Credit Rationing and Pass-Through in Supply Chains: Theory and Evidence from Bangladesh[1]

M. Shahe Emran
IPD at Columbia University

Dilip Mookherjee
Boston University

Forhad Shilpi
World Bank

M. Helal Uddin
Dhaka University

February, 2019

ABSTRACT

We study role of supply chain intermediaries in relaxing credit constraints of downstream traders, by examining effects of a policy reform that banned a layer of financing intermediaries in Bangladesh's edible oils market during 2011-12. The standard model predicts higher post-reform pass-through of international prices to wholesale prices, while the credit rationing model predicts the opposite if the resulting credit contraction is strong enough. Evidence from a difference-in-difference estimation rejects the standard model. Our estimates imply that the regulatory effort to reduce market power of financing intermediaries ended up raising consumer prices by restricting access to credit of downstream traders.

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

JEL Codes: O12, L13, Q13

---

[1]Emails: shahe.emran@gmail.com, dilipm@bu.edu, fshilpi@worldbank.org, umhelal@gmail.com. We are grateful to Wally Mullin, Chris Woodruff, Raymond Guiteras, Andrew Foster, Sabyasachi Das, Marcel Fafchamps, Sebastian Bustos, Nidhiya Menon, Wahiduddin Mahmud, Fahad Khalil and Will Martin for helpful comments. The paper has also benefitted from feedback from seminars at Cornell and Georgetown Universities, and at the AEA Annual Conference 2016 at San Francisco, NEUDC 2014 at Boston University, GCER Conference 2015 at Georgetown University and IGC conference at Dhaka. We thank Rubaiya Emran for help with the graphs. The project was funded by KCP Trust Fund (World Bank) and IGC Bangladesh country program. An earlier version of the paper was circulated under the title "Do Consumers Benefit from Supply Chain Intermediaries? Evidence from a Policy Experiment in Edible Oils Market in Bangladesh".

1 Introduction

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 underlie arguments for regulations, often taking extreme forms of outright bans on some intermediary layers, and, in come cases, jail term for and even execution of traders. For example,

> "For my part, I wish every one of them (speculators) had his devilish head shot off". (Abraham Lincoln, quoted in Carpenter (1866, p. 84))
>
> "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". ((Vladimir Lenin, 1964, p. 311).)

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 led to agricultural market liberalization starting from the late 1970s. 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 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. However, there is relatively little systematic evidence on the effects of such policy actions.

In this paper we argue that the standard models of pass-through in the literature pay insufficient attention to the financing role of intermediaries. Specifically, if the financing intermediaries in a supply chain help relax quantitative credit constraints faced by downstream traders, banning them can have dramatically different implications for pass-through and price margins when compared to standard models of double marginalization of rents. We show this in the context of a model of symmetric Cournot competition with given concentration at each layer. As in the recent work of Atkin and Donaldson (2015), a Bulow-Pfleiderer (1983) specification of downstream consumer demand generates explicit linear recursive expressions for

prices at each layer in the absence of any credit rationing.[2] Pass-through rates are independent of cost levels, and depend only on concentration at successive layers and the curvature of the demand function. Removing an intermediate layer is equivalent to eliminating market power at that layer, which raises pass-through and lowers the intercept term in the downstream price equation. Extending the model to incorporate credit constrained downstream traders, and the role of upstream intermediaries in alleviating these credit constraints, we show that the effects of regulations can get reversed: if the credit rationing effect is strong enough, the pass-through rate falls while the intercept term rises as a result of removing the financing intermediary layer.

We test these contrasting predictions using daily wholesale and retail palm oil price data in Bangladesh spanning 2008-2013, a period which includes the drastic policy reform banning financing intermediaries (DOTs) from the market. We compare estimated pass-through of shocks to import prices of crude palm (which constitutes 80% of oil refining costs) before and after the reform (which lasted approximately one year starting in July 2011). The main econometric issue with this before-after approach (henceforth B-A approach) is that the estimated pass-through rates may be biased owing to the omission of other sources of distribution costs when they are correlated with the oil import price. The direction of the change in the pass-through rate estimated by the B-A approach is unbiased under the assumption that the correlation between the omitted distribution costs and imported crude price did not change as a result of the reform. However, the direction of bias in the change in the intercept term cannot be assessed without making additional assumptions that are difficult to verify directly. We deal with this problem in two ways. First, we check the sensitivity of the B-A estimates and the direction of the omitted variables bias by including proxies for changes in distribution costs such as diesel price and exchange rate. Second, and more importantly, we develop a difference-in-difference strategy and compare changes in oil prices with the changes in wheat and lentil prices, which are also imported and incurs similar distribution (transport and storage) costs, and for which the parallel trend assumption cannot be rejected.

[2] Our benchmark model without credit rationing differs from Atkin and Donaldson (2015) by incorporating financing intermediaries who provide low interest loans compared to banks. Moreover, we extend the standard model to incorporate the consequences of credit rationing.

In the B-A analysis, we find a substantial fall in the pass-through rate (from 80% to 68%), statistically significant at the 5% level. Moreover, the estimated intercept term nearly doubled (the difference being significant at the 1% level). The increase in the intercept was large enough to make the net effect on consumer price positive. Consistent with the assumption of positive correlation of distribution costs with crude import prices due to factors unrelated to the reform, the B-A estimates are larger when we include proxies for distribution costs, and the DiD estimates are larger than the corresponding B-A estimates. We check subsequently that the DiD results are robust with respect to alternative specifications of oil import lags, duration of the reform and the pre-reform period. The credibility of the DiD design is strengthened by placebos for the timing of the reform.

These results reject the double marginalization model of supply chains extended to include a layer of financing intermediaries providing low-interest credit, and are consistent with the model of credit rationing where financing intermediaries help relax binding credit constraints faced by downstream traders. The intuitive explanation is that the DOT ban resulted in more severe credit constraints faced by downstream wholesale and retail traders, resulting in a contraction in trade volumes which raised downstream prices. Moreover, the tightening of credit constraints effectively lowered price elasticity of derived demand functions faced by upstream refiners, resulting in higher refiner markups. These disruptions overwhelmed whatever reductions in market concentration resulted from the elimination of the DOTs from the market. This explanation is consistent with independent evidence from case-studies, as well as data on aggregate crude import volumes which contracted sharply (at a time when import prices were falling). It also helps explain why the reform was reversed, following pressure from palm oil refiners who were struggling to offload their accumulating inventories. The evidence and analysis presented below suggest that credit market frictions and quantitative credit rationing are important for understanding the pass-through of international prices to domestic wholesale and retail prices.

The rest of the paper is structured as follows. Section 2 provides details of the institutional setting of the palm oil supply chain in Bangladesh and the nature of the reform. Section 3

develops the theoretical analysis, followed by a discussion of estimation strategy in Section 4. Section 5 then describes the data and presents the empirical results. Section 6 discusses possible competing explanations, while Section 7 discusses related literature. Finally Section 8 concludes.

2 The Palm Oil Marketing Chain in Bangladesh and the 2011 Reform

2.1 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 9 refiners, some of them have considerable excess capacity. The refiners import 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. DOs are purchased by DOTs from refiners, sometimes immediately after the crude oil is imported, and sold later 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 partly because of the credit implicitly provided by a DOT. Estimates from a trader survey we conducted 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. Our post-reform data period however coincided with a downswing in the international market when activities in the secondary (horizontal) DOT market were almost nonexistent.[3] 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.

2.2 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 SO system,

[3]The DO layer is not a futures market, because there is no settlement at the end of the day. Also, unlike a futures contract, payment is made at the time of the DO contract, not at the delivery date. The DO is also not a standard forward contract, because the stipulated delivery date is almost never enforced.

new dealers were appointed for each “marketing area” (for example, upazila or municipality) selected by the refiners, and a dealer is allowed to buy oil “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 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 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. Hence the intent was to reduce market concentration within the supply chain.

However, the elimination of DOTs also meant 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 banks for credit to finance dealership deposits and purchase of SOs for oil from the refiners. Many faced difficulty 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-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. After approximately six months of the reform, 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.

3 Theory

We model a vertical chain with three layers: refiners, DOTs and wholesale traders (depicted below respectively by $i \in \{r, d, T\}$). 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. So we assume that wholesalers sell directly to final consumers. 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. Indeed, the model with a retail layer reduces to the one developed below when there are sufficiently many retailers that the market power at that layer is negligible.

We also abstract from product heterogeneity and horizontal asymmetries across traders at each layer.[4] Concentration i.e., the number of (identical) traders at each layer is exogenously given: the number of traders in layer i is denoted as N_i. They engage in Cournot competition, taking as given prices of the intermediate input they purchase from the layer above (which determine their unit costs). We normalize units so that one unit of crude oil produces one unit of refined oil. Besides oil costs, traders at level i incur costs C_i per unit: for refiners this includes refining and storage costs; for wholesalers this includes transport, storage and other distribution costs. Since the DOTs do not incur transport and storage costs, the per unit distribution costs for them are likely to be small.

Production decisions and distribution flow vertically downwards. First, the crude oil import price P_m is determined in the international market. Then refiners decide how much to import and refine, taking the import price as given, but incorporating the effect of their quantity decisions on the price at which they sell to traders one level below (the DOTs). This determines total unit costs of traders at the next layer, who then decide their quantities, and so on.

The inverse demand function among consumers is assumed to take the Bulow and Pfleiderer (1983) form:

$$P_T(Q) = \alpha - \eta Q^{\delta}; \;\; \alpha, \eta, \delta > 0 \tag{1}$$

[4]This is a reasonable assumption in our empirical application because there is little product differentiation in the Palm oils market.

where P_T denotes the price at which wholesale traders sell to consumers. [5]

We now explain the role of credit, which arises from a time-lag associated with the refining and distribution process. There are two dates: $t = 0$ and $t = 1$. At $t = 0$, the crude oil is imported at price P_m, and DOs are sold by the refiners at price P_r to DOTs who in turn sell them at price P_d to the wholesalers, and, finally, the wholesalers take delivery of oil from the refiners and transport to the destination market. At $t = 1$ the refined oil is sold to the consumers by the wholesalers at price P_T. All distribution costs of DOTs and wholesalers are also incurred at $t = 0$.[6] DOTs are not constrained with respect to the amount of credit they have access to, and incur the lowest borrowing costs compared to refiners and wholesalers.[7] Being informal lenders with specialized expertise in financing, they can lend at a cost of i_d per taka, which is lower than (or equal to) the rate i_b charged by banks. This difference arises owing to lower transaction costs (screening and loan collection expenses) they incur compared with formal financial institutions. Hence DOTs provide loans to wholesalers to cover the time-lag between $t = 0$ and 1. Wholesalers finance their working capital needs at $t = 0$ by borrowing from DOTs. They need to borrow $P_d + C_T$ for per unit of oil purchased. These loans are repaid at $t = 1$ after they receive cash payments from consumers.

Loans are subject to moral hazard: a wholesaler could decide not to repay a loan at $t = 1$. Loan default is punished by lenders with a severity depending on who the lender is. DOTs are able to impose more punitive sanctions on defaulters than banks, due to their access to punishments not limited to purely legal routes. The maximal pecuniary cost of sanctions imposed by DOTs and banks respectively are denoted by R_d, R_b with $R_d > R_b$. We treat

[5] An alternative to the Bulow-Pfleiderer demand specification is the constant elasticity demand, widely used in the theoretical literature. A constant elasticity demand function implies a zero intercept in the pass-through equation. The evidence rejects the null hypothesis of a zero intercept at the 5 percent significance level in all of the pass-through regressions reported in this paper.

[6] In addition to the transport costs incurred by the wholesalers, these may include worker wages which are paid in advance at $t = 0$. The only role of this assumption is to simplify the notation; the cost expressions need to be adjusted if distribution costs are incurred at $t = 1$.

[7] This is motivated by the evidence from a survey of the edible oils market in Dhaka and Chittagong in 2013 reported in Emran et. al, (2015). See also the discussion in Taslim and Uddin (2010). 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 some cases, the religious injunctions against earning interest income may reduce the opportunity costs of own funds for DOTs, especially among the ethnic Bihari DOTs in the Dhaka market.

these sanctions as given.[8] Consequently the borrowing of any given wholesaler has to satisfy the constraint that the amount of repayment due to a DO trader cannot exceed R_d.

DOTs compete with one another (and with banks) in the market for lending to wholesalers. For simplicity we assume they compete over loan contracts in Bertrand fashion, thereby end up earning zero profits in equilibrium. This implies that wholesalers would be able to borrow at an interest rate of i_d. However, owing to the moral hazard problem the size of their loan would be subject to a ceiling given by $\frac{R_d}{1+i_d}$. This in turn translates into a ceiling on how many DOs the wholesaler can purchase; q DOs generate a need to borrow $[P_d + C_T]q$. Hence the ceiling on q is given by

$$q \leq \frac{R_d}{(1+i_d)(P_d + C_T)} \tag{2}$$

We focus on the case where the wholesalers do not find it profitable to borrow from banks to finance oil purchase if they have access to DOT loans.[9]

Taking the price of DOs (besides conjectured aggregate quantity Q_- of other wholesalers) as given, each wholesaler decides q, how many DOs to purchase. This is chosen to maximize profit

$$P_T(Q_- + q)q - (1+i_d)(P_d + C_T)q \tag{3}$$

subject to (2).

We can then solve for an equilibrium in the game played between wholesalers, taking DO price P_d as given. This generates the derived demand function for DOs from wholesalers. The DO price is determined by equating aggregate demand from wholesalers with aggregate supply from DOTs.[10]

[8] 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 will depend on prices, which will alter the expression for credit ceilings derived below. This complicates the analysis without affecting the results qualitatively.

[9] We discuss the implications of this assumption with and without credit rationing below.

[10] This is based on the standard assumption underlying the Cournot model that an auctioneer clears the market (for DOs between DOTs and wholesalers). We conjecture the same equilibrium will result in the absence of an auctioneer, as in Kreps and Scheinkman (1983) where DOTs choose their capacity first, and then engage in Bertrand competition in selling DOs in conjunction with loans to wholesalers.

To ensure that the market does not shut down, we assume

$$\alpha > (1 + i_b)\,[P_m + C_r + C_d + C_T] \tag{4}$$

3.1 The Standard Model without Credit Rationing

If loan default sanctions ($R_d,\ R_b$) are large enough, the credit ceilings will not be binding. Then each wholesaler maximizes profit (3) without being subject to any quantity constraint. Since the interest rate charged by the banks is higher, the wholesalers do not have any incentives to borrow from banks.

A symmetric equilibrium among wholesalers results in consumer price

$$P_T = \alpha\left[1 - \frac{N_T}{N_T + \delta}\right] + \frac{N_T}{N_T + \delta}\,(1 + i_d)\,(P_d + C_T) \tag{5}$$

implying a pass-through rate of $\frac{N_T}{N_T+\delta}$ which is rising in N_T, and converging to 1 as N_T approaches ∞.

Having solved for the equilibrium at the wholesaler level resulting from any given DO price, we can roll back to the earlier stage where DOTs make quantity decisions. Combining (5) and (3) we obtain the derived demand function facing DOTs:

$$P_d(Q) = \frac{1}{1 + i_d}\left[\alpha - \frac{N_T + \delta}{N_T}\eta Q^{\delta}\right] - C_T \tag{6}$$

The profit of a representative DOT selecting DO quantity q when the remaining DOTs select a total of Q_{-}, and P_r is the price at which DOs can be bought:

$$[P_d(Q_{-} + q) - P_r - C_d]\,q \tag{7}$$

Routine calculations yield the following expression for the symmetric equilibrium selling price of DOs

$$P_d = \left[\frac{\alpha}{1+i_d} - C_T\right]\left[1 - \frac{N_d}{N_d+\delta}\right] + \frac{N_d}{N_d+\delta}[P_r + C_d] \tag{8}$$

Using (5), this in turn implies a downstream price of

$$P_T = \alpha\left[1 - \frac{N_T}{N_T+\delta}\frac{N_d}{N_d+\delta}\right] + \frac{N_T}{N_T+\delta}\frac{N_d}{N_d+\delta}\left(1+i_d\right)\left(P_r + C_d + C_T\right) \tag{9}$$

if P_r is the price at which DOTs buy DOs.

Proceeding in similar fashion back to the refiner level, we can solve for the equilibrium P_r and end up with the following expression for wholesale (and also retail) price as a function of oil import price:

$$P_T = \alpha\left[1 - \frac{N_T}{N_T+\delta}\frac{N_d}{N_d+\delta}\frac{N_r}{N_r+\delta}\right] + \frac{N_T}{N_T+\delta}\frac{N_d}{N_d+\delta}\frac{N_r}{N_r+\delta}(1+i_d)(P_m + C_r + C_d + C_T) \tag{10}$$

The pass-through of oil import price to the consumer price is the product of σ_i across successive layers, where $\sigma_i \equiv \frac{N_i}{N_i+\delta}$ is a measure of competitiveness in layer i. The downstream price is a convex combination of the demand intercept α and total unit cost (aggregating import, refining, distribution and financing costs). Rising competitiveness at any layer raises the pass-through rate and lowers the consumer price (given (4)).

What does this model predict about the effects of a reform which bans the entire DOT layer from functioning? Then wholesalers buy directly from refiners, financing their purchase by borrowing from banks instead of the DOTs.[11] Under the assumption of no credit rationing (i.e., wholesalers face no credit ceilings in borrowing from banks, as R_b is large enough), wholesaler per unit costs rise owing to a rise in the borrowing interest rate from i_d to i_b. This tends to raise the wholesale price. On the other hand, the reduction in concentration at the DOT layer has an opposite effect of lowering P_T. Moreover, DOT costs C_d are no longer incurred.[12] The net

[11]The underlying assumption is that following the ban DOTs are not just unable to trade in oil, but also to lend to wholesalers. This is plausible as a large part of the loanable funds of DOTs comes from profits from buying and selling DOs. Moreover, in a dynamic setting the sanctions DOTs impose on the defaulting wholesalers involve refusing to sell them any DOs. Such sanctions cannot be used if DOTs are banned from functioning in the oil market.

[12]The effect of elimination of C_d is likely to be small, as the DOTS do not take physical delivery of oils,

effect on the wholesale (and consumer) price is ambiguous, depending on the relative strength of either effect (i.e., the size of $i_b - i_d$ compared with N_d and C_d). The post-reform price is given by

$$\hat{P}_T = \alpha\left[1 - \frac{N_T}{N_T+\delta}\frac{N_r}{N_r+\delta}\right] + \frac{N_T}{N_T+\delta}\frac{N_r}{N_r+\delta}(1+i_b)(P_m + C_r + C_T) \tag{11}$$

Although the net effect on consumer prices is uncertain, the above model yields unambiguous predictions regarding the changes in both the intercept of the price equation and the pass-through rate following the reform. The intercept term becomes smaller while the pass-through rate of the oil import price to P_T must go up as a result of the reform, as concentration declines and the interest cost of wholesalers rise ($i_b > i_d$). The post-reform pass-through rate equals $\frac{N_T}{N_T+\delta}\frac{N_r}{N_r+\delta}(1+i_b)$, as against $\frac{N_T}{N_T+\delta}\frac{N_d}{N_d+\delta}\frac{N_r}{N_r+\delta}(1+i_d)$ prior to the reform, and the intercept declines from $\alpha\left[1 - \frac{N_T}{N_T+\delta}\frac{N_d}{N_d+\delta}\frac{N_r}{N_r+\delta}\right]$ to $\alpha\left[1 - \frac{N_T}{N_T+\delta}\frac{N_r}{N_r+\delta}\right]$ following the reform. These predictions can be tested empirically.

3.2 The Model with Binding Credit Constraints

When default sanctions R_d, R_b are low enough, the credit constraint (2) is likely to bind. Then the best response of a representative wholesaler to DO price P_d and aggregate quantity Q_- of all other wholesalers in the pre-reform situation is

$$q(Q_-, P_d) = \min\{\bar{q}(P_d), q^*(Q_-, P_d)\} \tag{12}$$

where

$$\bar{q}(P_d) = \frac{R_d}{(1+i_d)(P_d + C_T)} \tag{13}$$

---

transport and storage costs incurred by them are zero.

is the constrained demand where the credit constraint binds, while $q^*(Q, P_d)$ denotes the corresponding unconstrained demand, which is the value of q that solves the first order condition

$$\alpha - (1 + i_d)(P_d + C_T) = \eta\big[(Q_- + q)^\delta + \delta q(Q_- + q)^{\delta - 1}\big] \tag{14}$$

The implicit assumption in the above formulation is that the wholesalers borrow from the DOTs, but do not borrow from the banks in the pre-reform period even when they are quantity rationed. This is a plausible assumption when the amount of credit offered by the DOTs (R_d) is not too small, and the interest rate differential between the bank loans and DOT loans ($i_b - i_d$) is large enough.[13]

The credit constraint does not bind in the symmetric equilibrium if

$$\frac{N_T}{N_T + \delta}\frac{1}{\eta}[\alpha - (1 + i_d)(P_d + C_T)] \leq \left[\frac{N_T R_d}{(1 + i_d)(P_d + C_T)}\right]^\delta \tag{15}$$

while if this condition is violated, the symmetric equilibrium with a binding credit constraint involves each wholesaler selecting

$$\bar{q} = \frac{R_d}{(1 + i_d)(P_d + C_T)} \tag{16}$$

The residual demand curve facing DOTs is now

$$P_d(Q) = \frac{1}{Q}\frac{N_T R_d}{1 + i_d} - C_T \tag{17}$$

instead of (6). The resulting Cournot equilibrium among DOTs given P_r is

$$P_d = \left(1 - \frac{1}{N_d}\right)^{-1}(P_r + C_d) - C_T \tag{18}$$

[13] This simplifies the exposition. The conclusions regarding pricing and pass-through implications of DOTs role in relaxing credit constraints of wholesalers are robust to the alternative assumption that, in the initial equilibrium, the wholesalers use both DOT and Bank credit, but still face binding credit constraint.

which yields a Cournot equilibrium among refiners that ultimately results in consumer price

$$P_T = \alpha - \eta \left[\left(1 - \frac{1}{N_r}\right) \left(1 - \frac{1}{N_d}\right) \frac{N_T R_d}{(1 + i_d)\,(P_m + C_r + C_d)} \right]^{\delta} \tag{19}$$

In contrast to the case where the credit constraint does not bind, this is nonlinear, with the pass-through rate no longer independent of the crude import price.

The marginal pass-through rate equals

$$\frac{\partial P_T}{\partial P_m} = \eta\delta \left[\left(1 - \frac{1}{Nr}\right) \left(1 - \frac{1}{N_d}\right) \frac{N_T R_d}{(1 + i_d)} \right]^{\delta} [P_m + C_r + C_d]^{-(1+\delta)} \tag{20}$$

which is increasing in R_d. A decline in credit limit (i.e., R_d) shifts the residual demand curve facing DOTs inward, and reduces the sensitivity of the consumer prices to changes in oil refining costs.

Following the DOT ban, wholesalers borrow from banks at a higher interest rate i_b and are subject to lower credit limit $\frac{R_b}{1+i_b}$. If credit constraints were binding in the pre-reform situation, they will continue to bind following the reform. The resulting equilibrium will involve

$$\hat{P}_T = \alpha - \eta \left[\left(1 - \frac{1}{N_r}\right) \frac{N_T R_b}{(1 + i_b)(P_m + C_r)} \right]^{\delta} \tag{21}$$

and a marginal pass-through rate

$$\frac{\partial \hat{P}_T}{\partial P_m} = \eta\delta \left[\left(1 - \frac{1}{N_r}\right) \frac{N_T R_b}{(1 + i_b)} \right]^{\delta} [P_m + C_r]^{-(1+\delta)} \tag{22}$$

The greater severity of credit constraints after the reform ($\frac{R_b}{1+i_b} < \frac{R_d}{1+i_d}$) now reduces the pass-through rate, which counters the increase owing to lowered concentration (equivalent to $N_d \to \infty$) and reduction in dealer costs ($C_d \to 0$). If the former effect is strong enough, the pass-through rate can now decline. The intensification of credit constraints also tends to raise the general level of P_T, i.e., the estimated intercept term, by shifting the oil supply curve inwards. The predictions about the effects of the reform on the intercept of the price equation and the

the pass-through rate are thus opposite to the standard model when credit contraction due to DOT ban is strong enough: the intercept goes up while pass-through declines after the reform.[14]

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

$$P_t^k = \gamma_k + \beta_k P_{tm} + \beta_k C_t + \epsilon_t \tag{23}$$

analogous to equations (10, 11), where $k = b, a$ refers to the regime (before and after the reform respectively), t denotes the date, the dependent variable P_t^k is the wholesale price during regime k, the regressor P_{tm} is the crude palm import price, and C_t denotes the sum of refining and distribution costs. The pass-through rate β_k equals the product of competition variables $\frac{N_i}{N_i+\delta}$ across various stages, and the interest rate at which wholesalers borrow. The key prediction of the standard double marginalization model is that $\beta_a > \beta_b$, owing to a rise in competition and the interest rate following the DOT ban. The change in the intercept $\gamma_a - \gamma_b$ is of independent interest, as it helps estimate the effect of the reform on the level of downstream prices. The standard model predicts that $\gamma_a - \gamma_b < 0$. Hence we are interested in a regression of the form

$$P_t = \theta_0 + \theta_1 d_R + \theta_2 [P_{tm} + C_t] + \theta_3 d_R * [P_{tm} + C_t] + \epsilon_t \tag{24}$$

where d_R is a regime dummy (1 after the reform, 0 before), and identifying the signs of coefficients of the reform dummy $\theta_1 (= \gamma_a - \gamma_b)$ and its interaction with the import price $\theta_3 (= \beta_a - \beta_b)$. We refer to this as the before-after (B-A) regression.

[14] In a model where only a proportion of wholesale traders face quantitative credit rationing, the effects of the reform can be modeled as an increase in the number of traders who face credit rationing. This also leads to a lower passthrough of international prices to the wholesale prices in the post-reform period. The details are available from the authors upon request.

The key difficulty is that we do not have data on costs of refiners, and financing and distribution costs of wholesalers. If these costs are correlated with the import price, the estimated pass-through rate will be biased. We deal with this problem in a number of different ways.

We could rely on plausible assumptions concerning the correlation between the omitted variables and the oil import price. Recall that our main interest is to infer the direction of *change* in the pass-through rate, i.e., the sign of θ_3. Denoting the coefficient on oil import price in a regression of C_t on P_{tm} by ρ_k in regime k, the estimated pass-through rate is $\hat{\beta}_k = \beta_k(1+\rho_k)$. If the correlation between C_t and P_{tm} did not change as a result of the reform, i.e., $\rho_a = \rho_b$, we can infer the direction of change in pass-through rate from a before after comparison. More generally, if $\rho_a \geq \rho_b$ and $\rho_a \geq 0$, we have $\hat{\beta}_a < \hat{\beta}_b$ only if $\beta_a < \beta_b$. Hence under this assumption we would be able to still reject the standard model despite the lack of cost data, if the estimated pass-through rate falls after the reform.

Data on diesel prices provide evidence in favor of the assumption that $\rho_a \geq \rho_b$ and $\rho_a \geq 0$. The correlation between diesel price and crude oil import price was virtually zero in pre-reform period as government controls decoupled the domestic diesel price from the fluctuations in international prices. During the post-reform period, the correlation was 0.45 as international oil prices eased, whence the government allowed more flexibility in price setting at gas stations.

A limitation of this approach is that the correlation of the oil import price with other sources of domestic processing and distribution costs cannot be assessed. Moreover, it does not permit any inferences concerning changes in the intercept term, which is relevant to assessing the impact of the reform on the level of downstream prices. The bias in the B-A estimate of the intercept term in regime k equals $\beta_k {C^0}_k$ where ${C^0}_k = \left(\bar{C}_k - \rho_k \bar{P}_{mk}\right)$ denotes the intercept term in the regression of distribution costs C_t on the crude oil import price P_{tm} in regime k. Inferring the direction of change in the intercept term is therefore not possible, without making assumptions regarding the before-after difference in average distribution costs.

An alternative way of dealing with the bias in the B-A estimates is to control for variables that proxy for refining and distribution costs, such as the diesel price and exchange rate.[15] We

[15]Most of the trucks run on diesel and the privately owned electricity generators also use diesel. Electricity outage and load shedding were common in Bangladesh during the study period. Since almost all transport

shall examine the robustness of the estimates with respect to these controls.

A second approach would be to compare price movements in palm oil with two other similar commodities: wheat and lentil, which are also imported from abroad in Bangladesh, and are subject to similar transport and storage costs. This would amount to a difference in difference (henceforth DiD) regression using data which pools oil, wheat and lentil:

$$P_t = \theta_0 + \theta_1 d_R + \theta_2 P_{tm} + \theta_3 (d_R * P_{tm}) + \lambda_1 d_O + \lambda_2 (d_O * P_{tm}) + \lambda_3 (d_O * d_R) + \lambda_4 (d_O * d_R * P_{tm}) + \epsilon_t^* \quad (25)$$

where d_O denotes an oil dummy, and the prices P_t and P_{tm} now include palm oils, wheat, and lentil. Then λ_3 and λ_4 would provide estimates of the effect of the reform on the intercept and pass-through rates in oil. Since the storage rental rates and transport rates do not vary across palm oil, wheat and lentil, the distribution costs in oil on the one hand, and wheat and lentil on the other will be positively correlated over time, and the estimates from the DiD design will be less biased than the before-after regression using data on oil alone.[16]

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. According to our benchmark model without credit rationing, the pass-through rate in the post-reform period depends on the interest rate charged by the banks, as the wholesalers deprived of the credit from DOTs turn to banks for financing their purchases. If the bank interest rate falls significantly due to central bank policy independent of the policy reform in edible oils market, it is conceivable that the interest rate paid by wholesalers fell compared to the pre-reform period. The evidence on interest rates discussed later, however, shows that the bank interest rate increased following the reform.

equipment are imported into Bangladesh, exchange rate changes can directly affect a major component of costs in the transport sector.

[16]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.1.

5 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 reported 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. Crude palm oil price data is obtained from the Malaysian Palm oil Board.[17] Lentil import prices are taken from the National Bureau of Revenue daily import data. Our full sample extends from January 24, 2008 to October 4, 2012. There are however 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. Our total sample sizes for palm oil and wheat are 966 days and for Lentil 820 days, spread over 57 months.

Table 1 provides the summary statistics for 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 dates of announcement and implementation of the reform. The international 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 retail price remained stationary, resulting in an increase in the margin, and suggesting that the pass-through rate had 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 international price). Prior to the reform, the two tend to move together, with the troughs and peaks in the average wheat and lentil margin tracking those in palm margin well.[18] A widening gap between

[17]Crude palm oil was listed in the TCB in January 2009. We compared TCB data with Malaysian Palm Board data on daily palm oil prices, there are nearly identical.

[18]The margins are calculated using 4-week lagged international price to reflect the transport and processing

the margins opens up in the post reform period, with the margin in palm oil higher, and the margins seem to converge again at the end of the sample period. Table 2 provides average wholesale and retail margins for the treatment and comparison commodities both before and after the reform. Margins are computed using the current (lower panel) and 4-week (upper panel) lagged import price. We see a 25% or higher rise in oil margins while the margin for both wheat and lentil fell slightly. Figure 3 shows the margin estimates, both at the wholesale and retail levels, and the 95 percent confidence interval, providing suggestive evidence that the increase in the oil margin relative to the wheat and lentil margins after the reform is statistically and economically significant.

To test the parallel trend assumption required for the empirical analysis below, we estimate the effects of placebo reforms in the pre-reform period. Table 3 reports the estimates from the BA and DiD regressions for the case where we move the reform date to one year prior to the actual reform. The evidence shows that the placebo reform has no significant effects in both the BA regression (see columns 1) and the DiD regression (see column 2) in Table 3. This is consistent with the identifying assumption that the passthrough of prices of wheat and lentil provides a reliable counterfactual for the passthrough of palm oil prices. As additional checks, we divide the pre-reform period into four quarters, and consider three placebo policy implementations at the end of each of the first three quarters. The DiD estimates and the confidence intervals are presented in figure 3; the evidence that none of the estimates are statistically significantly different from zero provides strong support to the DiD design.

Table 4 presents the results of the B-A and 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 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.[19] The regressions

lag. Our main empirical estimates also focus on the pass-through of 4-week lagged international prices.

[19]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.

include year and quarter dummies, and a dummy for the Ramadan period when food prices tend to spike. We exclude data for the few months between the date of announcement and implementation of the reform.[20] Data for two years prior to the announcement are compared with data following policy implementation. In our data, the passthrough rate of the world price of oil to the wholesale price in the pre-reform period does not depend on whether the world market is on an up or down turn. The passthrough is 0.50 when prices are falling, and 0.47 when prices are rising, and the difference is not significant at the 10 percent level. We thus do not need to worry about the market phase influencing our results. Based on a correlogram analysis of price data, we allow for an AR (1) 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. For example, for the DiD regressions, the Im, Pesaran and Shin (2003) test rejects the null hypothesis of unit root in the residuals for oil, lentil and wheat at the 1 percent level against the alternative hypothesis that at least one of them is stationary. The evidence against the null hypothesis of unit root in the panel of residuals is confirmed by the Breitung (2000) and Harris and Tzavalis (1999) tests where the alternative hypothesis is that all of the residuals are stationary. Standard errors are corrected for heteroskedasticity and autocorrelation using the Newey-West (1987) procedure.

The B-A regression shows a significant fall in the pass-through rate following the reform, and a significant rise in the intercept term. According to the B-A estimates without proxies for distribution costs (column 1 of Table 4), the pass-through rate declines from a point estimate of 0.81 to 0.62, while the point estimate of the intercept term rises from 22 to 41. This is inconsistent with the model of the supply chain without credit rationing, and consistent with predictions of the credit rationing model.

Next we address concerns regarding the extent to which this could have resulted from the omission of distribution costs. The B-A estimates of the effects of the reform become larger when we include diesel price and exchange rate as proxies for distribution costs (see column 2 of Table 4). This suggests that the omitted distribution costs results in underestimation of

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

the effects of the reform on palm oil price. The results are reinforced in the DiD regression with wheat and lentil as the comparison commodities (column 3 without controls, and column 4 with controls): the fall in the pass-through rate and the rise in the intercept are both larger compared to the corresponding B-A estimates. These conclusions do not depend on whether we allow for the passthrough to vary between the two comparison commodities: wheat and lentil. The estimates in Table 4 correspond to the case where the wheat and lentil passthrough rates are assumed to be the same, and appendix Table T.1 reports the estimates when we use a more flexible specification of the DiD model with different passthrough rates for wheat and lentil.[21]

The evidence that the fall in pass-through rate after the DOT ban is underestimated in the B-A regression is consistent with the assumption that the omitted distribution costs were positively correlated with import price in the post-reform period, and the correlation remained unchanged or became stronger in the post reform period. The fact that the increase in intercept is underestimated in the B-A on the other hand suggests that the combined effect of a higher crude import price and a higher ρ after reform is strong enough to make $C_a^0 < C_b^0$. A comparison of the DiD estimates in columns (3) and (4) of Table 4 shows that, unlike the B-A estimates, the DiD estimates are not affected substantially when proxies of distribution costs are included. This suggests that the DiD design accounts for the omitted distribution costs well.

Table 5A shows that the results are robust with respect to alternative lags for the oil import price.[22] 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. Longer lags weaken the BA regression results (which nevertheless remain statistically significant at the 10 percent level), while the DiD estimates yield numerically larger magnitudes of the relevant coefficients (highlighted in Table 5A). The first two columns of Table 5B shows that the results continue to hold when

[21] All specifications in this paper allow for different intercepts for wheat and lentil price equations.

[22] The specification used in Tables 5A-6B correspond to the specification in the odd columns in Table 4 with wheat and lentil as the comparison commodities, but without diesel price and exchange rate as additional controls. The results are similar if we include the proxies for distribution costs. The estimates are available upon request.

the pre-reform sample is expanded to include three rather than two years. Columns 3 and 4 show they also hold when the the 'announcement' period is included as part of the post-treatment period (i.e., the reform dummy takes a value equal to 1 for observations from after the announcement of the reform).

The exact period for which the effects of the reform lasted is unclear, as the ban on 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 9 months following the reform, from the post-9 month period. Both B-A and DiD results show that the effects were concentrated in the first 9 months; the DiD estimates imply a 45 percent lower passthrough rate and a 20 percent higher wholesale price of Palm oil resulting from the reform. Not surprisingly, the first 9-month effects are larger in magnitude compared to previous tables which pooled all post-reform dates into a single post-reform period. The estimates for the post 9-month period show a substantial weakening in the effects of the reform; the oil price passthrough was 27 percent lower, and the average wholesale price was only 5 percent higher because of a declining effect of the reform on the intercept of the price equation.

Our analysis predicts that the reform affected the wholesale margin 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 (retail price less the oil import price) would be similar to those of the wholesale margin. Table 7A presents results for the retail margin. These are very similar to the results in Table 4 for the wholesale margin. Table 7B 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).

6 Supplementary Evidence and Alternative Explanations

In this section, we provide additional 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, these two refiners accumulated excess inventory, 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 fell following the reform: see Figure 4 which plots monthly imports for 2009-10 and 2010-11. A simple before-after regression indicates a statistically significant decline following the reform (the coefficient of reform dummy is -20.15 which is significant at the 5 percent level (t=2.026)). It is striking that this happened during a period when world oil prices were declining, reversing the trend for the previous three years (see Figure 1).

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 wholesalers buying on credit from DOTs prior to the reform shows a 45% reduction in volumes. This suggests that the aggregate supply at the wholesale level dropped by approximately 15% after the reform owing to the difficulties faced by wholesale traders in obtaining credit in the post-reform period. The available estimate for edible oils demand in Bangladesh suggests a price elasticity of -1.16 (Talukder (1990)).[23] This yields a back-of-the-envelope estimate of a price increase of about 13% owing to the 15% quantity reduction after the reform. The DiD estimates in column (4) of Table 4 imply that the wholesale price was 15% higher as a result of credit contraction following the DOT ban.

A possible alternative explanation of the lower pass-through rate after the reform is that the

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

wholesalers always relied on banks for credit and the interest rate charged by banks declined after the reform because of a central bank policy shift. A lower interest rate would reduce the pass-through estimate according to our benchmark model without credit rationing. However, it turns out that the average bank interest rate was higher in the post reform period; the average interest rate on short-term bank loans increased from 11.46 to 13.38 in the post-reform period.

Another possible explanation of the rise in wholesale price is that the reform increased the market power of refiners who were selling directly to wholesalers, rather than indirectly through the DOTs prior to the reform. This would have implied an increase in total profits earned by the refiners, who would have an interest in ensuring that the reform was not reversed. Interviews with 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 wholesale dealers) 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.

Explanations based on increased search costs are also unlikely to account for a price increase resulting from the reform.[24] These search costs did not seem significant prior to the reform, as DOTs operate within a very narrow market area in Dhaka and Chittagong, and wholesalers could find out prices quoted by DOTs by making a telephone call to their contacts in these market areas. Following the reform, there were only nine refiners from whom they could purchase; finding out what prices they were charging would have been even easier than checking prices charged by the 300-400 DOTs previously.

7 Related Literature

The evidence and analysis presented in this paper are most closely related to a large literature on imperfect pass-through of international prices and exchange rate variations to domestic producer and consumer prices (e.g., recent contributions by Goldberg and Hellerstein (2008),

[24] Chau et al. (2016) and Casaburi et al. (2013) emphasize search costs in a context where small farmers search for best price offer.

Nakamura (2008), Nakamura and Zerom (2010), Gopinath et al. (2010), Berman et al. (2012), Bonnet et al. (2013), and recent surveys by Burstein and Gopinath (2013), Campa and Goldberg (2008)). Weyl and Fabinger (2013) presents 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). Analogous to our approach, they use the Bulow-Pfleiderer (1983) specification of demand to derive a constant pass-through rate that depends only on market concentration and demand curvature. They use this to recover trade costs from spatial price differences. As in the standard model, intermediaries in their model play a role in trade and physical distribution rather than financing, and contract frictions such as credit constraints have no role.

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 (1984), Bardhan (1984, 1989). Burkart and Ellingsen (2004) show that relative illiquidity of commodities implies that it is easier to provide trade credit compared to a pure credit contract. This argument is relevant for our application, because a DO is considerably less liquid than money, as it may not be easy for a wholesaler to find a DO buyer willing to pay cash without offering significant discounts. More important, the DOTs rely on accumulated information about the wholesalers to minimize adverse selection and moral hazard, and default information is shared quickly among the DOTs in a market, similar to multilateral punishment scheme a la Greif (1993). Information and monitoring advantages have been identified as important factors for supplier credit (see, for example, Smith (1987)).

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. (2016) consider implications of asymmetric price infor-

mation.[25] Macchiavello and Morjara (2016) analyze the effects of competition in procurement of inputs on relational contract 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. 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, indicating that markets were reasonably competitive and middlemen did not exert much monopsony power. Their paper complements ours by providing direct evidence of the role of middlemen in providing credit to farmers during planting season, besides assessing the extent of their market power. Our paper goes further by providing evidence of credit rationing, and evaluating the overall impact of the market power of middlemen and trade credit provision, using a natural experiment that affected the whole country. The testable implications of credit provision by financing intermediaries in our analysis refer to pass-through rate of international prices to wholesale prices directly observed in the data.

Although there has been a renewed interest in the domestic food markets in developing countries in response to price shocks in the international market, most studies (e.g., Ivanic et al. (2012)) estimate the effects of higher international prices on domestic prices (pass-through) in reduced form regressions without a theoretical model, and the focus is usually on the implications of higher consumer prices for poverty. These studies do not attempt to understand the role of intermediaries or the effects of efforts to regulate their activities.

[25]Rust and Hall (2003) consider a model of interactions between middlemen (dealers/brokers) and market makers. The prices offered by middlemen can be discovered through costly search process, but market makers post publicly observable bid and ask prices. They characterize the conditions under which the entry by a market maker into a middlemen-only initial equilibrium is Pareto-improving. Middlemen do not provide credit in their model.

8 Concluding Comments

This paper extends the model of vertical supply chain with imperfect competition to incorporate financing intermediaries who relax binding quantitative credit constraint faced by downstream traders. Such credit rationing lowers price elasticity of the demand curves that upstream market agents face. More stringent credit constraints lower the rate at which international prices pass through to domestic wholesale prices.

To discriminate between the models of supply chain with and without quantitative credit rationing, we study a policy experiment in Bangladesh where the government banned a layer of financial intermediaries in edible oils market called Delivery Order Traders (DOTs) in 2011. The reform was motivated by widely held belief that these intermediaries exert market power and keep the prices paid by consumers high even when the international prices are falling, by lowering the pass-through rate. The reform would be expected to increase the pass-through rate and reduce the marketing margin of traders in a standard double marginalization model without credit rationing. In sharp contrast, the reform is likely to reduce pass-through rate and increase the marketing margins and consumer prices if the role played by the DOTs before the reform was to provide credit to wholesalers and relax their binding credit constraints.

The empirical analysis based on a difference-in-difference design with wheat and lentil as the comparison commodities shows that, contrary to the expectations of the policy makers, the reform raised consumer prices. It reduced the pass-through rate of falling international prices after the reform, and increased the intercept of the price pass-through equation. The evidence of a lower pass-through rate and a higher intercept rejects the standard double marginalization model of pass-through in imperfectly competitive marketing chain widely used in the literature, and is consistent with the predictions from the model with quantitative credit rationing. The evidence and analysis presented here suggest that credit market frictions and quantitative credit rationing are important for a better understanding of the transmission of international prices to domestic wholesale and retail prices.

References

Atkin, D and D. Donaldson (2015), Whos Getting Globalized? The Size and Implications of Intra-national Trade Costs, Working paper, Stanford University.

Bardhan, Pranab K. (1984). *Land, Labor, and Rural Poverty: Essays in Development Economics.* Delhi: Oxford University Press/New York: Columbia University Press.

Bardhan, Pranab K.(1980). "Interlocking Factor Markets and Agrarian Development: A Review of Issues". Oxford Economic Papers 32.1 (1980): 8298.

Berman, N., P. Martin, and T. Mayer (2012): "How do different exporters react to exchange rate changes?", Quarterly Journal of Economics, 127, pp. 437492.

Bonnet, C., P. Dubois, S. Villas-Boas, and D. Klapper (2013): "Empirical evidence on the role of nonlinear wholesale pricing and vertical restraints on cost pass-through", Review of Economics and Statistics, Vol. 95, No. 2, pp. 500515.

Braverman, A and J. Stiglitz (1982), "Sharecropping and the Interlinking of Agrarian Markets". American Economic Review, 72, 695-715.

Breitung, J. (2000), The local power of some unit root tests for panel data. Advances in Econometrics, Volume 15: Nonstationary Panels, Panel Cointegration, and Dynamic Panels, ed. B. H. Baltagi, 161178. Amsterdam: JAY Press.

Burkart, M, and T. Ellingsen (2004), "In-Kind Finance: A Theory of Trade Credit", American Economic Review, June 2004.

Burstein, A., and G. Gopinath (2013): 'International prices and exchange rates', Handbook of International Economics, Volume IV, Elsevier

Carpenter, F., 1866. Six Months at the White House with Abraham Lincoln. Hurd, New York.

Casaburi L., Rachel Glennerster and Tavneet Suri (2013), Rural Roads and Intermediated Trade: Regression Discontinuity Evidence from Sierra Leone, Working paper, Stanford University.

Casaburi L. and T. Reed (2017), Competition in Agricultural Markets: An Experimental Approach, Working Paper, University of Zurich.

Chau, Nancy H & Goto, Hideaki & Kanbur, Ravi, (2016). "Middlemen, Fair Traders and

Poverty," Journal of Economic Inequality, 14: 81-108.

Emran, M. S, D. Mookherjee, F Shilpi, and H. Uddin (2015), Trading Margins and Contracts in a Vertical Marketing Chain: Evidence from Edible Oils Market in Bangladesh, Working Paper, World Bank.

Gita Gopinath & Oleg Itskhoki & Roberto Rigobon, 2010. "Currency Choice and Exchange Rate Pass-Through," American Economic Review, American Economic Association, vol. 100(1), pages 304-336, March.

Greif, Avner, (1993). "Contract Enforceability and Economic Institutions in Early Trade: the Maghribi Traders' Coalition," American Economic Review, American Economic Association, vol. 83(3), pages 525-548, June.

Goldberg, P., and R. Hellerstein (2008): "A structural approach to explaining incomplete exchange-rate pass-through and pricing-to-market", American Economic Review, Vol. 98, No. 2, pp. 423-429.

Harris, R. D. F., and E. Tzavalis. (1999). "Inference for unit roots in dynamic panels where the time dimension is fixed". Journal of Econometrics 91: 201226.

Im, K. S., M. H. Pesaran, and Y. Shin. (2003). "Testing for unit roots in heterogeneous panels". Journal of Econometrics 115: 5374.

Ivanic, M. and W. Martin, and H. Zaman, 2012. "Estimating the Short-Run Poverty Impacts of the 2010-11 Surge in Food Prices", World Development, Elsevier, vol. 40(11), pages 2302-2317.

Kojima, Y, J. Parcell, J. Cain (2014), A Demand Model of the Wholesale Vegetable Oils Market in the U.S.A, Working paper.

Kreps, David M, and Jose A Scheinkman. 1983. "Quantity precommitment and Bertrand competition yield Cournot outcomes. The Bell Journal of Economics 326337.

Lenin, V.I., 1964. Complete Collected Works, vol. 35. Moscow.

Macchiavello, R and A. Morjara (2016), Competition and Relational Contracts: Evidence from Rwandas Coffee Mills, mimeo, LSE and Kellog.

Minten, Bart & Kyle, Steven, 1999. "The effect of distance and road quality on food collection, marketing margins, and traders' wages: evidence from the former Zaire", Journal of

Development Economics, Elsevier, vol. 60(2), pages 467-495, December.

Mitra, Sandip & Mookherjee, Dilip & Torero, Maximo & Visaria, Sujata, (2016). "Asymmetric Information and Middleman Margins: An Experiment with Indian Potato Farmers," CEPR Discussion Papers 11548, C.E.P.R. Discussion Papers.

Nakamura, E., and D. Zerom (2010): "Accounting for Incomplete Pass-Through", Review of Economic Studies, Vol. 77, No. 3, pp. 1192-1230.

Nakamura, E (2008). "Pass-Through in Retail and Wholesale," American Economic Review, American Economic Association, vol. 98(2), pages 430-437, May.

Rust, J & George Hall, (2003). "Middlemen versus Market Makers: A Theory of Competitive Exchange," Journal of Political Economy, University of Chicago Press, vol. 111(2), pages 353-403, April.

Smith, J K (1987), "Trade Credit and Informational Asymmetry." Journal of Finance, September, 1987, 42(4), pp. 86369.

Srinivasan, P V (2005), Impact of Trade Liberalization on Indias Oilseed and Edible oils sector, IGIDR, Working Paper.

Talukder, R. K, (1990), "Food Consumption Parameters in Bangladesh: Implications for Food Policy", Bangladesh Journal of Agricultural Economics, December 1990.

Uddin, H and M. Taslim (2010), An Assessment of Competition in the Edible Oil Market of Bangladesh, Bureau of Economic Research, University of Dhaka, Bangladesh.

Weyl, E. G., and M. Fabinger (2013): "Pass-Through as an Economic Tool: Principles of Incidence under Imperfect Competition", Journal of Political Economy, Vol. 121, No. 3, pp. 528- 583.