease child labor use for extremely poor households while increasing child labor in households that borrow for discretionary consumption, even when the borrowed capital is not used to improve productivity. Baland and Robinson [6] show that a household's inability to borrow may lead to increased child labor relative to the socially optimal level; in contrast, we show that child labor may actually increase even further when credit becomes cheaper. Luckstead et al. [37] calibrate a smallholder farm model and estimate that a 2.81% cocoa price premium would eliminate the worst forms of child labor; yet, our model that captures intertemporal wealth transfers via borrowing and savings calls for caution when it comes to small premiums.

In the analytical models by Ranjan [45] and Jafarey and Lahiri [33], household heads may borrow in varying degrees for consumption. These papers show that poverty, in combination with the absence of credit markets, leads to child labor and less education. While Ranjan [45] shows that child labor may reduce household welfare and proposes other interventions, Jafarey and Lahiri [33] compares access to local credit markets and access to perfect international credit markets concerning their effect on child labor. Ranjan [46] examines the influence of a household's initial budget and the wage children can earn on a household's reliance on child labor. Our paper complements Ranjan [45], Ranjan [46], and Jafarey and Lahiri [33] in several ways. First, our operational model is significantly more general and allows for a stochastic outcome from using child labor that could even have negative marginal value in some states of the world; this is important in settings like those motivating our study, where child labor is used to produce commodities that are later sold to generate income. Second, we capture extreme poverty by integrating a consumption constraint. Third, we capture different ways borrowing and saving markets are established. These features allow us to derive new insights into the emergence of child labor. For example, we show that while better access to borrowing may increase or decrease child labor depending on whether a household is constrained or unconstrained households, better access to savings always reduces child labor.

Monitoring, certification, and auditing to ensure sustainable or responsible operations is a topic that has received increasing attention from the operations management community [14, 34, 44, 24]. For instance, and specific to child labor, Cho et al. [16] investigates auditing and pricing decisions by a large firm that tries to reduce child labor in its supply chain. These papers typically consider high-level, strategic interactions between supply chain participants; in contrast, our unit of analysis is a household that supplies commodities and decides whether to use child labor. A related topic that has received attention in the operations literature concerns itself with the effect of wealth and liquidity constraints on the effectiveness of operations strategy in low-income countries; for example, Calmon et al. [13] examine how a household's wealth shapes the optimal distribution strategy of life-improving goods and customer welfare, as well as the distributor's investment in finance and marketing. Different from Calmon et al. [13], our emphasis is on examining the effect of interventions on child labor.

Lastly, a different stream of related literature is the ample body of work dealing with smallholder farmers. The economics literature has studied smallholder farmers since the 1960s, and Angelsen [4] offers a good overview. In the operations community, researchers have devoted significantly more attention to this topic in recent years (see, e.g., [3, 36]). Chintapalli and Tang [15] and Pay et al. [43] compare different financing strategies that a government can use to support smallholder farmers, whereas de Zegher et al. [17, 18], Warnes et al. [54] and Yi et al. [56] analyze market-based solutions to support smallholder farmers, and Tang et al. [50] compare input and output subsidies. We complement this stream of work by examining the impact of interventions (including improved access to finance and price premiums) on the welfare of smallholder farmer households and their use of child labor on the farm.

3 Model

Consider a household with an initial capital budget of $x \geq 0$ at the start of the farming season, which makes four major decisions: how much money c to use for consumption during the season, how much money b to borrow, how much money to save, and how much child labor ℓ to use on the farm. Following literature in operations management and economics [45, 6, 33, 18], we assume that all decisions are made simultaneously at the start of the season.

Motivated by Maslow's hierarchy of needs [39] and following Basu and Van [9], we model the household's consumption during the season c by distinguishing between consumption for *subsistence* and *discretionary* consumption. The subsistence level $c_S \geq 0$ is the minimum consumption that the household must have to maintain a basic subsistence level. Thus, the total consumption c during the season must satisfy the constraint $c \geq c_S$. Subsistence consumption is a salient feature of our motivating context because many cocoa-producing households are very poor: 88% of cocoa-producing households live below Fairtrade International's minimum livable income level of $2.5 per day per person [2]. The household can, of course, consume more than c_S, so the additional consumption $c - c_S$ is discretionary. However, the household does not consume more than what its initial budget and the borrowed amount would allow, i.e., $c \leq x + b$.

When consuming $c \geq 0$, the household derives utility $u_1(c)$, where $u_1'(c) \geq 0$ and $u_1''(c) \leq 0$. We assume that u_1 has a coefficient of relative risk aversion (CRRA) of at most 1, i.e., $-cu_1''(c)/u_1'(c) \leq 1$ for any $c \geq 0$. This assumption is satisfied by many utilities in practice, including $u_1(c) = (c^{1-\rho} - 1)/(1-\rho)$ for $\rho \in [0, 1)$ and the logarithmic utility $u(c) = \log c$, and is common in microeconomic models [45].

Using child labor can improve the household's end-of-season income, albeit at the expense of incurring some disutility. For simplicity and to isolate the effects, we assume that child labor is the only flexible input

available to the household.[2] When using child labor ℓ, the household's farm output during the season is $q(\ell, \mathcal{W})$, where $\mathcal{W}$ is a random shock that captures several sources of uncertainty, such as weather and pests that impact the crop yield. Child labor does not lead to financial costs, but, as in Basu et al. [8] and Maffei et al. [38], it incurs a disutility $d(\ell)$, where $d'(\ell) \geq 0$ and $d''(\ell) \geq 0$. We assume the disutility occurs immediately, but our model readily accommodates a future disutility, e.g., as a result of lost wages. Consistent with standard microeconomic theory and with practice, we assume that the farm has some output without any child labor and that relying on child labor improves the output, at diminishing returns; that is, $q(0, \mathcal{W}) \geq 0, \partial q/\partial \ell \geq 0$, and $\partial^2 q/\partial \ell^2 \leq 0$. Producing the crop also incurs a financial cost of $c_o(\mathcal{W})$ per unit of output produced (e.g., related to processing or transporting the output after harvest), and the household sells all its output at a known price p. We assume that the price paid is sufficiently large to ensure a non-negative profit margin, i.e., $p \geq c_o(\mathcal{W})$ for all $\mathcal{W}$.

The household can borrow money for consumption and can save money that is not consumed. Specifically, the household can borrow any amount b at an interest rate $r_b \geq 0$, with the entire loan repayment consisting of interest and principal, $(1 + r_b) \cdot b$, due at the end of the current season. The household can also save any remaining cash not consumed during the season at an interest rate $r_s \geq 0$ satisfying $r_s \leq r_b$. Thus, the household's end-of-season financial position x' is given by any cash savings plus any income from selling its farm output minus any borrowing costs:

$$x' = (1 + r_s) \cdot (x + b - c) + \big(p - c_o(\mathcal{W})\big) \cdot q(\ell, \mathcal{W}) - (1 + r_b) \cdot b. \tag{1}$$

Following other literature in operations [35, 18], we consider a soft model of bankruptcy, so if the household cannot repay the entire loan from its available cash in the next period (i.e., if $x' < 0$), it will incur a suitable penalty, as discussed next.

When evaluating its end-of-season financial position, the household discounts the future and assigns a decreasing marginal value to improved wealth status. Specifically, the value assigned at the start of the season to the uncertain end-of-season financial position x' is $\beta \cdot \mathbb{E}[u_2(x')]$, where $\beta \in (0, 1)$ is a discount factor and u_2 is an increasing and concave function, $u_2' \geq 0, u_2'' \leq 0$. This models a bankruptcy penalty[3] as well as future utility from consumption (or reinvestment) of any remaining budget. We assume that u_2 has hyperbolic absolute risk aversion (HARA), i.e., it satisfies $u_2'(x') = -(Ax' + B)u_2''(x')$, where $A\,x' + B \geq 0$ for the range of interest for x'. Many common utility functions encountered in the literature, including quadratic, exponential, power or logarithmic, satisfy this condition, so the requirement is not too restrictive.

In summary, the household chooses the consumption c subject to the constraints $c_S \leq c \leq x + b$ and the amount of child labor $\ell \geq 0$ and the borrowed amount $b \geq 0$ to maximize the objective:

$$V(\ell, c, b) := u_1(c) - d(\ell) + \beta \cdot \mathbb{E}\Big[u_2\Big(\big(p - c_o(\mathcal{W})\big) \cdot q(\ell, \mathcal{W}) + (1 + r_s) \cdot (x - c) - (r_b - r_s) \cdot b\Big)\Big]. \tag{2}$$

We remark that several of our modeling primitives can be significantly generalized. For instance, the assumption that the price is known or that the profit margin is always positive can be relaxed, more general functional forms for the household's revenues and costs can be used, and the model can also accommodate a cost related to the farm's use of inputs. We refer the reader to the full paper [12] for details and proof of all our technical results.

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[2] Consistent with Baland and Robinson [6], Doepke and Zilibotti [20], Maffei et al. [38], we assume that adults work full-time and that this is already reflected in the production function q. The lack of labor for hire is consistent with realities facing smallholder farmers.

[3] Under the natural assumption that the household always borrows from the cheapest sources first, a penalty $p(x')$ satisfying $p' \leq 0$, $p'' \geq 0$ and $p(x') = 0$ for $x' \geq 0$ can capture the cost of borrowing an amount $\max(x', 0)$ in the future to repay any outstanding debt.

4 Analysis and Insights

We now investigate how improved financial access or paying a price premium impacts the household. We examine two forms of improved financial access: improved access to credit through a decrease in the interest rate for borrowing r_b or improved access to savings through an increase in the interest rate for saving r_s. To model the price premium offered by some commodity buyers, we consider increases in the price p that the household receives for its farm output.

Consistent with studies in child labor and family welfare, we examine several outcomes of interest: the household's general welfare, its consumption during the immediate season, and its use of child labor. Subsequently, we denote the optimal objective in the household's problem by V^* (and refer to it as "welfare"), and its optimal consumption, child labor, and borrowing decisions by c^*, ℓ^*, and b^*, respectively. To avoid technicalities, we assume that the optimal solution is unique and (c^*, ℓ^*) satisfies $c^* < \infty$ and $\ell^* \in (0, \infty)$. We use increasing and decreasing in a weak sense throughout.

Our first result characterizes the impact of changing the borrowing interest rate r_b. Because this affects those households that optimally choose to borrow ($b^* = c^* - x > 0$), the case already qualitatively captures "poorer" households, which do not save any of their budget for the future. However, the result draws a further stark distinction between two qualitatively different types of households: (i) those that are so poor that they are forced to borrow to support subsistence consumption (i.e., households with $x < c_S$) versus (ii) those that can afford to cover their subsistence from their initial budget, but prefer to borrow to expand their consumption (i.e., households with $c_S \leq x < c^*$).[4]

Proposition 1 *When the borrowing interest rate r_b increases,*
(i) the household's welfare decreases, i.e., $\frac{\partial V^*}{\partial r_b} \leq 0$;
(ii) the household's immediate consumption decreases, i.e., $\frac{\partial c^*}{\partial r_b} \leq 0$;
(iii) the household's use of child labor increases if the household is borrowing to be able to consume the subsistence level (i.e., $\frac{\partial \ell^*}{\partial r_b} \geq 0$ if $x < c_S$) and decreases otherwise.

Improved access to credit (i.e., a lower r_b) increases both the overall welfare and the immediate consumption of households. That welfare increases is intuitive and follows because improved access to credit – like all other interventions considered here – will increase the household's objective under any set of decisions. That immediate consumption also increases is slightly more subtle, but follows because loans are only used to support consumption in our model, so improved access to credit makes consumption more appealing in relative terms and does not improve any investment opportunities.

Critically, improved access to credit may either increase or decrease the household's use of child labor, depending on the *type of consumption* that the loan supports. Cheaper credit *reduces* child labor use for extremely poor households that are forced to borrow to ensure their basic subsistence consumption, i.e., have $x < c_S$. For such households, the debt burden is so high – due to the large loans and large interest rates – that the first-order effect of improved credit access is not to strictly increase immediate consumption, but rather to reduce the debt needed to support it; in turn, this significantly improves the household's future prospects and requires less child labor for farm production. In contrast, improved credit *increases* child labor use for those households that borrow for *discretionary* consumption. Such households leverage the reduced borrowing costs to borrow and strictly increase their immediate consumption, but the extra burden created leads the household to compensate by using more child labor to improve farm production.

[4] Note that all households that have $x \leq c_S$ and choose to borrow must have $c^* > c_S$.

Our next result deals with the prospect of improved savings; this applies to relatively "richer" households, which are endowed with sufficient capital to support their desired immediate consumption without borrowing (i.e., $x > c^*$) and can afford to save money for the future.

Proposition 2 *When the saving interest rate r_s increases,*
(i) the household's welfare increases, $\frac{\partial V^*}{\partial r_s} \geq 0$;
(ii) the household's use of child labor decreases, $\frac{\partial \ell^*}{\partial r_s} \leq 0$;
(iii) the household's consumption during the season may either increase or decrease, i.e., $\frac{\partial c^*}{\partial r_s} < 0$ and $\frac{\partial c^*}{\partial r_s} > 0$ are both possible, depending on problem parameters.

For such households, improved access to savings increases welfare (which, as discussed, is rather expected) but also reduces reliance on child labor. The latter follows because the increased interest rate on savings effectively acts as a riskless opportunity to increase the household's future earnings, which allows to marginally reduce the income that is needed from farm production and thus reducing the use of child labor.

The impact on immediate consumption, however, is more nuanced because two forces are at play. On the one hand, the improved access to savings allows the household to increase immediate consumption without affecting its future financial position. But on the other hand, improved access also constitutes an "investment" opportunity, which could lead the household to reduce its immediate consumption so as to to increase its investment and thus its future financial position. Naturally, this entire case could only impact households that are already sufficiently rich to afford a consumption that exceeds the subsistence level (i.e., $x > c_S$), so the reduction in immediate consumption is less a symptom of poverty and more a response to an attractive financial opportunity.

Our final result summarizes the effects of paying a price premium for the household's farm output.

Proposition 3 *Under our standing assumptions, when the price p increases,*
(i) the household's welfare increases, i.e., $\frac{\partial V^*}{\partial p} \geq 0$;
(ii) the household's consumption increases, i.e., $\frac{\partial c^*}{\partial p} \geq 0$;
(iii) the household's use of child labor decreases if and only if the price is sufficiently high, i.e., $\frac{\partial \ell^*}{\partial p} \geq 0$ if and only if $p > \bar{p}$ (where the threshold $\bar{p}$ could possibly be $+\infty$).

Like the improved access to credit, a price premium increases both the household's welfare and its immediate consumption. The rationale is similar: the premium increases the household's income at the end of the season without directly impacting the incentives to (refrain from) consumption, and the improved financial position enables the household to smoothen its consumption across the two periods and increase its immediate consumption.

However, the price premium only reduces child labor if it is high enough, and in some cases it may never succeed to do so. This happens because the price premium, which has a multiplicative effect on the household's income, yields two competing incentives to rely on child labor. On the one hand, because a higher price increases the household's mean income, it may increase its propensity to rely on child labor through a complementarity effect (higher prices make the farm's output more valuable, hence the marginal value of productive inputs, such as child labor, grows). On the other hand, the price also increases the variability (e.g., the standard deviation) of the household's income, and such variability is detrimental because the household is risk-averse in evaluating its future financial status. The latter effect may become particularly pronounced when prices are very large, which leads to both small marginal gains in value and high income variability, in which case the latter effect could dominate the former and lead to a reduction in child labor. However, instances exist when the latter effect is never sufficiently strong and the household would always raise its use of child labor as prices rise.

5 Discussion and Concluding Remarks

In comparing the three interventions, several lessons emerge from our analysis of their impact on the household's overall welfare, immediate consumption, and use of child labor.

Although all interventions we considered improve the welfare by design – because each improves the conditions facing the household, at least in a weak sense – the magnitude of the impact may not be uniform across households. Having access to cheaper credit or to savings accounts would only strictly help those households that borrow or save, respectively.[5] In contrast, a price premium would deliver strict improvements in welfare for any type of household, irrespective of its borrowing and saving behavior.

As for improving consumption, the outcomes are slightly more nuanced. Access to credit only increases immediate consumption for those households that borrow to support discretionary consumption, but it leaves immediate consumption unchanged for households that are either very poor (i.e., forced to borrow to meet basic subsistence) or sufficiently rich that they do not need to borrow to support their desired consumption. Access to savings also cannot improve immediate consumption for the very poor households that cannot afford to save, but does improve immediate consumption for the richer households, except in the (albeit rather exceptional) situation when a household views savings as such an appealing financial opportunity that it warrants refraining from consuming for the sake of making a bigger investment. Yet again, a price premium strictly improves consumption uniformly, for any type of household.

Lastly, the three interventions differ substantially in their impact on child labor. Improved access to credit is most effective in reducing child labor for the poorest households that borrow to support basic subsistence, but could actually backfire and result in increased child labor among households that borrow for discretionary consumption. Improved access to savings may appear as best on the surface because it can never lead to strict increases in child labor, but it is important to recall that this intervention would carry no effect – neither increasing nor decreasing child labor use – in households that are unable to save and instead borrow. Lastly, a price premium may lead to less child labor across all households, but only in case premiums are sufficiently high; otherwise, price premiums backfire and result in increased child labor.

That no single intervention emerges as the best one also implies that tailoring the intervention to the specific circumstances facing each household is critical in practice, especially if one seeks improvements along all three metrics – welfare, immediate consumption, and child labor – and for all types of households.

Our model has limitations and caveats that warrant discussion and require further research. For example, the model ignores the possibility of a market for hired labor; if instead we assumed that hired labor could be purchased at a suitable cost, this could substitute child labor and some interventions could become more nuanced, e.g., reducing borrowing costs could lead to an increased use of hired labor relative to child labor, while possibly inducing extra consumption. Additionally, modeling other costly inputs (such as fertilizer or better seeds) that the household could purchase and use to improve farm yields could impact both the household's financial position as well as the marginal value of child labor, leading to additional nontrivial interactions. Considering a multi-period model could capture significantly more realistic behavior, such as the possibility of long-term investments or interventions, the possibility that the same household might have savings in some time periods while borrowing at other times, or the option to implement more complex, conditional incentives. Future research could also be devoted to examining the effectiveness of other interventions or to empirically testing the disparate impact of child-labor-reducing interventions among richer and poorer commodity-producing households.

[5] When allowing for the possibility that the same household might borrow in some seasons but save in others, each intervention could yield strict improvements for any given household over the long run.

Child labor remains a profound challenge with multiple causes and with complex, long-term negative impact on the lives of many individuals and communities. The Operations Management academic community is well equipped to develop innovative interventions and tools to measure and tackle this issue, and our hope is that these results and insights will spur more interest and more effort in addressing this important issue.

References

[1] Aboa, A. (2020). Child labour on Ivory Coast cocoa farms rises during pandemic, study finds. *Reuters* (July 1).

[2] Aboa, A. and Bavier, J. (2019). Industry doubts remain over Ivory Coast, Ghana cocoa floor price. *Reuters* (July 3).

[3] An, J., Cho, S.-H., and Tang, C. S. (2015). Aggregating smallholder farmers in emerging economies. *Production and Operations Management*, 24(9):1414–1429.

[4] Angelsen, A. (1999). Agricultural expansion and deforestation: modelling the impact of population, market forces and property rights. *Journal of Development Economics*, 58(1):185–218.

[5] Aziz, A. (2020). How The Netherland's No. 1 Chocolate Brand, Tony's Chocolonely, Is Winning Fans In The U.S.—And Helping People Vote. *Forbes* (October 30).

[6] Baland, J.-M. and Robinson, J. A. (2000). Is child labor inefficient? *Journal of Political Economy*, 108(4):663–679.

[7] Basu, K. (1999). Child labor: cause, consequence, and cure, with remarks on international labor standards. *Journal of Economic Literature*, 37(3):1083–1119.

[8] Basu, K., Das, S., and Dutta, B. (2010). Child labor and household wealth: Theory and empirical evidence of an inverted-u. *Journal of Development Economics*, 91(1):8–14.

[9] Basu, K. and Van, P. H. (1998). The economics of child labor. *American Economic Review*, 88(3):412–427.

[10] Beegle, K., Dehejia, R., and Gatti, R. (2009). Why should we care about child labor?: The education, labor market, and health consequences of child labor. *Journal of Human Resources*, 44(4):663–684.

[11] Bhalotra, S. and Heady, C. (2003). Child farm labor: The wealth paradox. *The World Bank Economic Review*, 17(2):197–227.

[12] Calmon, A. P., Gernert, A. K., Iancu, D. A., and Van Wassenhove, L. N. (2024). An operational view into improving farmer welfare and reducing child labor in commodity supply chains. *Working Paper*.

[13] Calmon, A. P., Jue-Rajasingh, D., Romero, G., and Stenson, J. (2022). Operational strategies for distributing durable goods in the base of the pyramid. *Manufacturing & Service Operations Management*, 24(4):1887–1905.

[14] Chen, L. and Lee, H. L. (2017). Sourcing under supplier responsibility risk: The effects of certification, audit, and contingency payment. *Management Science*, 63(9):2795–2812.

[15] Chintapalli, P. and Tang, C. S. (2022). Crop minimum support price versus cost subsidy: Farmer and consumer welfare. *Production and Operations Management*, 31(4):1753–1769.

[16] Cho, S.-H., Fang, X., Tayur, S., and Xu, Y. (2019). Combating child labor: Incentives and information disclosure in global supply chains. *Manufacturing & Service Operations Management*, 21(3):692–711.

[17] de Zegher, J., Iancu, D. A., and Lee, H. L. (2019). Designing contracts and sourcing channels to create shared value. *Manufacturing & Service Operations Management*, 21(2):271–289.

[18] de Zegher, J. F., Iancu, D. A., and Plambeck, E. L. (2018). Sustaining smallholders and rainforests by eliminating payment delay in a commodity supply chain—it takes a village.

[19] Dessy, S. and Knowles, J. (2008). Why is child labor illegal? *European Economic Review*, 52(7):1275–1311.
[20] Doepke, M. and Zilibotti, F. (2005). The macroeconomics of child labor regulation. *American Economic Review*, 95(5):1492–1524.
[21] DW (2020). Cocoa farming, cheap chocolate and child labor. *DW*.
[22] Edmonds, E. and Theoharides, C. (2020). The short term impact of a productive asset transfer in families with child labor: Experimental evidence from the Philippines. *Journal of Development Economics*, 146:102486.
[23] Foubert, L. (2016). Risk models for predicting child labour. *ICI*.
[24] Ha, A. Y., Shang, W., and Wang, Y. (2023). Supplier audit information sharing and responsible sourcing. *Management Science*, 69(1):308–324.
[25] Harris, S. (2021). Ice cream giant Ben & Jerry's commits to paying cocoa farmers a living income in West Africa. *Forbes* (November 17).
[26] Hayford, K. (2021). Ghanas Cocoa Farmers Pension Scheme to enrol 1.5Million by October. *Cocoa Post* (June 23).
[27] Hazarika, G. and Sarangi, S. (2008). Household access to microcredit and child work in rural Malawi. *World Development*, 36(5):843–859.
[28] Hossain, M. A. (2023). Unintended Consequences of a Well-Intentioned Policy: Impact of Credit on Child Labor in Bangladesh. *Journal of Human Resources*, pages 0920–11179R2.
[29] Ibrahim, A., Abdalla, S. M., Jafer, M., Abdelgadir, J., and De Vries, N. (2019). Child labor and health: a systematic literature review of the impacts of child labor on child's health in low-and middle-income countries. *Journal of Public Health*, 41(1):18–26.
[30] ICI Cocoa Initiative (2022). Child labour in cocoa.
[31] ILO (2015). Child labour and education: progress, challenges and future directions.
[32] Jacoby, H. G. (1994). Borrowing constraints and progress through school: Evidence from Peru. *The Review of Economics and Statistics*, 76(1):151–160.
[33] Jafarey, S. and Lahiri, S. (2002). Will trade sanctions reduce child labour?: The role of credit markets. *Journal of Development Economics*, 68(1):137–156.
[34] Kalkanci, B. and Plambeck, E. L. (2020). Managing supplier social and environmental impacts with voluntary versus mandatory disclosure to investors. *Management Science*, 66(8):3311–3328.
[35] Li, L., Shubik, M., and Sobel, M. J. (2013). Control of dividends, capital subscriptions, and physical inventories. *Management Science*, 59(5):1107–1124.
[36] Liao, C.-N., Chen, Y.-J., and Tang, C. S. (2019). Information provision policies for improving farmer welfare in developing countries: Heterogeneous farmers and market selection. *Manufacturing & Service Operations Management*, 21(2):254–270.
[37] Luckstead, J., Tsiboe, F., and Nalley, L. L. (2019). Estimating the economic incentives necessary for eliminating child labor in ghanaian cocoa production. *PloS one*, 14(6):e0217230.
[38] Maffei, A., Raabe, N., and Ursprung, H. W. (2006). Political repression and child labour: theory and empirical evidence. *World Economy*, 29(2):211–239.
[39] Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, 50(4):370.
[40] Mondelēz International (2022). Tackling the root causes of child labour in cocoa farming.
[41] Nkamleu, G. B. and Kielland, A. (2006). Modeling farmers' decisions on child labor and schooling in the cocoa sector: a multinomial logit analysis in Côte d'Ivoire. *Agricultural Economics*, 35(3):319–333.
[42] NORC at the University of Chicago (2020). Norc final report: Assessing progress in reducing child labor in cocoa production in cocoa growing areas of côte d'ivoire and ghana.

[43] Pay, K., Singhvi, S., and Zheng, Y. (2022). Improving cash-constrained smallholder farmers' revenue: The role of government loans. *Available at SSRN 4135868*.
[44] Ramchandani, P., Bastani, H., and Wyatt, E. (2021). Unmasking human trafficking risk in commercial sex supply chains with machine learning. *Available at SSRN 3866259*.
[45] Ranjan, P. (1999). An economic analysis of child labor. *Economics Letters*, 64(1):99–105.
[46] Ranjan, P. (2001). Credit constraints and the phenomenon of child labor. *Journal of Development Economics*, 64(1):81–102.
[47] Ravetti, C. (2020). The effects of income changes on child labour: A review of evidence from smallholder agriculture. *ICI*.
[48] Riquet, C. (2021). Digital Financial Services for Cocoa Farmers in Côte d'Ivoire. *CGAP* (August 15).
[49] Sadhu, S., Kysia, K., Onyango, L., Zinnes, C., Lord, S., Monnard, A., and Arellano, I. (2020). Assessing progress in reducing child labor in cocoa production in cocoa growing areas of Côte d'Ivoire and Ghana. *NORC Final Report*, 202020.
[50] Tang, C. S., Wang, Y., and Zhao, M. (2023). The impact of input and output farm subsidies on farmer welfare, income disparity, and consumer surplus. *Management Science*.
[51] Thompson, M. (2021). A Dutch chocolate company's fight to end illegal child labor. *PBS* (July 11).
[52] UNICEF (2020). Child labour: Global estimates 2020, trends and the road forward.
[53] Vigneri, M., Sera, R., and Cardenas, A. (2016). Researching the Impact of Increased Cocoa Yields on the Labour Market and Child Labour Risk in Ghana and Côte d'Ivoire. *ICI Labour market research study*.
[54] Warnes, X., de Zegher, J., Iancu, D. A., and Plambeck, E. (2023). Area conditions and positive incentives: Engaging local communities to protect forests. *Working Paper*.
[55] World Cocoa Foundation (2022). Tackling child labor in the cocoa sector: An industry viewpoint of a work in progress.
[56] Yi, Z., Wang, Y., and Chen, Y.-J. (2021). Financing an agricultural supply chain with a capital-constrained smallholder farmer in developing economies. *Production and Operations Management*, 30(7):2102–2121.