Credit Rationing and Pass-Through in Supply Chains: Theory and Evidence from Bangladesh

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ABSTRACT

Traders are often blamed for high prices, prompting government regulation. We study the effects of a government ban of a layer of financing intermediaries in edible oil supply chain in Bangladesh during 2011-12. Contrary to the predictions of a standard model of an oligopolistic supply chain, the ban caused downstream wholesale and retail prices to rise, and pass-through of the changes in imported crude oil price to fall. These results can be explained by an extension of the standard model to incorporate trade credit frictions, where intermediaries expand credit access of downstream traders.

Keywords: Intermediary, Supply Chain, Market Power, Credit Rationing, Pass-through, Edible Oils, Bangladesh;

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The role of market power of trade intermediaries in earning high margins that unduly raise consumer prices has frequently been a matter of public concern. Such concerns motivate arguments for regulations, often taking extreme forms such as outright bans on some intermediary

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layers, and, in some cases, more extreme penalties. For instance, Abraham Lincoln (quoted in Carpenter (1866, p. 84)) stated "For my part, I wish every one of them (speculators) had his devilish head shot off". And Vladimir Lenin (1964, p.311) said: "For as long as we fail to treat speculators the way they deserve—with a bullet in the head—we will not get anywhere at all". In 1958 private trades in onions futures were banned in Chicago; distrust of private traders led to the establishment of marketing boards in many developing countries in 1950s and 1960s. However, disappointing results with the marketing boards prompted agricultural market liberalization starting from the late 1970s. The lack of trust in middlemen traders in commodity markets nevertheless remains widespread and deeply ingrained; the price spiral in international commodity markets in 2007-2008 brought their role back into focus. In July 2011, the Bangladesh government banned a layer of intermediaries called Delivery Order Traders (DOTs) in edible oils distribution trade, out of a concern that their market power was primarily responsible for the rising consumer prices since 2008. The ban lasted a little less than a year, and the previous system was effectively brought back from the middle of 2012 onwards.

Using daily data on downstream wholesale and retail prices of palm oil, as well as of imported crude oil between 2008-12, we examine the effects of the ban on downstream prices and pass-through of the crude import price. We use a difference-of-difference approach, comparing price movements in palm oil with wheat and lentils, two commodities that were not subject to similar regulations but incur similar storage and distribution costs. The results show that pass-through rate fell and downstream prices rose during the period when the ban was in effect. These effects were contrary to the intentions of the policy-makers, possibly explaining why the ban was lifted soon.

The observed effects contradict predictions of a standard model of the vertical supply chain involving double marginalization of rents. In this model, elimination of one layer of intermediaries leads to a reduction in the prices because of elimination of double marginalization, and higher competition which increases pass-through. As crude import prices were falling when the ban was in effect, a higher pass-through rate should have resulted in a faster decline in downstream price of edible oil.

A possible reason that downstream prices rose instead, is that efficiency-enhancing services provided by intermediaries (which help lower financing and distribution costs of downstream traders) were no longer available when the ban was in place. While this may potentially explain why the *level* of downstream prices rose (i.e. if the resulting cost increases outweighed the effects of increased competition), it cannot explain why the pass-through rate failed to rise — thus pointing to a deeper problem with the standard model.

We argue that the key lacuna in this model is its failure to incorporate contracting frictions in the provision of credit to downstream traders that result in credit rationing. Long term relational contracts between DOTs and traders provide the latter with greater access to credit compared with formal financial institutions such as banks (owing to lack of necessary physical collateral or credit histories). We show that extending the model to incorporate the role of DOTs in relaxing credit rationing helps explain both why price levels rose and the pass-through rate fell. The ban meant downstream traders had no longer access to trade credit from the DOTs, and had to turn to the banks. The resulting credit squeeze reduced the amount of oil they could buy and deliver to retailers and consumers, resulting in higher downstream prices that became less responsive to changes in oil import costs.

Such an explanation is plausible in the Bangladesh context, given that 32 percent of the oil transactions between the DOTs and wholesalers in a given week is on trade credit provided by the DOTs, and more than 80 percent of wholesalers report use of trade credit from the DOTs at least once a year (Emran et al. 2015). We provide other supplementary evidence in the paper of this explanation, and rule out a number of competing explanations (such as rising supply costs of traders owing to capacity constraints).

The Bangladesh experience is relevant to many other countries in which trade credit provision is an important function of supply chain intermediaries. Altinoglu 2019 provides evidence that trade credit accounts for more than half of short term firm liabilities in most OECD countries. It is likely to be even more critical in countries where formal financial institutions are underdeveloped (Fisman and Love 2003). Estimates based on recent surveys of agricultural value chain in India and Bangladesh show that about 30 percent of transactions are based on trade credit without any collateral (World Bank 2008, 2016). Fafchamps 2004 reports that 33 percent manufacturing firms receive credit from upstream suppliers in Burundi, Cameroon, and Cote d'Ivoire. Casaburi and Reed 2017 provide detailed evidence of the role of intermediaries in providing trade credit to smallholder farmers in Sierra Leone.

Besides the empirical analysis of the Bangladesh policy reform, our paper makes the following methodological contribution of wider relevance. We extend the standard model (e.g., Atkin-Donaldson 2015) of sequential Cournot competition with constant unit costs, using a Bulow-Pfleiderer 1983 specification of downstream consumer demand. This includes linear, log-linear and constant elasticity demand as special cases. As is well known, it generates closed form expressions for prices along the supply chain which clarifies the effect of concentration and costs at each layer. We then extend the model to incorporate the effects of credit rationing. If credit constraints are not binding, the model generates prediction (P1): passthrough rates (which fall with market concentration) are independent of crude import price or trader's distribution costs. This in turn leads to prediction (P2): the ban should have caused the pass-through rate to rise (owing to de-concentration). Whereas if trader credit constraints bind, the model predicts instead (P3): the pass-through rate falls if crude import prices rise or credit constraints shrink. The intuitive reason is that these induce a contraction in the volume of oil flowing to retailers and consumers, and derived demand of wholesalers becomes less price-elastic. These effects cause downstream prices to rise and become less responsive to cost shocks. Given the assumption that DOTs help relax credit constraints, this leads to prediction (P4) concerning the effects of the ban: the pass-through rate could fall or rise, depending on whether the resulting credit squeeze outweighed the effects of de-concentration. In contrast, if there is no credit rationing, but unit costs are rising owing to capacity constraints, the model predicts (P5): the pass-through rate is increasing in the import price. Since oil import prices were higher on average after the ban became effective compared to periods before the ban, this should result in a higher pass-through after the policy reform (again generating prediction (P2)). Testing these contrasting predictions regarding pass-through therefore provides a way to discriminate between different versions of the model.

Our empirical analysis fails to reject predictions P3 and P4 of the model where intermediaries relax credit constraints, while rejecting predictions P1, P2 and P5 of the other two versions. We now provide more detail regarding the context and empirical results. A delivery order (DO) is a sales receipt issued by the refiner (located at the apex of the chain) with the quantity of oil specified on it (30-45 drums of oil, each drum containing 150 maunds), to be deliverable after a specified time period. The DOTs (forming the second layer of the chain) buy the DOs from the refiners and sell them to wholesalers, usually after a period of time. The wholesalers take delivery of oil from the refiners in exchange for the DO, and repay the DOT only after they sell to the retailers or consumers. Since the DOTs play a pure financing role, we do not have to worry about other functions they may play in facilitating storage or distribution.

Before estimating the effects of the ban, we use data from the pre-reform period to test competing predictions P1, P2 and P5 of the three versions of the model, regarding how pass-through rates responded to import price shocks. Pass-through was significantly smaller when the import price was above the median, thereby rejecting predictions P1 and P5 in favor of prediction P3 of the credit rationing model. Moreover, consistent with the simple version of the credit rationing model, the pass-through rate depended only on the level of the oil import price, but not whether they were rising or falling over time.

Our subsequent analysis focuses on the effects of the ban on pass-through rates and price levels for edible oil, relative to those for wheat and lentils (where the ban did not apply, but whose raw material is also imported and incur similar transport and storage costs). Given the evidence in favor of prediction P3 in the pre-reform period, we compare post-reform prices with those in the pre-reform period where the average level of oil prices were comparable to those in the pre-reform period. The DiD estimates show that the policy reform reduced the pass-through rate and increased the price level in edible oil relative to wheat or lentils. Hence we reject predictions P2 and P5 of the model without credit rationing, in favor of P4 from the version with credit rationing. Our estimates imply a 11.34 percent increase in wholesale prices as a result of the ban. The average interest rate on short-term bank loans also happened to be 2 percentage points higher in the post-ban period. Assuming a 100 percent passthrough of the interest costs, it suggests that credit rationing caused a 9.4 percent increase in prices.

We utilize the data from the pre-ban period to test the validity of the parallel trends assumption using a series of placebo reforms. The evidence does not reject the null hypothesis of parallel trends at the 10 percent level for any of the placebo reforms. These conclusions are robust to alternative specifications of oil import lags and different data samples (including the announcement period in the sample, including two rather than one year data from the pre-reform period, or including data from both high and low crude import prices). We also check the results using wheat and lentil separately as the comparison commodity. We discuss supplementary evidence consistent with the credit rationing hypothesis, based on case-studies, besides data on aggregate crude import volumes which contracted sharply (at a time when import prices were falling).

One strand of related literature pertains to pass-through of international prices and exchange rate variations to domestic producer and consumer prices that are based on the standard model (e.g., Goldberg and Hellerstein 2008, Nakamura 2008, Nakamura and Zerom 2010, Gopinath et al. 2010, Berman et al. 2012, Bonnet et al. 2013, and surveys by Burstein and Gopinath 2013, Campa and Goldberg 2005). Weyl and Fabinger 2013 present a unifying framework for incidence with imperfect competition. This framework has been fruitfully utilized in the context of developing countries by Atkin and Donaldson 2015.

The literature in development economics has paid more attention to contracting frictions, resulting from adverse selection, moral hazard and enforcement problems. Models of interlinked trade-credit relationships have appeared in Braverman and Stiglitz 1982 and Bardhan 1980, 1989. Recent empirical work in developing countries on intermediaries and commodity supply chains have examined pass-through of international or retail prices to farm-gate prices when trade intermediaries operate as middlemen between farmers and retail or foreign buyers (Casaburi et al. 2013, Minten and Kyle 1999). Many of these focus on search frictions to explain pass-through patterns, while Mitra et. al. 2018 consider implications of asymmetric price information. Macchiavello and Morjaria 2016 analyze the effects of competition in procurement of inputs on relational contracts between farmers and coffee mills in Rwanda. Casaburi and

Reed 2017 focus on the supply chain from farmers to traders to wholesalers in Sierra Leone cocoa market. Price subsidies paid to randomly chosen middlemen did not result in higher output prices paid to farmers, but instead to higher advance payments.[1] Their paper complements ours by providing direct evidence of the role of middlemen in providing trade credit, besides assessing the extent of their market power. Our paper goes further by evaluating the overall impact of the presence of financing middlemen (aggregating the effects of their market power and trade credit provision), using a natural experiment that affected an entire country, and using data on actual prices.

The rest of the paper is structured as follows. Section I describes the institutional setting of the palm oil supply chain in Bangladesh and the nature of the 2011 policy reform. Section II develops the theoretical model, followed by extensions of the model in section III. A discussion of estimation strategy is in Section IV. Section V then describes the data and presents the empirical results. Section VI discusses supplementary evidence and possible competing explanations, while Section VII concludes.

I. The Palm Oil Marketing Chain in Bangladesh and the 2011 Reform

A. Pre-Reform

We start with a brief description of the Bangladesh palm oil marketing chain before the DOT ban in 2011; a more detailed discussion is provided in Uddin and Taslim (2010). As the reform was effectively suspended by mid-2012, the current structure of the supply chain resembles the way it was organized prior to the reform. The chain consists of four layers: refiners, delivery order traders (DOTs), wholesalers and retailers. The refining segment is highly concentrated with only nine refiners, some of them have considerable excess capacity. The refiners import

[1]The "effective price" paid to the farmers thus is not directly observable in the data and require indirect valuation of the advance payments. They report significant pass-through rate (0.92) of wholesale prices to the effective prices paid to farmers, suggesting that markets were reasonably competitive and middlemen did not exert much monopsony power.

crude palm oil from Malaysia and Indonesia and then refine it. While wholesalers can pick up refined oil directly from the refiners upon paying cash, such direct transactions between the wholesalers and the refiners are limited. The wholesalers mostly furnish a delivery order (DO) to take oil delivery, a paper document representing an entitlement to a defined quantity of refined oil from the refinery. DOs are purchased by DOTs from refiners, sometimes immediately after the crude oil is imported, and sold later to the wholesalers on credit or cash. The wholesalers buying DOs on credit repay in the next period after selling the oil to retailers. The DOTs thus offer a bundled oil and credit contract when selling DOs on credit to wholesalers.

There are approximately 300 DOTs divided between two principal cities Dhaka and Chittagong, forming an intermediate layer between refiners and over 7000 wholesalers. Wholesalers mostly prefer to purchase through a DOT rather than directly from a refiner primarily because of the credit implicitly provided by a DOT. Estimates from a trader survey that we conducted in the two main markets in Dhaka and Chittagong in 2013 shows that about 32 percent of quantity transacted between the DOTs and wholesalers was on credit without collateral, based on long-term relationships.

The DOTs buy DOs for oil deliverable by the refiner after a stipulated period of time (usually 2 weeks). It is important to note that DOTs never take physical delivery of the oil: they are pure financial intermediaries. This is helpful for our empirical analysis, as the banning of DOTs cannot affect the distribution costs such as storage and transport costs directly. The DOT layer interacts vertically with the refiners upstream and the wholesalers downstream. In effect, they purchase refined oil from the refiners and re-sell it after a time lag to wholesalers.

There are also some horizontal transactions among DOTs, representing arbitrage, speculation or purchase by smaller DOTs from the large DOTs. The horizontal transactions among the DOTs have evolved into something like an embryonic commodity exchange in Moulovibazar in Dhaka and Khatunganj in Chittagong where speculators operate with the help of brokers, primarily during upswings in the international market.[2] Our post-reform data period however

[2]It is difficult to characterize the DO layer neatly; it is like a nascent futures market, missing some features of a standard futures market. For example, unlike a futures market, there is no settlement at the end of the day, and payment is made at the time of the DO contract, not at the delivery date. The DO contracts have built in some flexibility similar to an option contract; for example, the stipulated delivery date is almost never

coincided with a downswing in the international market when activities in the secondary (horizontal) DOT market were almost nonexistent. An implication of this coincidental downturn in the international market is that our analysis cannot draw any inferences regarding the potential role of speculative activities by the DOTs (and other market agents) observed during the upturn in the market. Since one of the goals of the reform declared by the government was to curb harmful speculation, we cannot shed any light on whether such policies would help in attaining this policy goal. In our analysis, we focus on the pricing implications of market power and credit rationing across vertical layers in a static framework, and thus abstract from price dynamics, risk, or heterogeneity across traders within any layer.

B. The Reform

The policy reform focused on the DO layer of the market. The law banning DO (Delivery Order) transactions and instituting SO (Sales Order) dealers in its place (i.e., Essential Commodities Marketing and Distributor Appointment Order 2011) was passed on March 23, 2011. 90 days were allowed to implement the policy change, implying that the directive implementing the law came into effect on June 21, 2011.

It was argued by the government and popular media that in the DO system a few big players exert disproportionate market power and manipulate the market by strategically buying, holding and selling DOs. This layer was sought to be entirely eliminated in the new system, in which wholesalers were expected to purchase oil directly from refiners. In the new ('supply order' (SO)) system, new dealers were appointed for each "marketing area" (for example, upazila or municipality) selected by the refiners, and a dealer was allowed to buy oil up to a limit "commensurate with" the size of the market. In total, 7388 dealers for edible oil were appointed by different refiners. While wholesalers were principally expected to become the new SO dealers, it would have been difficult to prevent previous DOTs from acquiring dealerships. This was the logic underlying the quantity restrictions on the amount of oil that could be

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enforced.

purchased by a dealer, so that even if an ex-DOT became a dealer he would not be able to engage in bulk purchases and sales of SOs. Combined with the large number of SO dealerships created, the policy effectively reduced market concentration within the supply chain.

However, the elimination of DOTs also meant the disappearance of an important source of credit for wholesalers. Refiners were unable to step in to fill this gap because they lacked the information accumulated by the DOTs over decades. Accordingly, the wholesalers had to turn to the banks for credit to finance dealership deposits and purchase of SOs for oil from the refiners. Many faced difficulties in obtaining sufficient credit. This made it difficult for the refiners to set up a new network of SO dealers. City Group, one of the largest refiners which accounted for nearly half of all new dealerships created, was forced to waive the required security deposits. A related problem was the lack of storage among wholesalers, who were expected to pick up refined oil earlier in the new system in the absence of the DOTs.

As a result of these problems, the wholesale-traders-turned-SO-dealers were increasingly unable to pay for the required oil, and refiners began to accumulate stocks beyond their desired level of inventory. This prompted the refiners to look for alternative distribution channels; eventually they went back to some of the large DOTs to return into the business and undermine the new system. Approximately six months after the reform went into effect, the DOTs started to circumvent the quantity restrictions imposed, with the government taking little initiative to enforce these restrictions (presumably owing to pressure from refiners). This passivity set into motion forces that pushed back the marketing system towards the old DO system; within a year or so the old system was back in play.

II. Theory

We model a vertical chain with three layers: refiners, DOTs and wholesale traders (depicted below by $i \in \{r, d, t\}$) specializing in refining, financing, and distribution, respectively. Although the edible oil supply chain also includes retailers, we ignore them as the focus is on the effects of the elimination of the DOTs on wholesale prices.[3] So we assume that wholesalers sell directly to final consumers.[4]

The sequence of moves follows a classic hierarchical Cournot model: refiners move first and sell to DOTs. DOTs then sell to the traders, and finally, traders sell to the consumers. At each stage/layer, sellers make quantity decisions, incorporating their effects on the selling price. All sellers at each stage are symmetric, and move simultaneously. Buyers take the price as given. Given total quantity decided by sellers, an auction sets the price to clear the market. The sequence of moves and strategies at each stage is described below. We solve for a subgame perfect Nash equilibrium of this game, using backward induction.

There are two dates $T = 0, 1$. Crude oil is imported by refiners at $T = 0$. Refining takes one period, and refined oil becomes available at $T = 1$. Normalize units so that one unit of crude generates one unit of refined oil. At $T = 1$, refined oil is picked up by traders from the refineries, transported to retail markets where they are sold to the consumers. Transport and other distribution costs are incurred by the traders at $T = 1$.

At $T = 0$, the sequence of moves is as follows.

(i) Refiners decide how much crude oil to import (at an exogenously given price P_m) and sell DO's (entitlements to one unit of refined oil at $T = 1$) to the DOTs. The imported crude is refined at a unit cost of C_r.

(ii) Each DOT decides how many DOs to buy at the prevailing market price P_r which they take as given. Since the DOTs pay for these DO's at $T = 0$, they effectively finance the purchases of the refiners. P_r is determined, by equating refiners' aggregate supply of DO's to the total demand by the DOTs. DOTs do not incur any physical costs of handling the oil ($C_d = 0$); they only incur financing costs. Each DOT has unlimited access to credit at a fixed interest rate i_d. We assume that the financing costs incurred by the DOTs are lower than the

[3]In the empirical analysis, we will also report estimates of the effects of the policy reform on retail prices.

[4]Owing to its recursive structure, it is easy to extend the model to incorporate an additional fourth layer of retailers who sell to final consumers. The model with an additional retail layer reduces to the one developed below when there are sufficiently many retailers that the market power at that layer is negligible.

financing costs of refiners and the banks.[5]

(iii) DO's are resold (on credit) by DOTs to the traders, in the form of bundled oil-plus-credit contracts. Traders do not pay the DOTs anything for the DOs at $T = 0$. The price of this contract P_d is for the bundle of oil entitlement combined with credit which the trader promises to pay the DOT at $T = 1$ (after selling the refined oil to the consumers). We assume that the cost of borrowing from the bank (denoted as i_b) is high enough so that the traders do not find it profitable to buy directly from the refiners (paying cash).[6]

At stage (iii), traders decide how many DO's to buy, taking P_d as given. The market clearing price P_d is thus determined along with the allocation of DO's among traders.

(iv) Next, period $T = 1$ arrives. Traders use their DO's to pick up refined oil, incur unit distribution cost C_t and sell it to consumers at price P_t. Consumers take P_t as given and decide how much to buy. The inverse market demand function takes the Bulow-Pfleiderer (1983) form:

$$P_t = \alpha - \eta Q^{\delta} \tag{1}$$

where Q denotes the total quantity sold by traders to the consumers, and $\alpha, \eta, \delta > 0$. In addition to being tractable enough to generate closed form solution, the Bulow-Pfleiderer demand specification is also flexible and nests many of the standard demand functions widely-used in the literature such as linear, log-linear, and isoelastic functions. We assume $\delta > 0$ given the fact that passthrough is imperfect, i.e., it falls between 0 and 1. To avoid market shutdown, we assume that α is large enough relative to the sum of import, refining finance and distribution costs:

$$\alpha > \frac{(P_m + C_r)(1 + i_d)}{(1 - \frac{1}{N_r})(1 - \frac{1}{N_d})} + C_t \tag{2}$$

(v) Each trader decides whether to pay back P_d to the DOT from whom DO's were acquired.

[5] For further discussion, see Section 4 below.

[6] Section 4 explains in detail the justification for this assumption.

If they fail to pay back all the purchased DOs, the DOTs impose a fixed default penalty R_d.[7]

The payoffs are as follows. Refiner j's payoff (denominated at $T = 0$ taka) is

$$\Pi_j = [P_r - P_m - C_r]q_j \tag{3}$$

where q_j denotes the number of DO's sold by refiner j. DOT k's payoff (denominated at $T = 0$ taka) is

$$\Pi_k = [\frac{P_d}{1 + i_d} - P_r]q_k \tag{4}$$

upon selling q_k DO's on credit to traders, assuming they are all repaid (which will be the case on the equilibrium path). Trader t's payoff (denominated at $T = 1$ taka, since all financial receipts and payments by traders are undertaken at $T = 1$) is

$$\Pi_t = [P_t - P_d - C_t]q_t \tag{5}$$

upon buying q_t DO's on credit, selling the associated refined oil and repaying all DO's.

Traders decide on repayment as follows. If they do not repay all of their DOs, they incur the default penalty R_d. Hence if they default on a single DO, it amounts to defaulting on all of them. Relative to the payoff (5), they gain $P_d q_t$ while incurring the penalty R_d. Hence it is optimal to not default if

$$P_d q_t \leq R_d \tag{6}$$

[7]It is easy to extend the model to settings where sanctions are endogenous, e.g., in a dynamic setting where sanctions involve cutting off access to credit and the oil market in future. DOTs could engage in such collective punishments as in Kandori (1992) or Greif (1993): all DOTs could refuse to sell DOs or lend to any wholesaler who defaults on a loan with any DOT. If prices are stationary, the cost of these sanctions imposed on defaulters would depend on prices, which will alter the expression for credit ceilings derived below. This complicates the analysis without affecting the results qualitatively.

which translates to a borrowing constraint

$$q_t \leq \frac{R_d}{P_d}. \tag{7}$$

The quantity constraint above thus refers to the total credit a trader can get from the DOTs without violating the incentive constraint.[8] We assume that the market agent responsible for auctioning off DOs to traders checks that each trader respects this borrowing constraint. This ensures prevention of market breakdown, and simplifies the analysis. Imposing this incentive compatibility constraint then makes stage (v) of the game redundant. Hence we impose constraint (7) at stage (iii), and dispense with stage (v).

Observe that the borrowing constraint is akin to a capacity constraint, *with the exception that the capacity limit depends on the price P_d which is endogenously determined.* We shall return to this in Section .

A. Pass-Through When Credit Constraints Do Not Bind

We first consider the equilibrium without any borrowing constraint; this corresponds to the case where default penalties R_d are large enough (we derive the appropriate bound below). This is the standard case usually studied in existing literature (eg., Atkin and Donaldson (2015)).

Working backwards, we start by deriving the Cournot equilibrium among the traders at stage (iii), given the price of DOs P_d charged by the DOTs. With conjectured output q for each of the other $(N_t - 1)$ traders, each trader selects q_t to maximize

$$[P_t((N_t - 1)q + q_t) - P_d - C_t]q_t \tag{8}$$

[8] This assumes that the DOTs share information about loans and default which seems plausible from our own survey work in this market. The market is geographically very concentrated within a small area in Dhaka and also in Chittagong, and information sharing among DOTs is widely observed.

and the resulting symmetric equilibrium satisfies

$$[N_t q_t^*]^\delta = \frac{\alpha - P_d - C_t}{\eta(1+\frac{\delta}{N_t})} \tag{9}$$

Using the market-clearing condition $N_t q_t^* = \sum_k q_k$, this generates the inverse demand function in the stage (ii) Cournot game among the DOTs:

$$P_d = \alpha - C_t - \eta(1+\frac{\delta}{N_t})\left[\sum_k q_k\right]^\delta \tag{10}$$

In a symmetric equilibrium at refiner price P_r, $q_d = q_d^*$ maximizes the payoff of the DOT d:

$$\left[\frac{P_d((N_d-1)q_d^* + q_d)}{1+i_d} - P_r\right] q_d \tag{11}$$

implying

$$[N_d q_d^*]^\delta = \frac{\alpha - P_r(1+i_d) - C_t}{\eta(1+\frac{\delta}{N_d})(1+\frac{\delta}{N_t})} \tag{12}$$

Finally, we solve for the stage (i) game among the refiners, given the inverse demand function generated by (12) and market-clearing:

$$P_r = \frac{1}{(1+i_d)}\left[\alpha - C_t - \eta(1+\frac{\delta}{N_d})(1+\frac{\delta}{N_t})\left(\sum_r q_r\right)^\delta\right] \tag{13}$$

In a symmetric equilibrium, each refiner selects $q_r = q_r^*$ to maximize

$$[P_r((N_r-1)q_r^* + q_r) - P_m - C_r]q_r \tag{14}$$

which implies the industry output is

$$Q^* \equiv N_r q_r^* = [\frac{\alpha - (P_m + C_r)(1+i_d) - C_t}{\eta(1+\frac{\delta}{N_r})(1+\frac{\delta}{N_d})(1+\frac{\delta}{N_t})}]^{\frac{1}{\delta}} \tag{15}$$

and hence the consumer price equals

$$
\begin{aligned}
P_t^* &= \alpha\left[1-\left(\frac{N_r}{\delta+N_r}\right)\left(\frac{N_d}{\delta+N_d}\right)\left(\frac{N_t}{\delta+N_t}\right)\right] \\
&\quad +\left(\frac{N_r}{\delta+N_r}\right)\left(\frac{N_d}{\delta+N_d}\right)\left(\frac{N_t}{\delta+N_t}\right)[C_t+(P_m+C_r)(1+i_d)]
\end{aligned} \tag{16}
$$

So we obtain the hierarchical extension of the linear pass-through equation in Atkin-Donaldson (2015). This predicts a pass-through rate $(1+i_d)\left(\frac{N_r}{\delta+N_r}\right)\left(\frac{N_d}{\delta+N_d}\right)\left(\frac{N_t}{\delta+N_t}\right)$ of the import price to the consumer price that depends on market concentration at each layer relative to the demand parameter δ and the cost of funds faced by the DOTs.[9] The linearity of this equation in costs therefore generates prediction P1 described in the Introduction: the pass-through rate (while increasing in the number of firms at each stage) does not depend on the oil import price P_m, refining, distribution or financing costs (C_r, C_t, i_d).

The credit constraint will not bind in this equilibrium if the default penalty R_d exceeds the total amount borrowed by each trader:

$$P_d^* q_t^* \leq R_d \tag{17}$$

where

$$P_d^* = (\alpha - C_t)\left[1-\left(\frac{N_r}{\delta+N_r}\right)\left(\frac{N_d}{\delta+N_d}\right)\right] + (1+i_d)(P_m+C_r)\left(\frac{N_r}{\delta+N_r}\right)\left(\frac{N_d}{\delta+N_d}\right) \tag{18}$$

and

$$q_t^* = \frac{Q^*}{N_t} \tag{19}$$

where industry output Q^* is given by (15).

[9]Passthrough in the standard model in the literature does not depend on the interest rate as there are no financing intermediaries. In the absence of the financing role, the passthrough remains constant in the face of changing macroeconomic conditions (given the market structure). In so far as the cost of funds of the financing intermediaries are affected by macroeconomic conditions, our model predicts changes in the passthrough rate.

B. Effects of the Reform when Credit Constraints do not Bind

The policy reform banning the DOTs can be captured in the above model as elimination of the DOT layer (N_d goes to ∞).[10] The reform raises the financing costs, as the traders have to borrow from the banks in the post-reform period instead of the DOTs; they are subject to a lower borrowing limit (R_b rather than R_d) and a higher interest rate (i_b rather than i_d).[11]

The passthrough rate in the post-reform period is given by $(1+i_b)\left(\frac{N_r}{\delta+N_r}\right)\left(\frac{N_t}{\delta+N_t}\right)$. Assuming credit constraints never bind, even after the reform (i.e., R_b is large enough), the model thus predicts P2, that the reform should raise the pass-through rate. There are two reasons: the de-concentration resulting from elimination of the DO layer, and the rise in the interest cost of traders (i_b rather than i_d). The effect on the consumer price *level* is ambiguous, as the price-reducing effect of eliminating the DOT mark-up is counteracted by price-raising effect of higher costs of borrowing; the net effect can go either way.

C. Passthrough with Binding Credit Constraints

When default sanctions R_d, R_b are low enough, the credit constraint binds both before and after the reform. We solve for the corresponding symmetric subgame perfect equilibrium where the borrowing constraint binds for each trader. This means that the symmetric Cournot equilibrium at stage (iii) given P_d is characterized by

$$q_t = \frac{R_d}{P_d} \tag{20}$$

which generates the inverse demand function for the DOTs at stage (ii):

$$P_d = \frac{N_t R_d}{\sum_k q_k} \tag{21}$$

[10] Increasing the number of DOTs N_d has qualitatively similar effects.

[11] It could be argued that the former DOTs who became SO dealers after the reform could extend (pure) credit to the traders, but their ability to impose default sanctions by the threat of exclusion from trading in the oil market would no longer be available. Hence R_d would fall substantially. Moreover market power of the DOTs in the market for loans would result in charging a higher interest rate than i_d their cost of capital. So the effect would be qualitatively similar to borrowing from banks at a higher interest rate.

The demand function facing the DOTs now exhibits unit elasticity, with its position determined by the borrowing limits, i.e., the default penalties that can be levied on each trader by the DOTs. As trader credit constraints bind, their unit distribution costs C_d no longer play a role.

The implicit assumption in the above formulation is that the traders do not borrow from the banks in the pre-reform period even when they are quantity rationed. This is plausible when the financing advantage offered by DOTs over banks (difference between credit limits $(R_d - R_b)$, and interest charged $(i_b - i_d)$) is large enough. Section 4 provides a detailed discussion of this assumption, and its plausibility in the Bangladesh context.

Cournot competition among DOTs then yields the following symmetric equilibrium: given DO purchase price P_r (charged by the refiners), each DOT selects q_d to maximize (at $T = 1$ taka:)

$$\left[\frac{N_t R_d}{\left[(N_d - 1)q + q_d\right](1 + i_d)} - P_r\right] q_d \tag{22}$$

so each DOT must choose

$$q_d = \frac{N_t R_d}{(1 + i_d) P_r N_d}\left[1 - \frac{1}{N_d}\right] \tag{23}$$

implying the DOT equilibrium price is

$$P_d = (1 + i_d) P_r \left[1 - \frac{1}{N_d}\right]^{-1} \tag{24}$$

i.e, a constant markup $[1 - \frac{1}{N_d}]^{-1}$ over DOTs cost (including the financing cost). This is because of the unit elasticity of the demand function (21) facing the DOTs.

At stage (i) this implies the following inverse demand function for the refiners:

$$P_r = \frac{N_t R_d \left(1 - \frac{1}{N_d}\right)}{(1 + i_d) \sum_r q_r} \tag{25}$$

Observe that the demand function facing refiners also exhibits unit price elasticity, with the level depending on the borrowing limits on traders located two layers below in the supply chain. *Hence the bottlenecks created by borrowing constraints on traders cascades up the supply chain, even though agents at the upper layers are not themselves credit constrained.* This is because the upper layer agents cannot bypass the traders and sell to consumers directly.

The payoff function of the representative refiner (in $T = 1$ taka) in a symmetric equilibrium is:

$$\left[\frac{N_t R_d \left(1 - \frac{1}{N_d}\right)}{\left[(N_r - 1)q + q_r\right](1 + i_d)} - (P_m + C_r) \right] q_r \tag{26}$$

This equilibrium generates industry output

$$N_r q_r^{**} = \frac{N_t R_d \left(1 - \frac{1}{N_d}\right)\left(1 - \frac{1}{N_r}\right)}{(P_m + C_r)(1 + i_d)} \tag{27}$$

Refiners price DO's at a constant markup over cost:

$$P_r^{**} = (P_m + C_r)(1 + i_d)\left(1 - \frac{1}{N_r}\right)^{-1} \tag{28}$$

implying (via (24) a price charged by the DOTs:

$$P_d^{**} = (1 + i_d)^2 (P_m + C_r)\left(1 - \frac{1}{N_r}\right)^{-1}\left(1 - \frac{1}{N_d}\right)^{-1} \tag{29}$$

Hence both the refiners' and the DOTs' pricing is linear with a constant markup over cost. The binding borrowing constraints faced by the traders then determines the total output sold to the consumers, and the nonlinearity of the consumer demand function implies that the *consumer price ends up being nonlinear in import and refining costs:*

$$P_t^{**} = \alpha - \eta \left[\frac{N_t R_d}{(P_m + C_r)(1 + i_d)} \left(1 - \frac{1}{N_d}\right)\left(1 - \frac{1}{N_r}\right) \right]^{\delta} \tag{30}$$

This pass-through rate now depends on the import price:

$$\frac{\partial P_t^{**}}{\partial P_m} = \eta\delta \left[\frac{N_t R_d}{(1+i_d)} (1 - \frac{1}{N_d})(1 - \frac{1}{N_r}) \right]^{\delta} (P_m + C_r)^{-(1+\delta)}. \tag{31}$$

In particular, we obtain prediction P3 described in the Introduction: pass-through is falling in import, refining and financing costs P_m, C_r, i_d. It is also rising in credit limit R_d, and de-concentration of upper layers N_d, N_r.

To explain the former result, note that if refiners costs rise owing to an increase in the oil import price, the DOT price rises by the same proportion (see (29)). This owes to the lower price elasticity of downstream derived demand which is now unity, owing to the binding credit constraints. These constraints also imply that the quantity of oil sold must fall by the same proportion. If the prior output *level* was smaller, the actual change in output delivered to consumers and hence the change in consumer price will also be lower. To see this more clearly, observe that pass-through can be expressed as follows:

$$\frac{\partial P_t^{**}}{\partial P_m} = \eta\delta [Q^{**}]^{\delta} (P_m + C_r)^{-1} \tag{32}$$

and industry output Q^{**} falls while P_m rises. Since a decline in credit limits for traders (resulting from elimination of the DO layer) depresses industry output, it also causes the pass-through rate to fall.

Observe that while the pass-through rate depends on the level of the oil price, it does not depend on whether prices are falling or rising. This is another prediction that we shall test.[12] It owes to the static nature of the model. Extending it to a dynamic context, the same prediction holds if default penalties are exogenous and stationary. If part of the sanctions on defaulting traders includes exclusion from future trading (i.e., dealers refuse to sell DOs in any future date to a trader that defaults), it includes the payoff consequences of such future exclusion. If import price shocks are i.i.d. (as in the Rotemberg-Saloner 1986 model), the default penalty would be stationary. Even otherwise it will be approximately true if oil prices follow a stationary process

[12] Peltzman (2000) did not find evidence of asymmetry in passthrough for a third of the cases.

and expected future profits of traders do not fluctuate much with the current price.

D. Predicted Effects of the Reform When Credit Constraints Bind

The reform forces the traders to switch to borrowing from banks, and the banks impose a stricter borrowing limit besides charging a higher interest rate. In the post-reform period, there are no DOTs, which is equivalent to setting $N_d = \infty$. The traders borrow from banks, so (R_d, i_d) would be replaced by (R_b, i_b). The former effect (i.e., the elimination of the double marginalization due to DOT market power) would lower the downstream price, but the latter (increased financing cost) would raise it. The net effect can go either way, depending on which one is stronger to start with. For instance if N_d was already quite large in the pre-reform period, the competition effect would be negligible and the financing effect could dominate, resulting in a higher pa. Alternatively, the competition effect could be large if N_d was low in the pre-reform period, while the financing cost effect could be small ((R_b, i_b) could be close to $R_d, i_d)$).

In similar vein, the effect on pass-through is also ambiguous: as (31) shows the competition effect and financing effect move it in opposite directions. If the financing effect dominates, the price level rises and pass-through falls; otherwise the opposite happens. This is prediction P4. The model makes a supplementary prediction regarding the effect of the reform (which will turn out to hold empirically): *pass-through falls if and only if the price level rises.* To see this, use (30) and (31) to obtain the following expression for the pass-through rate

$$\frac{\partial P_t^{**}}{\partial P_m} = \delta \frac{\alpha - P_t^{**}}{P_m + C_r} \tag{33}$$

E. Relation to Model with Capacity Constraints without Credit Rationing

How does the model with binding credit constraints relate to an extension of the standard model with capacity constraints but without credit rationing? In the latter, unit costs are not constant: they rise with the quantity of oil traded. The extreme version of such a model would have unit costs constant up to some capacity limit $\bar{q}$ on quantity; the cost associated with any higher quantity is infinite. Alternatively, unit costs could be rising smoothly with quantity. Rising unit costs would lower pass-through: e.g., in the extreme version of the model pass-through would be zero if the capacity limit is binding; otherwise it will be the same as in the standard model. Whether capacity constraints will bind, depends on the price of oil. They would not bind if $q^* \equiv \frac{Q^*}{n}$ is smaller than the capacity limit $\bar{q}$, where Q^* is given by expression (15). Given all the other parameters and costs, the capacity constraint will bind when the import price of crude oil falls below a threshold defined by the level of P_m where the unconstrained per trader output q^* equals the capacity limit. Hence pass-through will be as predicted by the standard model if the price of oil is high (above the threshold), and zero otherwise.

Binding capacity constraints are similar to binding credit constraints insofar as they lower pass-through over some range of prices. However, observe that the two models differ in the exact manner in which pass-through depends on the oil import price. In particular, the pass-through rate is increasing in the price of oil in the capacity constrained model[13], referred to as prediction P5 in the Introduction. Moreover, prediction P5 implies that the capacity constraint model also leads to prediction P2 concerning the effects of the ban (since the crude import price was higher on average when it was operating). These are counter to predictions P3, P4 of the credit rationing model.

Nevertheless, as argued by a referee, one way to think about credit rationing is that it imposes a limit on the quantity for any trader; in this sense there is a conceptual similarity between credit constraints and capacity constraints. We agree, but wish to highlight that they vary with downstream prices in opposite ways, with important implications for the price and welfare effects of the policy reform. Our empirical analysis will also control for possible capacity

[13]This is true even when unit costs rise smoothly in quantity. For instance, consider the outcome with a single layer of N_t identical traders with unit distribution costs $C_t = d_0 + d_1 q$ with $d_0, d_1 > 0$ and DO price P_d which is increasing in P_m. Then the Cournot equilibrium price P_t satisfies $P_t = \alpha \frac{N_t}{N_t+\delta} + \frac{N_t}{N_t+\delta}[P_d + d_0 + d_1 q] + \frac{d_1}{N_t+\delta}[\frac{\alpha - P_t}{\eta}]^{\frac{1}{\delta}}$, with passthrough $\frac{\partial P_t}{\partial P_d} = \frac{N_t}{N_t+\delta}[1 + \frac{d_1}{\delta(N_t+\delta)}(\frac{\alpha-P_t}{\eta})^{\frac{1}{\delta}-1}]^{-1}$. Capacity constraints are represented by the parameter d_1, and it is evident that passthrough is falling in d_1. And given the natural restriction that $\delta \in (0,1)$ (needed for demand elasticity to exceed unity when quantity of output exceeds unity), it follows that passthrough is rising in P_d (hence also in P_m).

constraints in storage and transport, by comparing price movements with other commodities not subject to the ban but incurring similar storage and transport costs.

III. Extensions: Alternative Financing and Trading Options for the Traders

The preceding analysis is based on the assumption that the DOTs enjoy a comparative advantage in providing credit to the traders (lower interest rate and higher credit limit). In Bangladesh, the DOT's advantage over banks in financing derives from two sources. First, they can impose stronger default penalties, involving sanctions not available to banks (e.g., social sanctions, exclusion from oil trading opportunities in the future, forced seizure of assets, threats of violence etc).[14] Second, the DOTs have access to loanable funds at a lower interest cost compared to banks (see the discussion in Uddin and Taslim 2010), and have lower administrative and overhead costs. Among other factors, black money generated by tax evasion is likely to be an important source of DOT finance which cannot be deposited in banks to earn interest income.

In the online appendix, we discuss the implications of allowing the wholesale traders access to a wider range of financing and trading options. We consider the following cases: (i) the trader can purchase DOs from the DOTs paying cash with a loan from the Bank; (ii) the trader buy DOs from refiners directly from the refiner, again financed with a bank loan, and (iii) the trader uses bank credit to finance additional DOs. The results in the online appendix show that the equilibrium obtained in section (3) above prevails if the bank interest rate is not too low in the following sense:

$$1 + i_b > \frac{P_t^{**}}{P_r^{**}} \tag{34}$$

Intuitively, this condition implies that the price charged by DOTs is smaller than the cost

[14]Moreover, sanctions can be imposed speedily, without going through the complex and cumbersome procedures involving bureaucratic sanctions and judicial constraints that banks have to respect.

that wholesalers would incur if they purchased directly from refiners, and financed this by borrowing at interest rate i_b from banks. Since the price charged by refiners is lower than the price charged by DOTs, it also deters purchases from the latter which are financed by bank loans. This condition is precisely the reason the DOTs are able to function as intermediaries in the supply chain.

Using data from a 2013 survey of oil traders in Bangladesh that we conducted (Emran et al. 2015), we can check whether inequality (34) is satisfied. The ratio of wholesale price (P_t^{**}) to refiner price (P_r^{**}) is 1.097, while the estimate for $1 + i_b$ is 1.18 as the bank interest rate paid by the traders is 18 percent.[15] Thus, inequality (34) is satisfied in 2013 data for wholesale traders.

A question, raised by a referee, is whether condition (34) imposes an upper bound on DOT margins that implies prices must rise as a result of the reform. This is not necessarily true; hence the effects of the ban on the downstream price is theoretically ambiguous. The reason is that replication of the post-reform equilibrium as a counterfactual in the pre-reform period requires that *all* traders bypass the DOTs and purchase from refiners in a coordinated move, resulting in a stricter bound on DOT margins than is implied by no profitable unilateral move by a single trader. The pre-reform equilibrium bound is determined by the requirement of no profitable unilateral deviation by a single trader.[16]

We next consider an extension of the model where some traders are credit constrained, and others are not. Suppose there are N_{tu} unconstrained traders, and N_{tc} constrained traders. The two categories of traders (subscript 'u' for unconstrained, and 'c' for constrained) differ with respect to their ability to commit to repaying credit-based transactions to the DOTs, with respective default penalties R_{ud}, R_{ub} and R_{cd}, R_{cb} where the subscripts 'd' and 'b' refer to credit from the DOTs and the banks respectively. So R_{ud}, R_{ub} are large enough that the borrowing

[15]The mean interest rate reported by the traders is 17.74 and the median is 18 (Emran et al. 2015). The average interest rates on short-term bank loans reported by Bangladesh Bank (the central bank) is 13.38 percent in the post-reform period implying that $1 + i_b = 1.1338$ (data from Bangladesh Bank web site).

[16]Specifically, it is possible that condition (34) holds, while the reform causes the price to fall (i.e., $\frac{R_b}{1+i_b} > \frac{R_d}{1+i_d}(1 - \frac{1}{N_d})$). An example is when $N_d = 4, N_r = 5, i_d = .2.i_b = .25, R_b = 10, R_d = 12, P_m + C_r = 60$ and $\alpha = 125$, where it can be verified that price falls, while all the assumptions of the model are satisfied.

constraints of the unconstrained traders never bind, while R_{cd}, R_{cb} are substantially smaller so these represent their respective credit limits with the DOTs and the banks respectively. As before, $R_{cd} > R_{cb}$ and $i_d < i_b$. There are thus two markets for sale of DOs by the DOTs to the traders: one in cash, and the other bundled with credit. Each DOT decides how much to sell in each of these two markets. The cash price $P_{d\$}$ is paid at period $T = 0$, while the credit price P_d is paid at $T = 1$. The online Appendix shows that (a) every subgame perfect equilibrium of this model must be characterized by $P_{d\$}(1 + i_d) = P_d$, i.e., an implicit interest rate on trade credit of i_d, and (b) every subgame perfect equilibrium generates the same outcomes as the one in which *all* DOs are sold to traders on credit.

If traders are able to buy directly from refiners, and borrow from multiple sources, condition (34) ensures that in the case where the number of unconstrained (resp constrained) traders approaches zero, there is an equilibrium approaching one described in the previous section, where traders only purchase on credit from the DOTs.

IV. Empirical Strategy

We utilize daily data on crude palm import price and domestic wholesale price to estimate the pass-through equation and how it changed following the reform. The alternative theoretical models not only provide contrasting predictions about the effects of the reform, they also deliver testable predictions that can be tested with the data from the pre-reform period. An implication of the credit rationing model is that passthrough is lower when the import price is high, in contrast to a constant passthrough in the standard model.[17] Moreover, both models are static, so they do not predict any asymmetry in passthrough, i.e., it does not depend on whether the import price is rising or falling over time. We start by testing these predictions using data from the pre-reform period.

[17] If the standard model is extended to incorporate capacity constraints which cause use unit costs to rise with quantity, it predicts higher passthrough when the import price is high. See the discussion in Section VI.

In order to test the standard model, we would ideally estimate the following equation

$$P_\tau^s = \gamma_s + \beta_s P_{\tau m} + \beta_s C_\tau + \epsilon_\tau \tag{35}$$

analogous to equations (16), where $s = 0, 1$ refer to the regimes before (0) and after (1) the reform, τ denotes the date, the dependent variable P_τ^s is the wholesale price during regime s, the regressor $P_{\tau m}$ is the crude palm import price, and C_τ denotes the sum of refining and distribution costs. The pass-through β_s depends on the competition variables $\frac{N_i}{N_i+\delta}$ across various stages, and the interest rate at which wholesale traders borrow. The key prediction of the standard model is that $\beta_1 > \beta_0$, owing to a rise in competition and the interest rate following the DOT ban. The change in the intercept $\gamma_1 - \gamma_0$ is of independent interest, as it helps estimate the effect of the reform on the level of downstream prices. The standard model predicts that $\gamma_1 < \gamma_0$. Hence we are interested in a regression of the form

$$P_\tau = \theta_0 + \theta_1 d_s + \theta_3 d_s \left(P_{\tau m} + C_\tau\right) + \theta_2 \left(P_{\tau m} + C_\tau\right) + \epsilon_\tau \tag{36}$$

where d_s is a regime dummy (1 after the reform, 0 before), and identifying the signs of coefficients of the reform dummy $\theta_1 (\equiv \gamma_1 - \gamma_0)$ and its interaction with the import price $\theta_3 (\equiv \beta_1 - \beta_0)$. We refer to this as the before-after regression.

The key difficulty with the before-after approach is that we do not have data on costs of refiners, and financing and distribution costs of wholesale traders. When these costs are correlated with the import price, the estimated pass-through will be biased if the correlation varies significantly between the pre- and post-reform periods.[18] In the online appendix, we report some evidence on such correlations with the diesel price, and the estimates of the effects of the reform from the before-after regression (see Table T.1). However, in general, it is not possible to empirically verify the assumption of constant correlation for all the different components of the costs of the refiners and the traders. Moreover, it is not possible to make inferences

[18] This omitted variables bias remains important even if the marginal costs of the traders are constant as assumed in the standard model, and thus do not affect the passthrough rate directly.

regarding the changes in the intercept term on the basis of the before-after regression, and as a result we cannot assess the effects of the reform on the *level* of the wholesale and consumer (retail) prices.[19]

A more credible approach would be a difference-in-difference (DiD) design which compares price movements in palm oil with that in other commodities with similar vertical distribution channels, and comparable storage and transport costs. We use wheat and lentil as the comparison commodities in our DiD analysis, as they are also mostly imported from abroad in Bangladesh flowing through similar vertical chains, and are subject to similar transport and storage costs.[20] The reform did not apply to wheat or lentils, so their supply chains were not affected. This leads to a DiD regression using data which pools oil, wheat and lentil:

(37)

$$P_\tau = [\theta_0 + \lambda_1 d_O] + [\theta_1 d_s + \lambda_3 (d_O * d_s)] + [\theta_2 P_{\tau m} + \lambda_2 (d_O * P_{\tau m})] + [\theta_3 (d_s * P_{\tau m}) + \lambda_4 (d_O * d_s * P_{\tau m})] + \epsilon^*_\tau$$

where d_O denotes an oil dummy, and the prices P_τ and $P_{\tau m}$ now include palm oil, wheat, and lentils. Then λ_3 and λ_4 would provide estimates of the effect of the reform on the intercept and pass-through rates in oil. Assuming that storage rental rates and transport rates co-move in the same way for palm oil, wheat and lentil, the estimates from the DiD design will be less biased than the before-after regression using data on oil alone.[21] Naturally, the credibility of the DiD research design depends on the validity of the parallel trends assumption. The fact that we have daily data on prices for a long period from the pre-reform regime allows us to implement multiple tests of the validity of parallel trends at various points of time.

A final issue in assessing the effects of the reform on passthrough rate is a possible confounding effect of changes in bank interest rate in the post-reform period because of factors unrelated to the reform such as central bank policy. One might worry that if the bank interest

[19] In addition to possible changes in the correlation between omitted distribution costs and import price, any changes in the average distribution costs across the pre- and post-reform periods would cause bias in the estimate of the effects of the reform on the intercept from a before-after regression.

[20] All three commodities are nonperishable, and have similar space and transport requirements.

[21] This specification of the DiD regression does not allow for the passthrough to vary between the comparison commodities: wheat and lentil. The estimates from the alternative specification where wheat and lentil passthrough rates can be different are reported in the online appendix Table T.2.

rate fell significantly due to central bank policy independent of the policy reform in the edible oils market, the interest rate paid by the wholesale traders may have fallen compared to the pre-reform period. Then the standard model would be consistent with a lower pass-through after the reform. The evidence on bank interest rates actually shows the opposite: the interest rate increased following the reform.[22] Since the wholesale traders of wheat and lentils could rely on the financial intermediaries, while the oil traders lost their access after the reform, the DiD design captures the effects of higher interest rates paid by oil traders when borrowing from the banks. This would bias our results in a direction that would strengthen our conclusion that reform caused passthrough to decline in edible oils.

V. Data and Empirical Results

We use daily price data for palm oil, wheat and lentil at various stages of the supply chain from the Department of Agricultural Marketing (DAM) unit of Ministry of Agriculture, Bangladesh Government. These data are very similar to daily price data collected by The Trading Corporation of Bangladesh (TCB) for major urban centers. We utilize the DAM data owing to longer coverage and across multiple commodities. Daily international prices of wheat are derived from the data stream of Chicago Board of Trading.[23] Crude palm oil price data is obtained from the Malaysian Palm-oil Board.[24] Lentil import prices are taken from the National Bureau of Revenue (NBR) daily import data.[25] Our "full sample" extends from January 24, 2008 to October 4, 2012. There are some data gaps due to lack of price data during weekends and holidays as well as some missing data in the DAM original data set. However, the main estimation sample we use for our empirical analysis consists of data from 1 year before the implementation of the reform, excluding the announcement period and the observations corresponding to low import prices. Later we use alternative samples including the announcement period and the low prices

[22]According to the Bangladesh Bank (the central bank) data, the average interest rate on short-term bank loans increased from 11.46 to 13.38 in the post-reform period.

[23]The data access requires a subscription.

[24]The data used in this paper were downloaded from the Malaysian Palm oil Board web site.

[25]The data were obtained from the relevant government officials directly and are not downloadable from the web sites of DAM, NBR and TCB.

to check robustness of our conclusions.

Table T.4 in the online appendix provides summary statistics for our main estimation sample on wholesale, retail and import prices of palm oil, wheat, and lentil prior to the reform. Figure 1 plots wholesale price data for palm oil along with the crude import price over the the main sample period used for estimation. The close co-movement between the two series is apparent, with a margin that moves counter-cyclically, suggesting a pass-through rate between 0 and 1. The two vertical lines in the middle of 2011 correspond to the dates of announcement and implementation of the reform. The import price was rising continuously from late 2008 onwards, until a few months prior to the onset of the reform. This was reversed thereafter immediately for a few months following the reform. Despite this the wholesale price remained stationary, resulting in an increase in the margin, suggesting that pass-through declined following the reform.

Figure 2 compares movements in wholesale trading margins for palm oil with the average margin for wheat and lentil (calculated as average wholesale price minus average import price). Prior to the reform, the two tended to move together, with the troughs and peaks in the average wheat and lentil margin tracking those in palm margin well.[26] The gap between the margins widened during the post reform period, with the margin in palm oil higher; they then seemed to converge thereafter. Estimates of the margins reported in the online appendix suggest a 25% or higher rise in oil margins while the margin for both wheat and lentil fell slightly. This preliminary evidence suggests that the primary goal of the reform to reduce trader's margin did not materialize; the effects of the reform might have been the opposite of what was intended by the policy makers.

A. Passthrough in the Pre-reform Period

Tables 1 and 2 show estimates of the passthrough of import price of crude palm oil to the wholesale prices of palm oils for different phases: (i) high vs. low prices, and (ii) rising vs.

[26]The margins are calculated using 4-week lagged import price to reflect delays caused by transport and processing. Our main empirical estimates also focus on the pass-through of 4-week lagged import prices.

falling prices in the international market. The sample consists of data from the pre-reform (pre-announcement) period. The first two columns in Table 1 report the estimated passthrough of the import price of crude palm oil to the wholesale price during the high vs. low international price regimes (where the high regime is defined by above-median prices). The evidence is clear that the passthrough rate is substantially *lower* in the high-price regime, 0.14 (high-price) vs. 0.83 (low-price). The null hypothesis that the passthrough rates are equal across high and low price regimes is rejected at the 1 percent level. This is consistent with the credit rationing model, but rejects the standard model. Similarly, for wheat, the passthrough is significantly lower during high world prices, while the passthrough rates are not significantly different for lentil across high and low price regimes.

The first two columns in Table 2 test whether the passthrough rate differed between phases when prices were falling or rising in the international market. The pre-reform period consists of one rising and one falling price regimes (period before July 2009 is falling price, July 2009-2010 is flat, July 2010-April 2011 is rising). Please see Figure F.1 in the online appendix. We divide the pre-reform period into two equal sub-periods with the flat part roughly equally divided into two sub-parts. The sample for this estimation is 2/27/2008 to 11/23/2009 for falling price, 11/24/2009 to 3/22/2011 for rising price. The estimates of passthrough rates are similar in magnitude across falling and rising prices regimes, and the null hypothesis of equal passthrough across the market phases cannot be rejected (p-value = 0.95). The evidence in the last four columns show that there is no evidence of asymmetry in price passthrough for wheat and lentil either. This is consistent with the simple static versions of both the standard and the credit rationing models that we have considered.

B. The DiD Estimates

The evidence in Table 1 that passthrough of oil prices vary significantly with the level of international prices has important implications for suitable choice of data samples for our subsequent tests of the effects of the policy reform. The post-reform period corresponded to a high price regime in the international market for crude palm oil. Our main empirical results from the DiD approach below are therefore based on a sample that includes only data from the high-price regime during the pre-reform period defined by the cut-off of median price.[27] We also report estimates from the full sample. A second issue is the choice of the time window for the pre-reform period. Although we have data from a long period (2 years) from before the reform, one might worry that as we move away from the date of reform, the possibility of other exogenous factors contaminating the DiD design increases. To address this, we focus on the sample consisting of data from the 1 year period immediately before the reform for our main results, and report the corresponding estimates using the 2 years pre-reform sample as part of the robustness checks.

To test the parallel trend assumption underlying the DiD analysis, we estimate the effects of placebo reforms in the pre-reform sample (1 year period immediately before the implementation of the reform). We define fictitious reform dates at many arbitrary points in time during the pre-reform period and estimate the "effects" of these placebo reforms in DiD regressions with wheat and lentils as the comparison commodities. If the identifying assumption of parallel pre-reform trends is violated, we should observe significant effects of these placebo reforms. Table 3 reports the estimates for two such placebo reforms (dated 3 months, 6 months before the announcement of the reform) which fail to reject the identifying assumption. The effects of six additional placebo reforms on the edible oils price passthrough rate are shown in the online appendix Figure F.2 along with the 95 percent confidence intervals; all of them fail to reject the null hypothesis of parallel trends.

C. Effects of the DOT Ban: DiD Estimates

Table 4 presents results of the DiD regressions for the actual reform where the reform dummy takes on the value of 1 when an observation comes from the period after the policy reform took effect on June 21, 2011. The dependent variable in the regressions is the wholesale price and

[27] The high-price sample defined by the median cut-off does not eliminate the difference in the average import prices of crude palm oil between pre and post reform estimation samples because of generally higher prices in the international market in the post-reform period. When we picked a sub-sample from the pre-reform period in a way so that the average prices are equal across the pre- and post-reform periods, the results from the DiD estimation still deliver the same set of conclusions. The results are reported in online appendix Table T.3.

the 4-week lagged import price is the independent variable of interest. We check the robustness of the results later with alternative lags for import price.[28] The regressions include year and quarter dummies, and a dummy for the Ramadan period when food prices tend to spike.[29] We exclude data for the few months between the date of announcement and implementation of the reform.[30]

Based on a correlogram analysis of price data, we allow for an AR (3) process in the residuals. The null hypothesis of a unit root in the residual is rejected at the 1 percent level by augmented Dickey-Fuller and panel unit root tests for all of the price regressions reported in this paper. Standard errors are corrected for heteroskedasticity and autocorrelation using the Newey-West (1987) procedure.

The first two columns in Table 4 report the estimates from the DiD regressions (column 1 without controls for distribution costs, and column 2 with controls). The results show that the reform reduced the price passthrough rate for edible oils, but increased the intercept of the price equation.[31] These conclusions are robust to allowing passthrough to vary between wheat and lentil.[32] The next two columns in Table 4 show the estimates from the DiD regressions with wheat only (column 3) or lentils only (column 4) as the comparison commodity; the estimates again deliver the similar conclusions. The last column (i.e., column 5) takes advantage of the fact that we have more than one comparison commodity: we see that the reform did not affect passthrough of a placebo treatment commodity (say wheat) in comparison to the other (lentils).

Table 5 shows the results from a series of robustness checks.[33] The first two columns show

[28]The 4-week lag is chosen to reflect the fact that it takes about 10-14 days to transport the crude oil from Malaysia to Chittagong port after an order is placed, and then the oil needs to be transported to the mills and refined which require approximately 2 more weeks. The conclusions of this paper, however, do not depend on this particular lag assumption. See the evidence based on alternative lags below.

[29]The main conclusions are not affected if we include year×month fixed effects. The results are reported in online appendix Table T.3.

[30]Later we show that the conclusions are robust to the inclusion of data for these months in the sample.

[31]Compared to the estimates from the before-after approach reported in the online appendix, the fall in the pass-through rate and the rise in the intercept are both larger. This suggests substantial biases in the before-after estimates. For a fuller discussion on the nature of the biases, see the online appendix.

[32]This is shown in appendix Table T.2 which uses a more flexible specification of the DiD model with different passthrough rates for wheat and lentil. All specifications in this paper allow for different intercepts for wheat and lentil price equations.

[33]The specification used in Tables 5 and 6 below corresponds to the specification in the odd columns in Table 4

results when the estimation sample includes the announcement period (column 1) and data from the pre-reform low price regime (column 2). The conclusions regarding the effects of the reform on the passthrough rate and the intercept remain unchanged. The next two columns in Table 5 relate to robustness with respect to the lags in the import price. Instead of the four week lag used in Table 4, column (3) uses no lag, and column (4) adopts a 8-week lag for the import price of crude palm oils. These correspond to alternative hypotheses concerning the way refiners set prices for refined oil, based on historic or current cost, and alternative specifications of the lag between the time of import of crude oil and sale of refined oil. The central conclusions from Table 4 are robust to such alternative specifications of the lag in import price used for estimation. The last column of Table 5 shows that the results continue to hold when the pre-reform sample is expanded to include two years. As to be expected, the numerical magnitudes differ across these different lag specifications and data samples.

Observe also that the estimates in Tables 4 and 5 imply that the effect of the reform on the level of the wholesale price was positive. For instance, Column 2 in Table 4 indicates an increase in the intercept by between 47-50 taka, which outweighs the effect of a lower pass-through (0.544 multiplied by the average import price of between 75-80 taka). The same is true for all the estimates reported in Table 5. This is consistent with the prediction of the credit rationing model that pass-through will decline if the price level rises. If we estimate a simple DiD specification without allowing for changes in the passthrough rate following the reform, the increase in the price level is larger; the estimates imply a 10.41 taka higher wholesale price level during the post-reform period as compared to an estimate of about 6.50 taka higher price from Table 4 (evaluated at the mean price level).

The exact period for which the effects of the reform lasted is unclear, as the ban on the operation of DOTs started to unravel gradually about 6 months after the implementation of the reform. According to informal accounts, the reform was in place for about a year. Table 6 thus separates the post-reform period into the first 6 and 9 months following the reform,

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with wheat and lentils as the comparison commodities, but without diesel price and exchange rate as additional controls. The results are similar if we include proxies for distribution costs. The estimates are available upon request.

from the post-6/9 month period. The DiD results show that it is not possible to find any definitive effect beyond 9 months. Moreover, the first 9-month effect was larger than the effects in the previous tables which pooled all post-reform dates into a single post-reform period. In the online appendix (Figures F.3, F.4) , we report estimates for the first 5 months, for 5-10 months after the reform, and after 10 months separately; the evidence suggesting monotonically declining magnitude of the effects of the reform.

Our analysis predicts that the reform affected the wholesale margin (i.e, wholesale price - import price) but did not directly affect the wholesale-retail margin, since it affected DOTs who intermediated between the refiners and the wholesalers. This would imply that the effects on the retail margin (consumer price less the oil import price) would be similar to those for the wholesale margin.[34] The first column in Table 7 presents the results for the retail margin for our main estimation sample used for the estimates in Table 4. These are very similar to the results in Table 4 for the wholesale margin. Column 2 of Table 7 shows that the effects for the first 9 months following the reform had similar but somewhat larger effects on the retail margin (compared with the effects on the wholesale margin shown in Table 6).

VI. Supplementary Evidence and Alternative Explanations

We now discuss additional but less formal evidence consistent with our finding of an increase in the wholesale price of palm oil resulting from intensified credit constraints of wholesalers following the reform. Choudhury and Clara Costa 2012 provide case studies of the experience of two refiners (Nurjahan Group and Bangladesh Edible Oils Limited) following the reform. Owing to a drop in the demand from wholesalers (and the SO dealers), these two refiners accumulated excess inventories, and thereafter lowered their imports of crude oil by 39% between 2010 and 2011. Consistent with this account, aggregate imports of crude oil for Bangladesh as a whole

[34]However, if the reform had some (weaker) effects on the retail margins, the total impact on the consumer prices may be somewhat larger than what is suggested by the estimates for the wholesale prices.

fell following the reform: see Figure 3 which plots monthly imports for 2009-10 and 2010-11. A simple before-after regression indicates a statistically significant decline in crude imports following the reform (significant at the 5 percent level). It is striking that this happened during a period when world oil prices were declining, reversing the trend for the previous years (as seen in Figure 1).

Do the estimates seem plausible in magnitude? The DiD estimates for the first 9 months in Table 6 imply that the wholesale price was 9.29 taka higher, i.e., a 11.34 percent increase in prices as a result of the reform (evaluated at the median import price). This price increase is statistically significant at the 1 percent level; a formal test of the null hypothesis of no effect of the reform (at the median import price) yields F= 58.70. As noted earlier, the DiD estimates capture the effects of both the bank interest rate and tighter credit rationing faced by the traders when borrowing from the banks. According to the central bank (Bangladesh Bank), the average interest rate on short-term bank loans increased by 2 percentage points in the post reform period. Can this increase in interest rate alone account for the higher prices? The median wholesale price of palm oil in the post-reform period was 92 taka, which would suggest a maximum of 1.84 taka higher prices due to the higher bank interest rates caused by factors unrelated to the reform.[35] This in turn implies 7.45 taka higher prices because of the reform (which amounts to a 9.4 percent increase).

However, the effects of the credit limits applied only to traders who switched from the DOTs to the banks after the reform; it is possible that at least some traders were able to arrange alternative financing. In 2013, two years following the reform, we conducted a survey of edible oil traders in the Dhaka and Chittagong markets (Emran et al. 2015). Data on 6176 transactions between DOTs and wholesalers revealed that 30% of transactions between DOTs and wholesalers were on credit, and supplier credit from DOTs accounted for 32 percent of the volume. A retrospective survey we conducted in February 2016 of a sub-sample of 50 wholesale traders buying on credit from DOTs prior to the reform shows that a 45% reduction in volume had occurred following the ban. This suggests that the aggregate supply at the wholesale level

[35] This assumes a 100 percent passthrough of interest costs to prices.

should drop by approximately 15% after the reform, assuming that all of the previously DOT-dependent traders experienced a 45% reduction in volume on average. The available estimate for edible oils demand in Bangladesh suggests a price elasticity of 1.16 (Talukder 1990).[36] This yields a back-of-the-envelope estimate of a price increase of about 13% owing to the 15% quantity reduction after the reform. This is higher than the DiD estimate of a 9.4% increase, suggesting some of the traders previously dependent on the DOTs were able to find alternative sources of financing from other informal channels that were less expensive and constraining than the banks.

A possible alternative explanation of the rise in wholesale price is that the reform inadvertently increased the market power at some layer of the vertical chain despite the policy goal of de-concentrating the market. The refiner layer seems the most likely locus of such market power because it is the most concentrated with only 9 refiners who were selling directly to wholesalers, rather than indirectly through the 300 DOTs prior to the reform. This would have implied an increase in total profits earned by the refiners, who would then have a vested interest in ensuring that the reform was not reversed. Interviews with the refiners and traders, as well as the retrospective survey of 50 traders we conducted in February 2016 instead report that the refiners were unhappy with the reform (owing to the limited take up from the sales order (SO) dealers in the new system) and surreptitiously went back to the DOTs to offload their accumulated inventory. This indicates that the refiners' profit was adversely affected by the reform, consistent with the prediction of the credit rationing model.[37]

We have already explained at the end of Section that the results cannot be explained by rising costs of capacity utilization, as a model with such a feature but without credit rationing makes opposite predictions concerning how passthrough varies with the oil import price and the

[36]An estimate for edible oils price elasticity in USA is 1.24 (Kojima et al. 2014).

[37]As noted by an anonymous referee, if the ban on the DOTs were enforced only selectively then the number of DOTs would be smaller in the post-reform period with increased market power; if in addition there was no fresh entry, the lower passthrough rate after the reform could be consistent with the predictions of the standard model. However, the evidence does not support this hypothesis: there was a considerable extent of new entry, as the 300 DOTs in the Dhaka and Chittagong markets were replaced with more than 7000 SO-dealers, thus making the market more competitive.

reform. Search cost based explanations also do not seem plausible.[38] Search costs did not seem significant prior to the reform, as DOTs operate within a very narrow market area in Dhaka and Chittagong, and wholesale traders could find out prices quoted by the DOTs by making a telephone call to their contacts in these market areas. Following the reform, there were only 9 refiners from whom they could purchase; finding out what prices they were charging would have been even easier than checking prices charged by the 300 DOTs previously.

Yet another possibility is that the quantity caps imposed on the newly appointed SO dealers were binding and the resulting reduction in quantity led to higher prices after the reform. This explanation, however, is not consistent with the fact that many of the SO dealers were not taking delivery of the entitled oil, and the refiners were facing unwanted stockpiles of refined oils which ultimately unraveled the reform.

VII. Concluding Comments

To discriminate between the models of supply chains with and without quantitative credit rationing, this paper studies a policy experiment in Bangladesh where the government banned a layer of financial intermediaries in edible oils market in 2011. The reform was motivated by widely held belief that these intermediaries exert market power, which keeps consumer prices high and lower pass-through of crude import costs. These expectations were consistent with the predictions of a a standard double marginalization model without credit rationing. We first showed that these predictions can get reversed in the presence of financial contracting frictions that result in binding credit constraints for downstream traders, where intermediaries expand their credit access.

We then tested the competing predictions of the two models, using a difference-in-difference (DiD) design with wheat and lentil as the comparison commodities because, like palm oil, they incur similar distribution costs and are imported into Bangladesh. A series of placebo reforms using data from the pre-reform period provided evidence in favor of the parallel trends

[38]Chau et al. 2016 and Casaburi et al. 2013 emphasize search costs for small farmers looking for the best price offered by the middlemen.

assumption underlying the DiD research design. The estimates of the effects of the reform from the DiD approach shows that, contrary to the expectations of the policy makers, the reform raised consumer prices and reduced pass-through of crude import prices. Therefore, credit market frictions and quantitative credit rationing are important in understanding how international price shocks are transmitted to domestic wholesale and retail (consumer) prices in developing countries, and in the formulation of regulatory policies.

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Table 1: Wholesale Price Pass-Through during Pre-reform period: High vs. Low world price

(Dependent Variable Wholesale Prices)

	Palm		Wheat		Lentil	
	High Price	Low Price	High Price	Low Price	High Price	Low Price
	(1)	(2)	(3)	(4)	(5)	(6)
World Price	0.139	0.828	0.879	1.800	0.839	0.752
	(0.127)	(0.0784)	(0.169)	(0.129)	(0.175)	(0.314)
Constant	79.70	22.31	10.23	-5.207	22.70	27.87
	(10.27)	(4.149)	(3.117)	(1.626)	(11.17)	(16.59)
	Test of equality of coefficients					
F-statistics	29.42		29.82		0.08	
P-value	0.00		0.00		0.78	
Observations	143	402	186	346	266	83

Notes: The estimation sample is the entire pre-reform period (January 24, 2008-March 22, 2011). High (low) price sample is defined as all periods when world price is higher (lower) than median (over the entire sample including post-reform period). Standard errors are in parentheses and corrected using Newey-West (1987) procedure for heteroskedasticity and autocorrelation, assuming AR (3) process.

Table 2: Pass-Through During Pre-reform period: Test of Asymmetry

(Dependent Variable Wholesale Prices)

	Palm		Wheat		Lentil	
	Falling Price	Rising Price	Falling Price	Rising Price	Falling Price	Rising Price
	(1)	(2)	(3)	(4)	(5)	(6)
World Price	0.487	0.494	0.863	0.863	0.408	0.227
	(0.105)	(0.0732)	(0.119)	(0.0937)	(0.194)	(0.0532)
Constant	51.27	49.73	13.52	8.912	53.99	55.85
	(7.236)	(6.260)	(2.715)	(1.757)	(12.70)	(3.030)
	Test of equality of coefficients					
F-statistics	0.00		0.00		0.87	
P-value	0.95		0.99		0.35	
Observations	273	272	205	327	176	173

Notes: The estimation sample is the entire pre-reform period (January 24, 2008-March 22, 2011). Standard errors are in parentheses and corrected using Newey-West (1987) procedure for heteroskedasticity and autocorrelation, assuming AR (3) process.

Table 3: Test of Parallel Trends between Wheat/Lentil and Oil Prices in Pre-reform Period
(Dependent Variable Wholesale Prices)

	Fictitious Policy Reform before X months of announcement of actual reform	
	X=6-month	X=3-month
	(1)	(2)
Fictitious Reform Dummy	-31.37	3.198
	(8.224)	(1.016)
Reform Dummy*Palm Dummy	**-10.68**	**-12.34**
	(20.22)	**(10.24)**
Reform Dummy*Palm Dummy* World Price	**0.432**	**0.243**
	(0.382)	**(0.147)**
Reform Dummy*World Price	0.468	-0.152
	(0.131)	(0.024)
World Price*Palm Dummy	0.0151	0.716
	(0.371)	(0.105)
World Price	-0.307	-0.00473
	(0.107)	(0.0520)
Palm Dummy	27.45	7.018
	(19.86)	(5.210)
Intercept	52.81	-98.33
	(71.31)	(88.22)
Observations	379	379
Year and Quarter dummies	Yes	Yes
Lentil Dummy	Yes	Yes
Ramadan Dummies	Yes	Yes

Notes: (a) The placebo reform is dated 6 and 3 months before the announcement of reform date (March 22, 2011) respectively. (b) Main coefficients of interest are in bold. (c) Pre-reform sample spans from June 3, 2010 to March 22, 2011. (d) Standard errors are corrected using Newey-West (1987) procedure for heteroskedasticity and autocorrelation, assuming AR (3) error process. Standard errors in parentheses.

Table 4: Effects of the Policy Reform on Wholesale Prices: DiD Estimates from High Price Sample
(Dependent Variable: Wholesale Prices)

	Effects on Palm Oil				Placebo Treatment
	Palm vs Lentil & Wheat		Palm vs Wheat	Palm vs. Lentil	Lentil vs. Wheat
	(1)	(2)	(3)	(4)	(5)
Reform Dummy	-5.805	-1.404	-14.21	-14.78	-3.151
	(1.180)	(1.519)	(6.571)	(7.117)	(5.803)
Reform Dummy*Palm Dummy	**47.35**	**49.52**	**49.80**	**63.23**	**-14.50**
	(7.710)	**(7.260)**	**(8.374)**	**(11.19)**	**(9.126)**
Reform Dummy*Palm Dummy* World Price	**-0.532**	**-0.544**	**-1.229**	**-0.775**	**0.262**
	(0.105)	**(0.099)**	**(0.307)**	**(0.174)**	**(0.317)**
Reform Dummy*World Price	0.0422	0.0267	0.900	0.240	0.0206
	(0.0182)	(0.0177)	(0.328)	(0.127)	(0.284)
Palm Dummy*World Price	0.600	0.603	1.002	0.871	-0.0881
	(0.0955)	(0.0886)	(0.258)	(0.109)	(0.228)
World Price	0.210	0.179	-0.302	-0.0413	0.103
	(0.0752)	(0.0659)	(0.293)	(0.0724)	(0.208)
Palm Dummy	1.662	3.312	1.027	-48.37	
	(3.697)	(3.582)	(4.323)	(6.811)	
Intercept	23.52	97.60	95.94	140.0	111.7
	(1.405)	(17.22)	(20.07)	(17.69)	(21.85)
Observations	1,090	1,090	684	832	664
Year and Quarter dummies	Yes	Yes	Yes	Yes	Yes
Ramadan Dummies	Yes	Yes	Yes	Yes	Yes
Lentil Dummy	Yes	Yes	Yes	Yes	Yes
Proxies for Distribution Costs	No	Yes	Yes	Yes	Yes

Notes: (a) Reform dummy=1 if an observation is from after the date of the actual reform: June 21, 2011. (b) The sample consists of the period from June 3, 2010 to October 4, 2012, but the announcement phase (90 days) is excluded. Observations for palm, wheat and lentil: Pre-reform: 399; Post reform: 691. (c) Unit for Palm is Litre and for Wheat and Lentil is Kg. (d) Proxies for distribution costs include diesel price and exchange rate. (e) Standard errors are in parentheses and corrected using Newey-West (1987) procedure for heteroskedasticity and autocorrelation, assuming AR (3) process. (f) Augmented Dickey-Fuller and Panel Unit Root Tests Reject the Null Hypothesis of Unit Roots in the Residuals.

Table 5: Effects of Reform on Wholesale Price of Palm Oil: Robustness to Alternative Samples and Lags in Crude Palm Oil Price
(Dependent Variable: Wholesale Price)

	Main Sample (High price & 1-year pre-reform)				**Two-year Pre-Reform**
	Includes Announcement	**Includes Low Price**	**No Lag**	**8 Week Lag**	**and High Price Sample**
	(1)	(2)	(3)	(4)	(5)
Reform Dummy	-3.673	-1.017	-1.210	-1.403	1.572
	(1.096)	(1.475)	(1.556)	(1.609)	(1.401)
Reform Dummy*Palm Dummy	**50.93**	**36.58**	**43.84**	**60.71**	**72.15**
	(7.114)	**(6.653)**	**(7.118)**	**(6.799)**	**(7.247)**
Reform Dummy*Palm Dummy* World Price	**-0.561**	**-0.362**	**-0.437**	**-0.744**	**-0.816**
	(0.0959)	**(0.0896)**	**(0.0949)**	**(0.0908)**	**(0.0997)**
Reform Dummy*World Price	0.0332	-0.0229	0.0326	0.0267	0.000366
	(0.0157)	(0.0167)	(0.0195)	(0.0173)	(0.0224)
Palm Dummy*World Price	0.634	0.442	0.475	0.659	0.694
	(0.0858)	(0.0757)	(0.0668)	(0.0934)	(0.118)
World Price	0.149	0.293	0.243	0.199	0.371
	(0.0633)	(0.0592)	(0.0485)	(0.0640)	(0.0902)
Palm Dummy	2.746	9.760	6.619	1.961	-15.12
	(3.507)	(2.963)	(3.028)	(4.190)	(4.346)
Intercept	81.80	68.82	101.3	96.34	105.0
	(15.67)	(19.28)	(15.97)	(20.26)	(17.22)
Observations	1,252	1,252	1,084	1,082	1,391
Year and Quarter dummies	Yes	Yes	Yes	Yes	Yes
Ramadan Dummies	Yes	Yes	Yes	Yes	Yes
Lentil Dummy	Yes	Yes	Yes	Yes	Yes
Proxies for Distribution Costs	Yes	Yes	Yes	Yes	Yes

Notes: (a) Reform dummy=1 if an observation is from after the date of the actual reform: June 21, 2011. (b) The 1-year sample consists of the period from June 3, 2010 to October 4, 2012, and 2-year sample spans from May 31, 2009 to October 4, 2012, and both samples exclude the announcement phase (90 days) with the exception of Column 1. (c) The DiD Comparisons for Palm are Wheat and Lentil. World Price Includes Palm, Wheat and Lentil. (d) Unit for Palm is Litre and for Wheat and Lentil is Kg. (e) Standard errors are in parentheses and corrected using Newey-West (1987) procedure for heteroskedasticity and autocorrelation, assuming AR (3) process.

Table 6: Effects of the Reform on Wholesale Palm Oil Prices: Short-run vs. Long-run
(Dependent Variable: Wholesale Price)

	Effects of Policy Reform Over Time	
	X=6-Month	X=9-Month
	(1)	(2)
Effects during first X months		
Reform Dummy^{SR} (D=1 for First X Months after June 21, 2011)	-4.271	-1.522
	(1.892)	(1.689)
Reform Dummy^{SR}*Palm Dummy	**60.49**	**60.55**
	(8.003)	**(5.951)**
Reform Dummy^{SR}*Palm Dummy *World Price	**-0.663**	**-0.641**
	(0.110)	**(0.0845)**
Reform Dummy^{SR}*World Price	0.0254	-0.0241
	(0.0240)	(0.0230)
Effects After First X months		
Reform Dummy^{LR} (D=1 for X months After June 21, 2011)	-4.959	-4.003
	(3.268)	(2.377)
Reform Dummy^{LR}*Palm Dummy	**20.21**	**-10.29**
	(10.25)	**(12.27)**
Reform Dummy^{LR}*Palm Dummy *World Price	**-0.204**	**0.132**
	(0.132)	**(0.156)**
Reform Dummy^{LR}*World Price	0.0335	0.0788
	(0.0223)	(0.0213)
World Price *Palm Dummy	0.564	0.568
	(0.0835)	(0.0792)
World Price	0.215	0.210
	(0.0609)	(0.0569)
Palm Dummy	4.311	4.290
	(3.466)	(3.362)
Intercept	64.95	90.96
	(24.92)	(14.07)
Observations	1,090	1,090
Year, Quarter and Ramadan dummies	Yes	Yes
Lentil Dummy	Yes	Yes
Proxies for Distribution Costs	Yes	Yes

Notes: (a) The estimates are from a specification that includes both reform dummy^{SR} and reform dummy^{LR} (b) The sample consists of the period from June 3, 2010 to October 4, 2012, but the announcement phase (90 days) is excluded. Observations for palm, wheat and lentil: Pre-reform: 399; Post reform: 691. (c) Unit for Palm is Litre and for Wheat and Lentil is Kg. (d) Proxies for distribution costs include diesel price and exchange rate. (e) Standard errors are in Parenthesis and are corrected using Newey-West (1987) procedure for heteroskedasticity and autocorrelation, assuming AR (3) process.

Table 7: Effects of the Reform on Retail (Consumer) Palm Oil Prices

(Dependent Variable: Retail Price)

	Mean Effect (1)	Short vs. Long term (2)
Reform Dummy	-3.754	
	(1.435)	
Reform Dummy*Palm Dummy	**47.11**	
	(6.396)	
Reform Dummy*Palm Dummy *World Price	**-0.471**	
	(0.0874)	
Reform*World price	-0.00726	
	(0.0159)	
Effects during first 9 months		
Reform Dummy^{SR} (D=1 for First 9 Months after June 21, 2011)		-3.838
		(1.716)
Reform Dummy^{SR}*Palm Dummy		**60.07**
		(4.991)
Reform Dummy^{SR}*Palm Dummy *World Price		**-0.609**
		(0.0697)
Reform Dummy^{SR}*World Price		-0.0388
		(0.0178)
Effects After First 9 months		
Reform Dummy^{LR} (D=1 for 9 months After June 21, 2011)		-5.134
		(2.853)
Reform Dummy^{LR}*Palm Dummy		**-0.874**
		(11.12)
Reform Dummy^{LR}*Palm Dummy *World Price		**0.0790**
		(0.145)
Reform Dummy^{LR}*World Price		0.0283
		(0.0247)
World Price*Palm Dummy	0.618	0.598
	(0.0801)	(0.0701)
World Price	0.139	0.157
	(0.0619)	(0.0522)
Palm Dummy	5.445	5.914
	(3.044)	(2.830)
Intercept	67.71	61.31
	(12.59)	(9.787)
Observations	1,090	1,090
Full set of controls	Yes	Yes

Notes: (a) The estimates are from a specification that includes both reform dummy^{SR} and reform dummy^{LR} . (b) The sample consists of the period from June 3, 2010 to October 4, 2012, but the announcement phase (90 days) is excluded. Observations for palm, wheat and lentil: Pre-reform: 399; Post reform: 691. (c) Unit for Palm is Litre and for Wheat and Lentil Kg. (d) Proxies for distribution costs include diesel price and exchange rate. (e) Standard errors are in Parenthesis and are corrected using Newey-West (1987) procedure for heteroskedasticity and autocorrelation, assuming AR (3) process.

Figure 1: World Market and Wholesale Prices of Palm Oil: 2009-2012

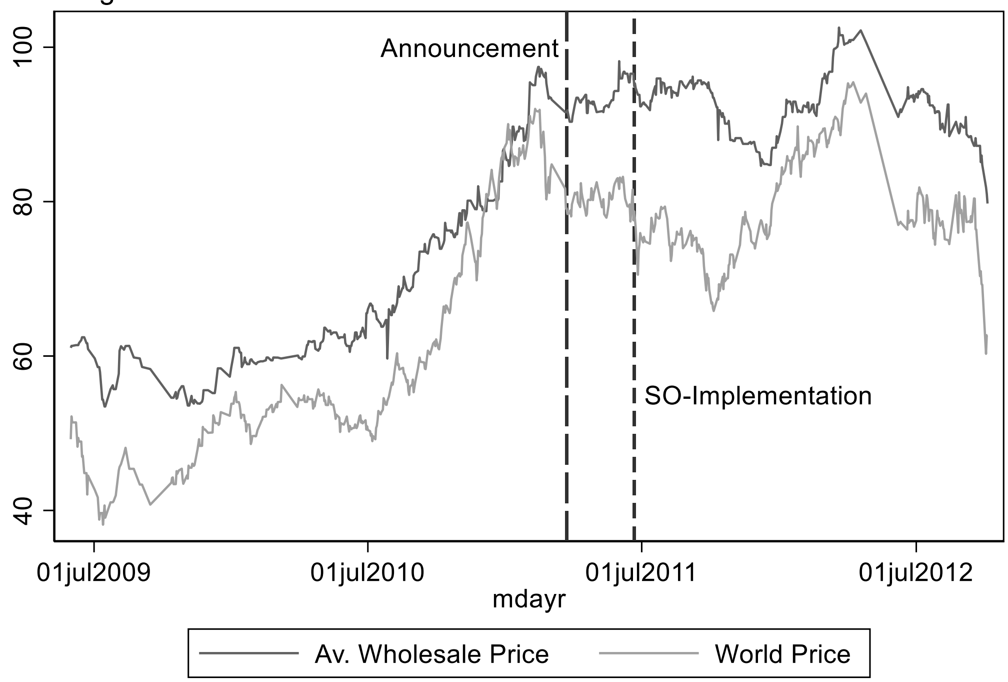

Figure 2: Wholesale- World Price Margins: 4-weeks lag in World Price

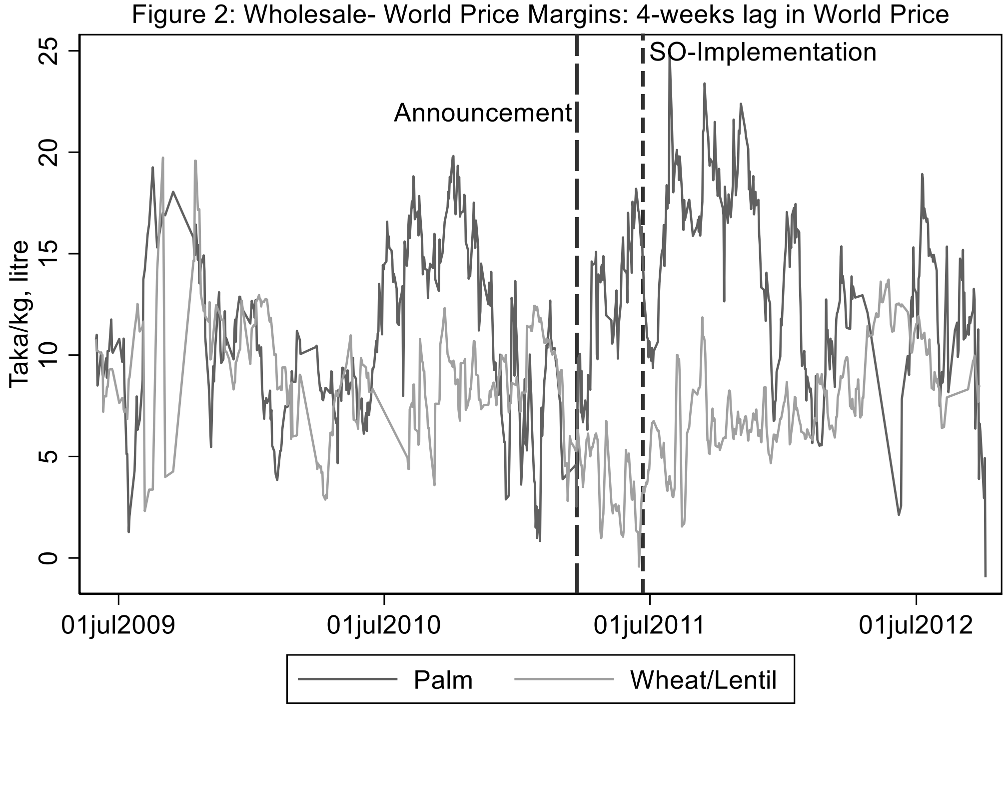

Figure 3: Monthly Average Palm Oil Imports