ONLINE THEORETICAL APPENDIX
PERVERSE CONSEQUENCES OF WELL-INTENTIONED REGULATION: EVIDENCE FROM INDIA'S CHILD LABOR BAN

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1. Effects of a Child Labor Ban in a Model with Two Sectors

We consider an economy in which there are two sectors, agriculture and manufacturing (denoted by lower-case subscripts a and m respectively). Firms in these sectors have representative technologies, $Y_m = f_m(L_m)$ and $Y_a = f_a(L_a)$, where L_i is the effective units of labor in sector i. Child labor and adult labor are perfect substitutes up to a constant, γ, which is the same in both sectors; each unit of adult labor is equal to 1 unit of effective labor ($L_i^A = L_i$) and each unit of child labor is worth only γ units of effective labor ($L_i^C = \gamma L_i$). Furthermore, there is an imperfectly enforced ban on child labor, leading to a fine D being applied with probability p, which only applies to the manufacturing sector.[1,2] Both firms and households are take wages as a given.

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[1]A more general specification of the ban allows the probability of detection to vary non-linearly with the level of child labor, i.e. where $p(L)$. Since firms are more likely to be detected the more children they hire, $p(L)$ is increasing in the amount of child labor employed. Here we assume a very simple linear form of $p(L)$, i.e. $p(L) = pL$, where p is a constant. When p is large, a linear function may not be a suitable approximation for $p(L)$ as $p(L)$ may exceed 1 when both p and L are large. However, as discussed in the previous section, enforcement of the ban was perceived to be quite weak and thus p was likely to be very low. In this case, a linear specification as an approximation of $p(L)$ is more justifiable, as there is less concern that $p(L) > 1$.

[2]Note that this definition of imperfect enforcement is as in Basu (2005) and differs from that used in Basu and Van (1998), which specifies that the ban is perfectly enforced for a proportion of firms while the remainder of firms are unregulated. While most of the intuition is similar with this alternate definition of enforcement, the perfect enforcement assumption does change some of the predictions of the model. Most importantly, depending on size of labor demand from the perfectly enforced firms relative to the supply of adult labor, N, there are cases in which an imperfectly enforced ban on child labor (of the Basu and Van (1998) type) could increase adult wages and possibly decrease child labor. However, we model the imperfect enforcement as in the Basu (2005) model because we believe that this is more applicable to the way in which the *actual* 1986 ban was enforced and therefore is the most relevant for our empirical work.

Normalizing output prices to 1, we can thus say that a firm in sector a is solving

$$\max_{L_a^A, L_a^C} f(L_a^A + \gamma L_a^C) - w_a^A L_a^A - w_a^C L_a^C$$

and a firm in sector m will be solving

$$\max_{L_m^A, L_m^C} f(L_m^A + \gamma L_m^C) - w_m^A L_m^A - (w_m^C + pD) L_m^C.$$

As above, from the first order conditions it can be seen that if both children and adults are working in the agricultural sector, then $w_a^C = \gamma w_a^A$, and if both children and adults are working in the manufacturing sector, then $w_m^C = \gamma w_m^A - pD$.

There are N families in the entire economy, each endowed with 1 unit of adult labor which they supply inelastically, and m children who are endowed with 1 unit of labor. In addition to whatever income is provided by children, adult income in each family is assumed to be the average of the wages in each market.[3] Households only supply child labor when otherwise below the subsistence level s, and when they do so, they supply only enough labor to reach s.[4]

1.1. **Complete Mobility**

The case of complete mobility is discussed in Edmonds and Shrestha (2012a). The basic intuition is that without frictions limiting mobility between sectors, labor simply reallocates after a ban in one sector such that child labor flows out of the regulated sector and into the unregulated sector while adult labor flows in the opposition direction. There is no change in the overall level of child labor following a ban in one sector in the complete mobility case.

[3]This assumption is made to make the modeling of labor supply curves simpler. However, all of the qualitative results of the model go through as long as *either* there is at least partial labor mobility so that changes in the manufacturing market have effects on the agricultural market *or* some children who have access to the agricultural market have household income coming from the manufacturing sector. In the pre-ban data, we see that for those employed in agriculture, 23% live in a household where the head of the household works in manufacturing. Therefore it seems likely that a sizeable portion of the agricultural sector will be affected by the wages being paid in the manufacturing even if there were no mobility between sectors.

[4]The model in this paper is a one-period model. In a multiple period setting, binding liquidity constraints would be necessary to generate the following results. Earlier work (see for example Edmonds (2006) and Edmonds et al. (2010)) gives both direct and indirect evidence of the effect of liquidity constraints on child labor in the developing country setting.

1.2. **No Mobility**

To move to the case in which we have no mobility, we assume that both children and adults are only able to work in a single sector. The adults still supply labor inelastically, but now only in the sector they have access to, regardless of the wage. Thus, adult labor supply is

$$S_m^A(w_m, w_a) = \begin{cases} 1 \text{ if } k_m^A = 1 \\ 0 \text{ if } k_m^A = 0 \end{cases} \quad \text{and} \quad S_a^A(w_m, w_a) = \begin{cases} 1 \text{ if } k_m^A = 0 \\ 0 \text{ if } k_m^A = 1 \end{cases} \tag{1}$$

where $k_m^A = 1$ if the adult has access to the manufacturing sector, and $k_m^A = 0$ if the adult has access to the agricultural sector. Children face the same incentives as in the complete mobility case, but now their mobility is also restricted, so

$$S_m^C(w_m, w_a) = \begin{cases} 0 \text{ if } \frac{1}{2}(w_m + w_a) > s \text{ or } k_m^C = 0 \\ \min\left\{ \dfrac{s - \frac{1}{2}(w_m + w_a)}{\gamma w_m - pD}, m \right\} \text{ if } \frac{1}{2}(w_m + w_a) \leq s \text{ and } k_m^C = 1 \end{cases} \tag{2}$$

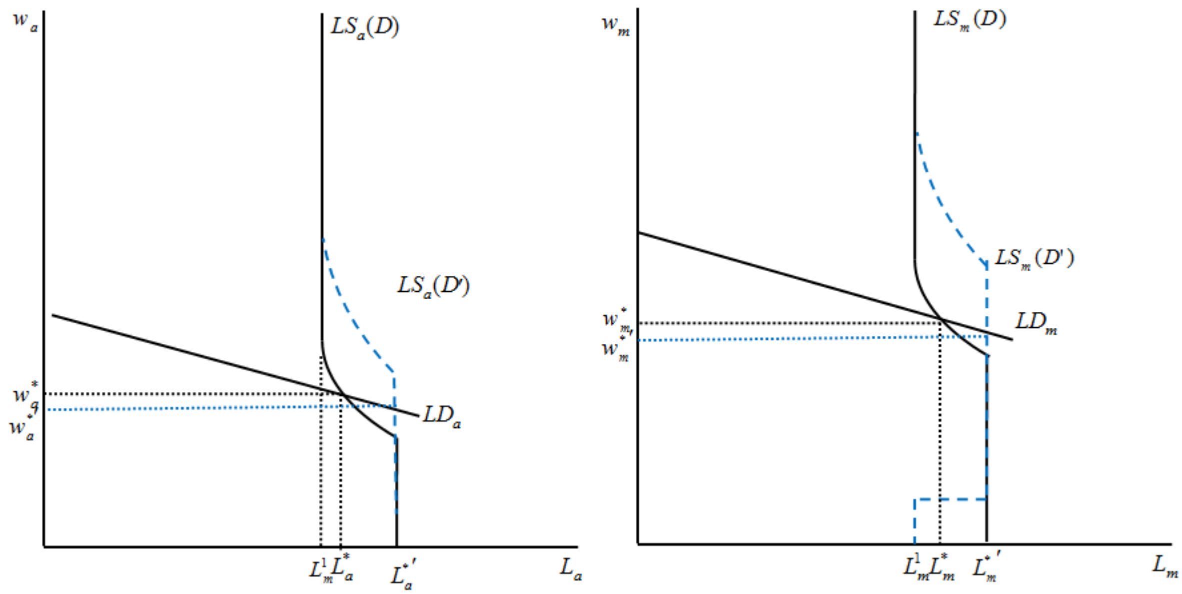
$$S_a^C(w_m, w_a) = \begin{cases} 0 \text{ if } \frac{1}{2}(w_m + w_a) > s \text{ or } k_m^C = 1 \\ \min\left\{ \dfrac{s - \frac{1}{2}(w_m + w_a)}{\gamma w_a}, m \right\} \text{ if } \frac{1}{2}(w_m + w_a) \leq s \text{ and } k_m^C = 0 \end{cases} \tag{3}$$

with $k_m^C = 1$ if the child has access to the manufacturing sector, and $k_m^C = 0$ if she has access to the agricultural sector. Finally, for reasons that will be apparent later, we make the technical assumption that a unit change in the equilibrium wage of one sector leads to a change smaller than a unit in the other.

Restricting ourselves to the cases of interest, the pre-ban equilibrium can be seen in with the solid lines in Figure 1.[5] As it has been drawn in this case, the equilibrium wage in manufacturing is higher than that in agriculture, but none of the children or adults in agriculture have access to the manufacturing sector. The total effective supply of child labor is $(L_a^* + L_m^*) - (L_a^1 + L_m^1)$.

[5]As in earlier work, the one-sector version of this framework allows for multiple equilibria, where an economy can be in either a good equilibrium in which no children work and aggregate firm demand is satisfied by aggregate adult labor supply) or a bad one in which children are forced to work (a possibility raised by many previous works such as Basu and Van (1998), Swinnerton and Rogers (1999), and Jafarey and Lahiri (2002)). It is worth noting that when multiple equilibria exist and an economy is in the "bad" equilibrium, a *perfectly* enforced ban on child labor can jolt the economy to the "good" equilibrium, making households better off (see Basu and Van (1998) for details.)

FIGURE 1. Effect of a ban on child labor in a two sector model assuming no labor mobility.



The dashed labor supply curves illustrate the post-ban equilibrium. The effect on the manufacturing sector should be intuitive; it looks much like the one sector case of Basu (2005). The lower wage in manufacturing implies that the children in the agricultural sector are receiving less income from their parents[6], inducing them to supply more labor in that sector. This in turn lowers the the wage in agriculture, causing children in manufacturing to work more, etc. until the markets equilibrate. Effective child labor increases by $(L_m^{*\prime} + L_a^{*\prime}) - (L_m^* + L_a^*)$. Wages for children and adults fall proportionally in the agricultural sector, but child wages fall more significantly in manufacturing, because $\frac{\gamma w_m^{*\prime} - pD}{\gamma w_m^*} < \frac{w_m^{*\prime}}{w_m^*}$.

1.3. **Partial Mobility**

Finally, the partial mobility case assumes that some agents have access to both sectors, while other have access only to agriculture. Adults supply labor inelastically in the sector having

[6] This general equilibrium labor supply response to the demand shift is formally discussed in Basu et al. (1998).

the highest wage, conditional on having access to that sector. Thus, adult labor is given by

$$S_m^A(w_m, w_a) = \begin{cases} 1 \text{ if } w_m > w_a \text{ and } k_m^A = 1 \\ q^A \text{ if } w_m = w_a \text{ and } k_m^A = 1 \\ 0 \text{ if } w_m < w_a \text{ or } k_m^A = 0 \end{cases} \tag{4}$$

$$S_a^A(w_m, w_a) = \begin{cases} 1 \text{ if } w_a > w_m \text{ or } k_m^A = 0 \\ 1 - q^A \text{ if } w_a = w_m \text{ and } k_m^A = 1 \\ 0 \text{ if } w_a < w_m \text{ and } k_m^A = 1 \end{cases} \tag{5}$$

where $k_m^A = 1$ implies the adult has access to both sectors, $k_m^A = 0$ implies the adult has access only to the agricultural sector, and q^A is determined in equilibrium if wages are equal in the two sectors.

Child labor is supplied very similarly to the other cases, except that now a family's children may or may not have access to the manufacturing sector. Children supply labor to the sector with the highest wage, conditional on having access to that sector, until they reach subsistence or cannot supply any more labor. Thus, child labor supply is

$$S_m^C(w_m, w_a) = \begin{cases} 0 \text{ if } \frac{1}{2}(w_m + w_a) > s, \gamma w_a > \gamma w_m - pD \text{ or } k_m^C = 0 \\ \min\left\{ q^C \cdot \frac{s - \frac{1}{2}(w_m + w_a)}{\gamma w_m - pD}, q^C m \right\} \text{ if } \frac{1}{2}(w_m + w_a) < s, \\ \qquad \gamma w_m - pD = \gamma w_a, \text{ and } k_m^C = 1 \\ \min\left\{ \frac{s - \frac{1}{2}(w_m + w_a)}{\gamma w_m - pD}, m \right\} \text{ if } \frac{1}{2}(w_m + w_a) < s, \\ \qquad \gamma w_m - pD > \gamma w_a, \text{ and } k_m^C = 1 \end{cases} \tag{6}$$

(7)

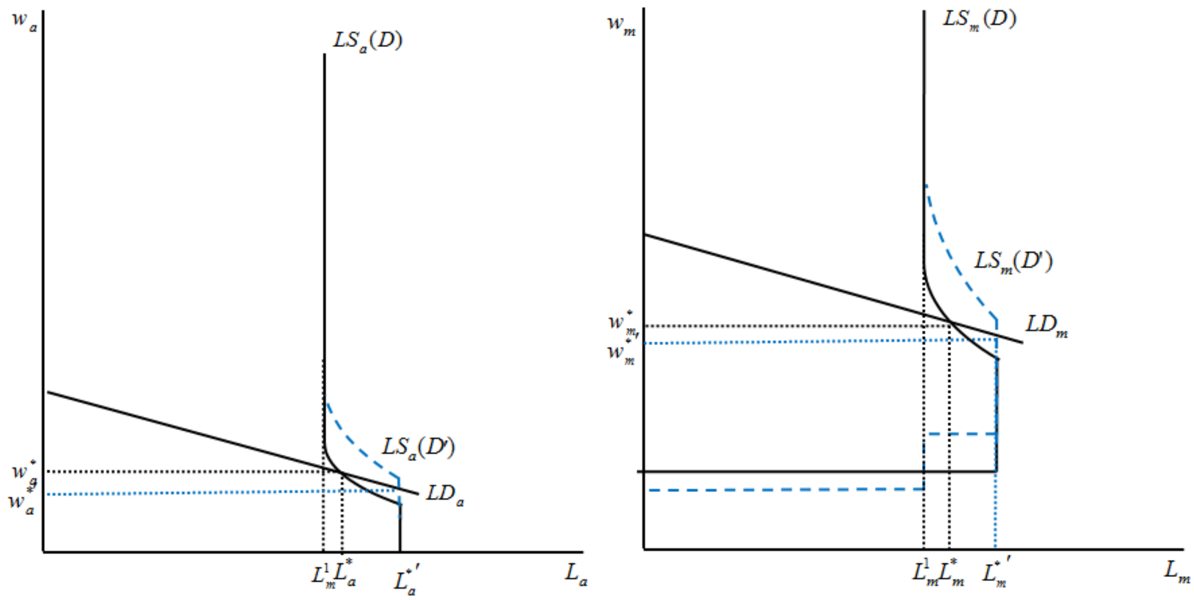
$$S_a^C(w_m, w_a) = \begin{cases} 0 \text{ if } \frac{1}{2}(w_m + w_a) > s,\ \gamma w_m - pd > \gamma w_a \text{ and } k_m^C = 1 \\ \min\left\{(1 - q^C) \cdot \dfrac{s - \frac{1}{2}(w_m + w_a)}{\gamma w_a}, (1 - q^C)m\right\} \text{ if } \frac{1}{2}(w_m + w_a) < s, \\ \qquad\qquad \gamma w_a = \gamma w_m - pD, \text{ and } k_m^C = 1 \\ \min\left\{\dfrac{s - \frac{1}{2}(w_m + w_a)}{\gamma w_a}, m\right\} \text{ if } \frac{1}{2}(w_m + w_a) < s, \\ \qquad\qquad \text{and } \gamma w_a > \gamma w_m - pD \text{ or } k_m^C = 0 \end{cases}$$

where $k_m^C = 1$ implies the child has access to both sectors, $k_m^C = 0$ implies the child has access only to the agricultural sector, and q^C is determined in equilibrium if wages are equal in the two sectors.

The solid lines in Figure 2 show the equilibrium in the partial mobility case before the ban has been imposed. The agricultural sector looks very similar to the single sector case. The manufacturing sector has a higher wage since those in the agricultural sector can't shift. The flat portion of the labor supply curve in manufacturing comes from the fact that if wages in manufacturing fall below those in agriculture, all manufacturing workers shift to the agricultural sector. The total effective child labor is once again $(L_a^* + L_m^*) - (L_a^1 + L_m^1)$.

The post ban equilibrium can be split up into three different cases, effectively differentiated by the relationship between the initial effect of the ban on child wages in both sectors. The first case, in which child wages are still higher in manufacturing (i.e.$\gamma w_m' - pD' > \gamma w_a'$) can be seen with the dashed portion of Figure 2. Since child wages are still higher in manufacturing, adult wages must also still be higher in manufacturing, none of the children or adults who have access to the manufacturing sector will switch to the agricultural sector. The increase in the fine lowers the wage for children in manufacturing, increasing labor supply in that sector and lowering the equilibrium wage. Similar to the no mobility case, this lower wage in manufacturing increases the labor supply of children in agriculture, because they need to work more to make up for their parents' lower income. This again leads to an iterated increase in labor supply in both markets until

FIGURE 2. Effect of a ban on child labor in a two sector model assuming partial labor mobility.



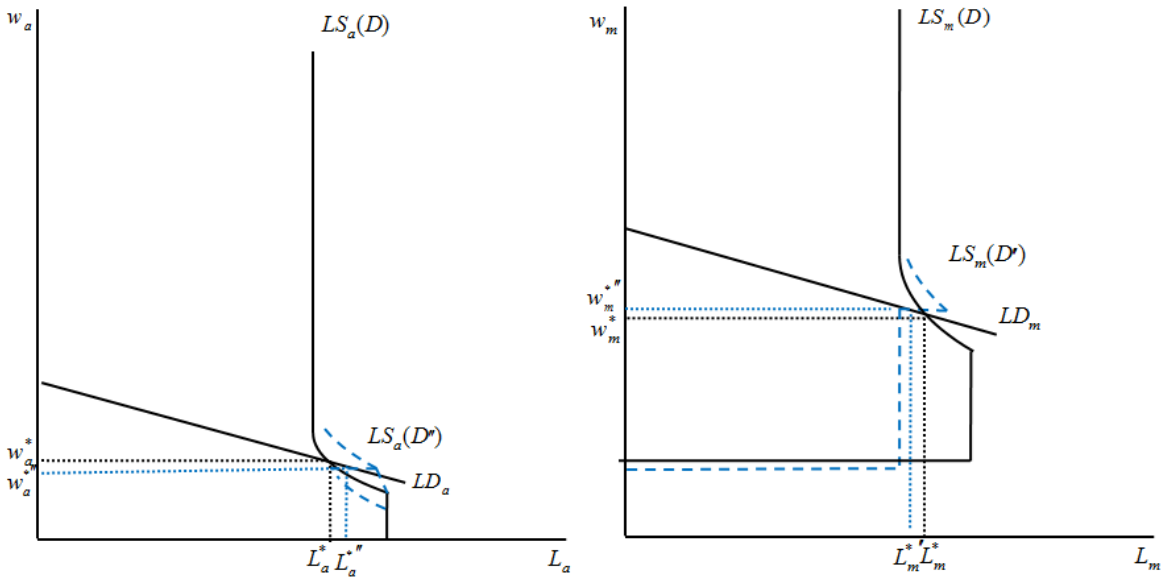
Case I: $\gamma w_m^{*\prime} - pD > \gamma w_a^*$

the markets equilibrate in an equilibrium with increased effective labor supplied and lower equilibrium wages in both sectors. Since adult labor supply has not changed, this implies that effective child labor has increased in both sectors. Finally, we can see that wages have fallen for children more in the manufacturing sector than they have in the agricultural sector, because $\frac{\gamma w_m^{*\prime} - pD}{\gamma w_m^*} < \frac{w_m^{*\prime}}{w_m^*}$.

Figure 3 shows the pre and post ban equilibria in the case in which the ban initially equates child wages in the two sectors ($\gamma w_m'' = \gamma w_a''$). In this case, children are now indifferent between working in agriculture and working in manufacturing. However for families with children who initially worked in manufacturing, wages are now lower so more children must work to achieve subsistence consumption. Total labor supply shifts out, lowering wages in both sectors. The end result is more child labor and lower wages though child wage has fallen by a larger proportion relative to adult wages in manufacturing (not in agriculture where adult and child labor fall by the same proportion).

Figure 4 shows one potential illustration of the final case, in which the equilibrium child wage in agriculture is higher than the equilibrium child wage in manufacturing ($\gamma w_m''' - pD < \gamma w_a'''$). Intuitively, one could think of this as the case in which the government set p and D high

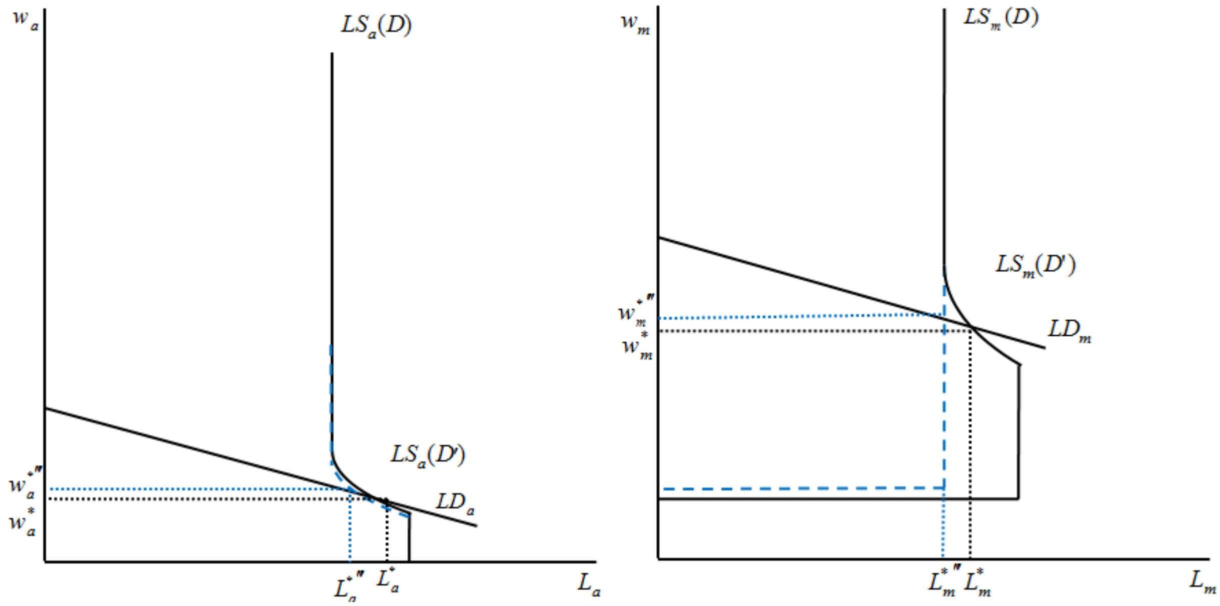
FIGURE 3. Effect of a ban on child labor in a two sector model assuming partial labor mobility.



Case II: $\gamma w_m^{*\prime} - pD = \gamma w_a^*$

enough to push children out of the manufacturing market. The effect on labor supply in the manufacturing sector is simple; only adults work in the sector for any wage, and if the wage falls below the wage in agriculture, all of the adults will leave. Labor supply in the agricultural sector looks as if it would if all children *only* have access to the agricultural sector. Wages unambiguously rise in manufacturing. If this wages increase is large enough to reduce overall child employment, this leads to a reduction in agricultural labor supply and wages rise in that sector as well. However, if the manufacturing wage increase is not enough to reduce the number of working children, the labor supply curve will shift out in agriculture, lowering wages in that sector. The combination of the two effects - higher manufacturing wages but lower agricultural wages - leads to an ambiguous overall effect of the ban on levels of child labor.

FIGURE 4. Effect of a ban on child labor in a two sector model assuming partial labor mobility.



Case III: $\gamma w_m^{*\prime} - pD < \gamma w_a^*$

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