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Optimal Payment Contracts in Trade Relationships*

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Abstract

In buyer-seller trade relationships, long-term collaboration and payment contract selection are mutually dependent: While the provision of trade credit to buyers increases the stability of trade relationships, its availability varies systematically as relationships evolve. To explain this reciprocity, we model the optimal provision dynamics of trade credit when the seller's information about the buyer's type is incomplete and parties can sign contracts with limited enforceability. We investigate how self-enforcing relational contracts and formal contracts complement each other and show how their interaction determines optimal payment contract choice. We find that payment contracts can be interpreted as screening technologies and imply distinct learning opportunities for the seller about the buyer's type. When buyers are stochastically liquidity-constrained and sellers can observe their liquidity status, in line with empirical evidence the model predicts that all transitions between payment terms lead to the provision of seller trade credit in the long run.

Keywords: Payment contracts, Trade credit, Trade dynamics, Relational contracts

JEL Classification: L14, F34, D83, O16

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1 Introduction

A limited enforceability of formal contracts is a recurring challenge to the success of buyer-seller transactions. Payment contracts provide firms with a tool to shift the risks of contract non-compliance between trade partners. Relative to the date of shipment these define the timing according to which the buyer must pay the seller for traded products. On the one side, the seller can request cash in advance which eliminates the seller's risk of not receiving payment for products already delivered but exposes the buyer to the residual risk of not receiving the seller's shipment. Conversely, the seller can offer open account payment terms in which case the buyer needs to pay only after product arrival. This causes a reversion of the residual non-compliance risk between the buyer and the seller. In international trade, these risks are economically particularly relevant since the shipment of products over longer distances and across borders costs time. This implies that the choice of payment contracts goes hand-in-hand with a financing decision over the working capital involved in a transaction and, correspondingly, a decision over the provision of trade credit. Banks and insurance firms offer a comprehensive set of trade finance products that allow to reduce or eliminate the residual risks of contract non-compliance.¹ However, the share of global trade falling under their coverage is limited and a substantial share of firms rely on non-intermediated payment modes despite the ubiquitous challenge of institutional enforcement deficiencies.²

This self-sufficiency suggests a strong reliance of trade partners on informal, relational mechanisms to ensure contractual performance. A large literature documents that establishing long-termed, trustful trade relationships can help firms to overcome the obstructions of weak institutions and guarantee contractual performance.³ At the same time, empirical evidence obtained in recent research points at a mutual dependence of the payment contract choice of firms and

¹An overview on the most relevant products in international trade finance can be found in [U.S. Department of Commerce \(2012\)](#).

²This reliance has been documented for several countries. Using representative trade data from Chile, [Garcia-Marin et al. \(2020\)](#) show that more than 95% of export transactions from Chile are taking place on cash in advance or open account payment terms. [Antràs and Foley \(2015\)](#) document a very comparable usage pattern for a large U.S. poultry exporter. [Cuñat \(2007\)](#) documents that direct lending between buyers and sellers is economically important not only in terms of trade flows but also in terms of the overall firm liabilities. He shows that for small and medium-sized firms from the U.S. and the U.K. trade credit accounts for almost 50% of their short term debt. A review over the reasons for the high prevalence of inter-firm trade credit is available in [Petersen and Rajan \(1997\)](#), and our findings are complementary to them. They argue that sellers tend to have a financing cost advantage over traditional lenders due to a better ability to monitor buyers and to enforce credit repayment. In addition, trade credit gives sellers a device to price-discriminate, assure high product quality, and a tool to reduce transaction costs across repeat transactions with the same buyer.

³Important insights and a literature review on the role and interplay of formal and informal mechanisms in enforcing contracts can, e.g., be found in [Johnson et al. \(2002\)](#) and [Greif \(2005\)](#).

the sustained success of trade relationships. [Antràs and Foley \(2015\)](#) and [Garcia-Marin et al. \(2020\)](#) show that while payment terms powerfully predict the stability of trade relationships, their choice varies systematically with relationship age. They document that the provision of trade credit by sellers has a substantial positive impact on the stability of buyer-seller trade relationships, and their robustness to economic shocks. Moreover, while in a large share of new relationships payment is made in advance of shipment, sellers proceed to offer open account terms more frequently and provide larger amounts of trade credit to buyers as their relationships mature.

To explain these patterns, we propose a first relational contracting model of payment contract choice. Our analysis provides novel micro-foundations for the highlighted empirical patterns and shows that their validity crucially depends on the quality of information transmission between trade partners and enforcement institutions in the buyer's economy. We set up a model of repeated trade between a buyer and a seller who can sign contracts on individual transactions with limited enforceability. We investigate how relational incentives interact with the seller's choice of the trade volumes and the payment terms of transactions when information over the buyer's type is incomplete. We analyse how a payoff-maximizing seller can design stage contracts and adjust them over the course of the trade relationship to resolve contractual and informational frictions optimally.

In a first step, our study shows that payment contracts impact the stability of trade relationships by providing the seller with distinct learning opportunities over the buyer's type. Payment contracts can be interpreted as *screening technologies* and we find that the seller's information acquisition about the buyer's type is faster under cash in advance terms compared to open account terms. While under the former it is optimal for the seller to propose a stage contract that immediately separates buyers in new trade relationships, under open account terms the optimal contract pools buyer types and as a consequence information acquisition is more gradual. To understand this outcome, note first that the buyer's type relates to her discount factor and either she is fully myopic or patient. The type is fixed and the buyer's private information. Second, we assume that time elapses between the seller's investment in production and the buyer's revenue realization from product distribution to final consumers, making the buyer's type decisive for contract compliance.

The separating nature of cash in advance contracts implies a lower stability of trade relationships as these are only accepted by patient buyers. In established relationships, cash in advance

terms also threaten stability due to their inflexibility in adjusting the size of the buyer’s payment to unforeseen, temporary revenue shocks that the buyer may face when distributing the product. In contrast, under open account the payment size can be conditioned on final market outcomes which decreases the relationship’s vulnerability to such shocks. At the same time, since open account terms are less efficient in the selection of patient buyers, destination market institutions matter for the enforcement of buyer payment. Our model predicts that while relationship stability increases with the quality of institutions under open account terms, they have no effect under cash in advance.

From this screening outcome it follows that the seller’s choice between pre- and post-shipment payment terms takes place in an *inter-temporal trade-off between relationship stability and stage payoff growth*. While the strong screening efficiency of cash in advance terms has a destabilizing effect on relationships, at the same time the implied learning advantage boosts the profitability of subsequent transactions under any payment type. We find that whenever trade partners are patient enough, this trade-off is sufficient to provide unique predictions on how the seller can choose payment terms optimally over the entire course of a trade relationship. When the seller finds it optimal to transition between payment terms over time this leads to the usage of open account terms and thereby to an increasing provision of trade credit as relationships become more established. In this context, the seller initially exploits the buyer-separating nature of the cash in advance terms and by subsequently switching to open account he eliminates the risk of relationship breakdown due to buyer liquidity shocks in future transactions.

Decisive for the optimal usage pattern of payment terms is the seller’s assessment of the buyer type distribution, as well as the amount of information available about the buyer’s revenue situation. For both – new and established relationships – the model predicts that the seller will more likely extend trade credit to the buyer the smaller his belief of getting matched to a patient buyer in future relationships. While our transition predictions are confirmed by the external evidence summarized above, we show in an extension of the model that the documented patterns can only be rationalized when the seller is able to verify the buyer’s revenue realizations from the distribution of products to final consumers. When this is not possible, the model predicts that requesting cash in advance from buyers is strictly preferable for sellers in established relationships. Our findings suggest that information transmission between trade partners plays a key role in explaining the financing patterns used in inter-firm trade.

In a further model extension, we incorporate the possibility for the seller to obtain trade

credit insurance from a competitive insurance market. When it comes to international trade, an important share of transactions with payment intermediation are backed by export credit insurances (cf. [Van der Veer, 2015](#)). In our model, the insurance takes over the risk of non-repayment of the trade credit and generates value for the seller through the insurer’s expertise in the screening of buyers. We show that the unique identification of the optimal payment terms remains possible when insurance is available. When revenue shocks are verifiable for the seller, the model continues to predict that the provision of seller trade credit increases over the course of relationships which is consistent with the empirical findings of [Antràs and Foley \(2015\)](#).

Our analysis builds on several strands of literature where the first studies the financing terms of inter-firm trade. It extends the interpretation of trade credit by [Smith \(1987\)](#) who first acknowledged its role as a screening device for sellers to elicit information about buyer characteristics. More generally, the paper is related to a literature that sees credit rationing as a way to screen borrowers in markets with incomplete information (cf. [Stiglitz and Weiss, 1981](#)). Our model gives conditions under which, in equilibrium, trade credit is rationed either temporarily or permanently where in the former case this is due to screening considerations and in the latter case because financing trade is costly for the seller. While we focus on the self-financing of trade through the buyer and the seller, a complementary line of work investigates the rationales of firms to use trade credit instead of credit provided by external financial institutions.⁴ Moreover, the article is connected to a literature on payment guarantees in international trade finance through our analysis of trade credit insurance. A concise summary of the most relevant work from this field was recently provided by [Foley and Manova \(2015\)](#).

Most closely related to our work is a small set of papers that studies the provision of trade credit in settings with repeated buyer-seller interaction. Their results are complementary to ours. The setup of our model features similarities to that of [Antràs and Foley \(2015\)](#) who investigate the impact of a financial crisis in a dynamic model of payment contract choice. While they also study transitions between payment terms over time their model does not incorporate that the information acquisition process of sellers differs fundamentally between pre- and post-shipment terms, inducing structural differences in the optimal growth patterns of transaction volumes and per-period payoffs. [Garcia-Marin et al. \(2020\)](#) derive conditions under which the provision of trade credit increases in attractiveness to sellers as their relationships with buyers mature. While

⁴For example, [Burkart and Ellingsen \(2004\)](#) derive conditions under which trade and bank credit interact either as complements or substitutes with each other. [Demir and Javorcik \(2018\)](#) interpret trade credit provision as a margin of firm adjustment to competitive pressures arising from globalization. [Engemann et al. \(2014\)](#) understand trade credit as a quality signalling device that facilitates obtaining complementary bank credits.

in their model this prediction originates from a financing advantage for sellers under trade credit terms, it originates from an improved payment flexibility for buyers in our setting. [Fuchs et al. \(2022\)](#) conduct a field experiment in Uganda to show that restricted access to liquidity is a key impediment to the business of buyers in developing countries. Like us, they study in a model of self-enforcing relational contracts how the distribution of products in developing markets can be implemented optimally in a dynamic setting. While in their work the buyer’s credit line is fixed over time, in our model the existence and size of the optimal trade credit line can vary with the age of trade relationships.⁵ Our model variant with non-verifiable revenue shocks and truth-telling incentivization is inspired by [Troya-Martinez \(2017\)](#) who studies relational contracting between a buyer and a seller for the situation when trade credit is provided in every transaction.

Also beyond the context of our application, the paper is related to the literature on self-enforcing relational contracts (cf. [Thomas and Worrall, 1994](#); [Baker et al., 2002](#); [Levin, 2003](#)). Like us, [Sobel \(2006\)](#), [MacLeod \(2007\)](#), and [Kvaloy and Olsen \(2009\)](#) study the interaction of formal and self-enforcing contracts in repeated game models when legal contract enforcement is probabilistic. Closely related to us is [Kvaloy and Olsen \(2009\)](#) who investigate a situation of repeated investment in a principal-agent setting with endogenous verifiability of the contracting terms. While in their setting verifiability is endogenized through the principal’s investment in contract quality in our model the relevance of verifiability itself is endogenized through payment contract choice. The paper also adds to a growing literature on non-stationary relational contracts with adverse selection, in which contractual terms vary with relationship length. While in our paper learning about the buyer induces transitions between payment contract types, previous work has studied non-stationarities in different contexts. Particularly closely related in terms of the modelling is the paper by [Yang \(2013\)](#) who investigates firm-internal wage dynamics when worker types are private information.⁶

A further strand of related literature investigates the microeconomic aspects of learning and

⁵Beyond relationship aspects, the economic literature discusses further and complementary channels affecting the availability of trade credit to buyers. Common membership in business or ethnic networks tends to increase the willingness of sellers to provide trade credit (see [Biggs et al., 2002](#); [Fafchamps, 1997](#)). Also, the level of competition among sellers is positively associated with the availability of trade credit to buyers (see [Hyndman and Serio, 2010](#); [Demir and Javorcik, 2018](#)). In contrast to our work, these papers do not study the dynamic aspects of trade relationships.

⁶Besides, [Chassang \(2010\)](#) examines how agents with conflicting interests can develop successful cooperation when details about cooperation are not common knowledge. [Halac \(2012\)](#) studies optimal relational contracts when the value of a principal-agent relationship is not commonly known and, also, how information revelation affects the dynamics of the relationship. [Board and Meyer-ter-Vehn \(2015\)](#) analyze labor markets in which firms motivate their workers through relational contracts and study the effects of on-the-job search on employment contracts. Moreover, [Defever et al. \(2016\)](#) study buyer-supplier relationships in international trade in which new information can initiate a relational contract between parties.

trade dynamics which, on the one side, considers applications to topics in international trade and, on the other side, contains papers of a purely contract-theoretic nature. [Araujo et al. \(2016\)](#) study how contract enforcement and export experience shape firm trade dynamics when information about buyers is incomplete. We share with their work the probabilistic approach to contract enforcement institutions. Across countries with different institutional qualities the level and growth predictions for trade volumes in our model are analogous to theirs when the seller provides trade credit to the buyer throughout the trade relationship. [Rauch and Watson \(2003\)](#) study a matching problem between a buyer and a seller with one-sided incomplete information. They derive conditions under which starting a relationship with small trade volumes is preferable to starting with large transaction volumes from the very beginning. This pattern features a clear analogy to our model in which starting a relationship on open account terms corresponds to starting small, and on cash in advance terms to starting large. Extending beyond the scope of our analysis, [Ghosh and Ray \(1996\)](#) and [Watson \(1999, 2002\)](#) study agents' incentives to start small when information is incomplete on both sides of the market.⁷

The remainder of the paper is organized as follows. In Section 2, we introduce the building blocks of our analysis and, in Section 3, we study supply relationships under cash in advance and open account payment terms when switches between payment terms are ruled out. Section 4 introduces this possibility and we investigate the seller's optimal usage of payment terms over the course of trade relationships. In Section 5, we extend our model and study trade credit insurance on the one side and the case of private revenue shocks on the other. Section 6 translates our most important model outcomes into empirically testable predictions. The last section concludes with a summary of our findings.

2 The model

The model considers the problem of a seller ("he") who markets a product through a buyer ("she") to final consumers. There exists a continuum of potential buyers with the ability to distribute the seller's product. The seller is a monopolist for the offered product and has constant marginal production costs $c > 0$. Selling $Q_t \geq 0$ units of the product to the final consumers in period $t + 1$ generates revenue $\mathcal{R}(Q_t, r_t) = r_t R(Q_t)$ to the buyer, where $R(Q_t) = Q_t^{1-\alpha}/(1-\alpha)$. The revenue function is increasing and concave in the trade volume Q_t , where $\alpha \in (0, 1)$ determines the shape

⁷Beyond the case of buyer-seller transactions, relationship building has also been analyzed in the context of different applications. E.g., see [Kranton \(1996\)](#) and [Halac \(2014\)](#).

of the revenue function.⁸ Moreover, the revenue generated from the sales of Q_t is stochastic and depends on the realization of the revenue shifter $r_t \in \{r^l, r^h\}$, where $r^h > r^l > 0$. We assume that with an i.i.d. probability of $\gamma \in (0, 1)$ the revenue shifter takes value $r_t = r^h = 1$, and $r_t = r^l \rightarrow 0$ otherwise.⁹ The realizations of the revenue shifter are public information to both, the buyer and the seller.¹⁰

We model the buyer-seller relationship as a repeated game, where in every period $t = 0, 1, 2, \dots$ a transaction is performed. The seller can engage in only one partnership at the same time. In every period, the seller first decides either to continue the relationship with his current buyer or to re-match and start a new partnership. He then proposes a spot contract $C_t = \{Q_t, T_t, F_t\}$ to the buyer specifying a trade volume $Q_t \geq 0$, a transfer payment T_t from the buyer to the seller, and a payment contract, $F_t \in \mathcal{F} = \{A, \Omega\}$, that determines the point in time at which the transfer T_t is made. Depending on the payment contract, the seller receives the transfer either before he produces and ships the goods (cash in advance terms, $F_t = A$) or after the buyer has sold them (open account terms, $F_t = \Omega$). The contract C_t therefore determines the timing of the stage game which we summarize graphically in Figure 1.

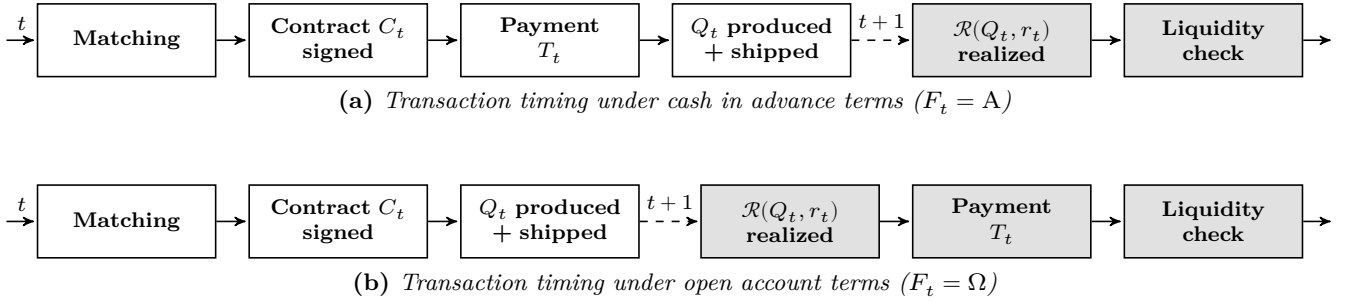


Figure 1: The spot contract C_t determines the timing of the stage game.

The timing of the transfer is payoff-relevant because shipment is time-consuming and players discount payoffs over time. Goods that are produced and shipped by the seller in period t can be sold to consumers only in the subsequent period $t + 1$. The corresponding discount factor of the seller is denoted by $\delta_S \in (0, 1)$. The buyer comes in one of two possible fixed types, $j \in \{M, B\}$.

⁸Whether the concave shape of the revenue function stems from technology, preferences or market structure is not important for the analysis below. Note that for this revenue function the price-elasticity of demand is given as $\epsilon_{Q_t, p} = -1/\alpha$, and therefore final consumer demand is price-elastic. The elasticity can be calculated using the Amoroso-Robinson relation.

⁹In Appendix A.2, we discuss the effects of generalizing the revenue shock distribution to arbitrary levels of r^h and r^l . We avoid discussing the case where $r^l = 0$ as it implies uninformative complications in the open account scenario that are tedious to resolve.

¹⁰In Section 5.2, we discuss a model variant in which the realization of r_t is private information to the buyer.

Either she is fully myopic, $j = M$, with discount factor $\delta_M = 0$ and associates positive value only to payoffs of the current period.¹¹ Alternatively, the buyer is patient, $j = B$, with discount factor $\delta_B \in (0, 1)$. Her type is the buyer's private information. The assumptions imply that by choosing open account terms the seller extends *trade credit* to the buyer while this is not the case under cash in advance terms. Whenever the seller decides to match with a new buyer he draws her type from an i.i.d. two-point distribution, where with probability $\hat{\theta} \in (0, 1)$ the buyer is myopic, and patient otherwise. We denote the seller's belief that the buyer is myopic in period t by θ_t and assume that the seller holds the belief $\theta_0 = \hat{\theta}$ at the beginning of the initial transaction with a new buyer.

Access to sufficient credit and liquidity are key obstacles to the success of firms in international trade (cf. [Manova, 2013](#); [Harrison and McMillan, 2003](#)). We introduce liquidity constraints into the model by assuming that the buyer goes bankrupt and leaves the market whenever her realized transaction payoff is negative. This means that the buyer remains liquid after a transaction under contract C_t if and only if the made transfer payment T_t is not larger than the revenue $R(Q_t, r_t)$ realized from sales to final consumers.¹² Formally:

$$\mathcal{R}(Q_t, r_t) - T_t \geq 0. \quad (\text{LC}_t)$$

Note from the stage game timing described below that while the seller can rule out any risk of buyer bankruptcy under open account terms by conditioning transfers on revenue realizations this is not possible under cash in advance terms where the transfer payment is made already before the revenue is realized.¹³

In every period, the contract C_t is enforced with an i.i.d. probability $\lambda \in (0, 1)$. We think of λ as being positively associated with the quality of contract enforcement institutions in the destination market, and to be public information for all market participants. In our application, for the buyer it corresponds to the probability of not being able to deviate from making the prescribed transfer T_t and for the seller to the probability of being forced to produce and ship as agreed upon. We assume that at the point where parties decide on whether or not to comply with the contractual terms they are unaware of the institutional enforcement outcome. By using this

¹¹In Appendix A.4, we study the case of a myopic type with positive discount factor, i.e. $\delta_M \in (0, \delta_B)$.

¹²Alternatively, (LC_t) can be interpreted as a solvency constraint that the buyer must comply with in every period.

¹³Conditioning the transfer on the realization of r_t is possible if either the revenue realization is observable for the seller, or, if the buyer truthfully reports r_t in case the realized value is her private information. In the analysis, we focus on the public information case and summarize the results of the private information scenario in Section 5.2.

probabilistic approach of contract enforcement we follow an established literature that studies trade relationships in the presence of heterogeneous enforcement institutions (see [Araujo and Ornelas, 2007](#); [Araujo et al., 2016](#); [Antràs and Foley, 2015](#)).¹⁴

In the following, we summarize the stage game of period t which is repeated ad infinitum. The strategy sets of both players contain the decision problems highlighted *in italics* below.

Stage game timing.

1. ***Revenue realization.*** The level of the revenue shifter r_{t-1} is realized and learned by the buyer and the seller. The product shipped in the previous period generates revenue $\mathcal{R}(Q_{t-1}, r_{t-1})$ to the buyer from the sale to final consumers.
2. ***Payment (open account).*** The buyer *decides whether to make* transfer T_{t-1} to the seller. She finds an opportunity not to pay with probability $1 - \lambda$. Upon non-payment the match is permanently dissolved.
3. ***Liquidity check.*** The partnership remains active only if (LC_{t-1}) is fulfilled. The seller can *decide to forgive the buyer's transfer* and save her from bankruptcy. Otherwise, the match is permanently dissolved.
4. ***Matching.*** If unmatched, the seller *decides whether or not to start* a new partnership. If matched, the seller *decides whether to stay* with the current buyer *or to re-match*.
5. ***Contracting.***
 - The seller *decides on the design* of a one-period spot contract $C_t = \{Q_t, T_t, F_t\}$ proposed to the buyer. The contract specifies a trade volume Q_t , a transfer T_t , and a payment contract F_t . If no proposal is made the match is permanently dissolved.
 - The buyer *decides whether to accept* C_t . Upon rejection, the match is dissolved.
6. ***Payment (cash in advance).*** The buyer *decides whether to make* transfer T_t to the seller. She finds an opportunity not to pay with probability $1 - \lambda$. Upon non-payment the match is permanently dissolved.

¹⁴The enforcement concept assumes that the seller is not able to distinguish whether payment follows from the intrinsic motives of the (patient) buyer, or whether institutions enforce the (myopic) buyer's compliance with the contract. In Appendix A.3, we show that our qualitative findings remain valid when the seller can make this distinction.

7. **Production and Shipment.** The seller *decides whether to produce and ship* Q_t as specified in the contract. Upon non-shipment the match is permanently dissolved.¹⁵

We define by $C = (C_t)_{t=0}^{\infty}$ the sequence of spot contracts offered by the seller over the course of the relationship. Moreover, we denote by $Q = (Q_t)_{t=0}^{\infty}$, $T = (T_t)_{t=0}^{\infty}$, and $F = (F_t)_{t=0}^{\infty}$ the corresponding sequences for trade volumes, transfer payments, and payment contracts, respectively. The proofs to all the results stated below can be found in the Appendix.

3 Payment contracts in isolation

In this section, we study in isolation the two cases where the seller is restricted to choose either cash in advance or open account payment terms for all periods and rule out switches between payment terms over time. This corresponds to a situation in which the seller grants trade credit for either none or all transactions of a relationship. The possibility to vary trade credit provision over time is introduced in Section 4.

We consider the following *strategy profile*. The seller forms a new partnership whenever unmatched. He terminates an existing partnership if and only if the buyer defaults on the contract. In any period t , the seller chooses a trade volume Q_t and a transfer profile T_t that maximize his current period expected payoffs.¹⁶ The seller saves the buyer from bankruptcy whenever this gives him higher continuation payoffs. The buyer accepts the proposed contract C_t whenever participation promises an expected payoff that at least covers her outside option. The buyer's behavior with respect to an accepted contract is determined by her type and the realization of the revenue shifter. The myopic type deviates from any contract and not pay the transfer whenever possible. By assumption, the patient buyer is patient enough to never default from a contract as long as she does not suffer bankruptcy. Following [Mailath and Samuelson \(2006\)](#), we employ *sequential equilibrium* as equilibrium concept.¹⁷

¹⁵In principle, the seller's production and shipment decision is also subject to contract enforcement through institutions. However, since it does play a role in the subsequent analysis we do not formally introduce an institutional parameter applicable in the seller's home market.

¹⁶Since we assume that only spot contracts are feasible and switching between payment contract types is ruled out here, the maximization of the current period expected payoffs implies that the ex-ante expected payoffs are maximized simultaneously.

¹⁷The authors explain on pp. 158–159 that for adverse selection scenarios as we study them here, sequential equilibrium is appropriate to use. Intuitively, the strategy profile is *sequentially rational* “[...] if, after every personal history, player i is best responding to the behavior of the other players, given beliefs over the personal histories of the other players that are ‘consistent’ with the personal history that player i has observed” ([Mailath and Samuelson, 2006](#), p. 147). In the context of our model, at any decision point a *personal history* consists of the observable behavior of both players that was previously generated within the same buyer-seller match.

To simplify the exposition of our results, we normalize the outside option of the buyer to zero. In the Online Appendix, we show that our results extend to the case where the buyer has a positive outside option.

3.1 Cash in advance terms

First, we study the case where the seller is restricted to write contracts on cash in advance terms (A-terms) only, i.e. in any trade relationship $F = (A, \dots)$.¹⁸ Under this payment sequence the seller never provides trade credit to the buyer. The participation constraint of a buyer of type $j \in \{M, B\}$ in period t is:

$$\delta_j \mathcal{R}(Q_t, r_E) - T_t \geq 0, \quad (\text{PC}_{j,t}^A)$$

where $r_E = \gamma r^h + (1 - \gamma)r^l$ denotes the expected value of the revenue shifter. The constraint states, that tomorrow's expected revenue $\mathcal{R}(Q_t, r_E)$ realized from the sale of today's shipment Q_t must be larger than the transfer T_t made to the seller before shipment. Because goods can be sold to final consumers only in the period following t , the revenue is multiplied by the buyer's discount factor δ_j . Observe that because $\delta_M = 0$, the myopic buyer's participation constraint, $(\text{PC}_{M,t}^A)$, cannot be fulfilled for any $T_t > 0$. Consequently, the myopic buyer will never accept any contract on A-terms and the seller offers a *separating contract* that only a patient buyer accepts. Hence, whenever a new trade relationship survives the initial transaction the seller can be certain to be matched with a patient buyer and his belief jumps from $\theta_0 = \hat{\theta}$ to $\theta_1 = 0$ and remains at this level for all further transactions with the same buyer.

While a patient buyer accepts any contract on A-terms when $(\text{PC}_{B,t}^A)$ holds, she may suffer from liquidity problems in case (LC_t) is not satisfied. Anticipating the risk of buyer bankruptcy the seller has two options to set the transfer. On the one side, he can set $T_t^A = \delta_B \mathcal{R}(Q_t, r_E)$ such that $(\text{PC}_{B,t}^A)$ binds. In this case, whenever the realized revenue is low the buyer is threatened by bankruptcy. Note that given revenue shocks are public information and the seller has learned from contract acceptance that the buyer is patient he may find it profitable to save her from going bankrupt and repay T_t^A . In the main text, we present the model outcomes for the scenario where the buyer does not forgive the cash in advance payment as only this scenario turns out relevant for our main results in Section 4.¹⁹ On the other side, the seller can set $T_t^{A,l} = R(Q_t, r^l) < T_t^A$ such

¹⁸In the following, in the expressions for the sequence of payment contracts F we drop the time index for notational convenience.

¹⁹In Appendix A.1, we show how the seller optimally decides between letting the illiquid buyer go bankrupt and not. It turns out that bankruptcy is preferable to the seller whenever the share of myopic buyers in the population, $\hat{\theta}$, is sufficiently small.

that the liquidity constraint in the low revenue state binds, ensuring that the trade relationship with the patient buyer is maintained in all revenue states. However, when the value of r^l is small (as we assume it here) setting $T_t^A = \delta_B R(Q_t, r_E)$ in all transactions is payoff-maximizing for the seller.²⁰ Hence, $T_t = T_t^A$.

Acknowledging this transfer strategy, the seller's trade volume choice solves the following maximization problem:

$$Q_t^A \equiv \arg \max_{Q_t} \pi_t^A = T_t^A - cQ_t, \quad (1)$$

i.e. he sets Q_t to maximize the difference between received transfer payment and production costs. The optimal trade volume and the corresponding stage payoffs conditional on contract acceptance are given for all transactions on A-terms as:

$$Q^A = \left(\frac{\gamma \delta_B}{c} \right)^{\frac{1}{\alpha}}, \quad \bar{\pi}^A \equiv \pi_t^A = Q^A \frac{c\alpha}{1-\alpha}.$$

Building on the observations above, the ex-ante expected payoffs from conducting an infinite sequence of transactions on A-terms can be derived from solving the following dynamic programming problem. Denoting by V_t^i the payoff value function for payment contract type $i \in \mathcal{F}$ in period t we have:

$$\begin{aligned} V_0^A &= (1 - \theta_0) \bar{\pi}^A + \delta_S [\gamma(1 - \theta_0) V_1^A + (1 - \gamma(1 - \theta_0)) V_0^A], \\ V_1^A &= \bar{\pi}^A + \delta_S [\gamma V_1^A + (1 - \gamma) V_0^A]. \end{aligned} \quad (2)$$

Note that a trade relationship with the same patient buyer is productive and continued only if this buyer does not go bankrupt in the respective transaction, i.e. with probability γ . Otherwise, a trade relationship with a new buyer is started. Solving the programming problem for V_0^A gives the seller's ex-ante expected payoffs under A-terms, Π^A . They are:

$$\Pi^A = \frac{(1 - \theta_0) \bar{\pi}^A}{(1 - \delta_S)(1 - \gamma \theta_0 \delta_S)}.$$

Under A-terms, the buyer has to make the transfer before the seller's production and shipment decision. Consequently, the seller may have an incentive to deviate and not produce the output, seize the transfer, and re-match to a new buyer in the next period. To avoid this deviation, the following incentive constraint of the seller has to hold:

$$-cQ^A + \delta_S V_1^A \geq \delta_S V_0^A. \quad (\text{IC}_S)$$

²⁰For further details and a discussion of the more general case with $r^l \in (0, r^h)$, see Appendix A.2.

Lemma 1 provides parameter conditions to ensure that (IC_S) holds and guarantees equilibrium existence.²¹

Lemma 1. *Suppose that consumers' price elasticity of demand is sufficiently constrained, i.e. $\alpha > \tilde{\alpha} \in (0, 1)$. Then there exists a repeated game equilibrium that maximizes the seller's ex-ante expected payoffs under cash in advance terms, Π^A , for all $\delta_S \geq \tilde{\delta}_S \in (0, 1)$.*

Some remarks on Lemma 1 are in order. For an equilibrium of the repeated game to exist the stage payoffs generated from the sale of Q^A units of the product must be large enough, i.e. larger than the threshold level implied by $\tilde{\alpha}$ and satisfied for all $\alpha > \tilde{\alpha}$. Otherwise, a deviation by the seller cannot be ruled out since the transaction's profit margin becomes negligible and the deviation ensures the seller the full transfer at zero cost. Stated differently, the lower bound on α implies that final consumer demand must not be too price-elastic, i.e. $|\epsilon_{Q^A, p}| < 1/\tilde{\alpha}$ must hold.²² Provided that $\alpha > \tilde{\alpha}$ holds there exist repeated game equilibria rationalizing the behavior prescribed by the strategy profile if the seller is sufficiently patient, as implied by the minimum discount factor $\tilde{\delta}_S$. Proposition 1 summarizes our key findings on the cash in advance equilibrium.

Proposition 1. *Suppose that payment is only possible on A-terms and Lemma 1 holds. Then the seller proposes a separating contract C_t that only patient buyers accept. In every period, the seller produces and ships the payoff-maximizing trade volume Q^A . The expected stage payoffs increase from $(1 - \theta_0)\bar{\pi}^A$ to $\bar{\pi}^A$ after the first transaction and stay at this level for the remainder of the trade relationship. The seller's ex-ante expected payoffs are Π^A .*

There are several points noteworthy about this equilibrium. First, profit maximization under cash in advance terms necessarily separates buyer types as these are very demanding for the buyer. This is demonstrated by the fact that A-terms exclude myopic buyers from cooperation altogether. For the seller, cash in advance terms have the advantage of excluding any risk of non-payment and imply that the time-invariant trade volume Q^A is optimal beginning with the first transaction. Moreover, all information about the buyer's type is acquired immediately with the acceptance or rejection of the initial contract C_0 . The stability of the trade relationship with

²¹To improve readability, the explicit statement and the derivations of all parameter thresholds of the paper are omitted in the main text and can be found in Appendix A.1. Thresholds $\tilde{\delta}_S$ and $\tilde{\alpha}$ are defined in equations (A.2) and (A.3), respectively.

²²A more extensive discussion on the relevance of this parameter constraint can be found after the presentation of our main results in Proposition 3.

a patient buyer depends on the realizations of the revenue level and is maintained as long as revenue realizations are high (i.e., $r_t = 1$).

Let us stress that the separation outcome under A-terms does not depend on our assumption of a fully myopic buyer. In Appendix A.4, we show that for any $\delta_M \in [0, \delta_B)$ any contract that is incentive compatible and payoff-maximizing for the seller is separating and as such only accepted by the more patient buyer. Note also, that optimal contract design under A-terms does not depend on whether the revenue shock is realized publicly or privately to the buyer. The reason is that under A-terms the buyer's contract acceptance as well as her transfer payment decision take place before the revenue shifter is realized (for details, see Section 5.2). This implies a contrast to the situation under Ω -terms which we study in the following section.

3.2 Open account terms

Let us now turn to the case where the seller is restricted to write contracts on open account terms (Ω -terms) only, i.e. in any trade relationship $F = (\Omega, \dots)$. This case implies that trade credit is offered to the buyer in all transactions.

In contrast to A-terms discussed above, under Ω -terms the buyer can make the transfer specific to the size of the realized revenue since payment is conducted subsequently. We denote by $T_t^{\Omega,h}$ and $T_t^{\Omega,l}$ the transfer that a contract assigns to a high respectively low revenue realization and denote by $ET_t^\Omega = \gamma T_t^{\Omega,h} + (1-\gamma)T_t^{\Omega,l}$ the expected transfer payment.²³ Based on the strategy profile, we can write the participation constraints of the two buyer types for a period t contract as:

$$\gamma R(Q_t) - ET_t^\Omega \geq 0, \quad (\text{PC}_{B,t}^\Omega)$$

$$\gamma R(Q_t) - \lambda ET_t^\Omega \geq 0, \quad (\text{PC}_{M,t}^\Omega)$$

where $(\text{PC}_{B,t}^\Omega)$ is the participation constraint of the patient buyer and $(\text{PC}_{M,t}^\Omega)$ that of the myopic buyer, respectively. A comparison reveals that under Ω -terms it is impossible to construct a separating contract that would guarantee to select only patient buyers. The reasons are twofold. First, myopic buyers anticipate to transfer a share of the generated revenue only if the contract is enforced. This happens with probability λ and makes their PC more lenient compared to that of the patient type. Second, discounting does not affect the buyer's participation decision

²³Alternatively, the seller can offer a "flat" contract to the buyer specifying a transfer level that is independent of the revenue realization. While this approach is payoff-maximizing when revenue realizations are private information to the buyer it is payoff-dominated in the public information case. For a discussion, see Section 5.2.

since both, revenue realization and payment for a period t contract happen in period $t + 1$. Consequently, any feasible transaction on open account terms involves a *pooling contract*.

Suppose now that buyers behave as prescribed by the strategy profile and consider the seller's belief on the buyer's type. If the risk of buyer bankruptcy is ruled out (which the seller does by setting the state-contingent transfers accordingly, see below) then patient buyers will never deviate and myopic buyers do so whenever possible (i.e. they do not make the transfer when contracts are not enforced). Hence, if no deviation occurs up to the t th transaction with the same buyer, the seller's belief of facing a myopic type in period t is given by Bayes' rule as:²⁴

$$\theta_t^\Omega = \frac{\hat{\theta}\lambda^t}{1 - \hat{\theta}(1 - \lambda^t)}. \quad (3)$$

Using equation (3), the payment probability in period t of a relationship can be written as $\Lambda(t, \hat{\theta}, \lambda) = 1 - \theta_t^\Omega(1 - \lambda) = [1 - \hat{\theta}(1 - \lambda^{t+1})]/[1 - \hat{\theta}(1 - \lambda^t)] \equiv \Lambda_t$. Note that $\lim_{t \rightarrow \infty} \theta_t^\Omega = 0$ and $\lim_{t \rightarrow \infty} \Lambda_t = 1$, i.e. as the relationship with a buyer continues the seller's belief of being matched with a myopic buyer converges to zero while the associated payment probability converges to one. In the following, we refer to this limiting situation as the *full information limit*.

Equipped with this notion of belief formation and updating, the seller's expected stage payoff function takes the following form:

$$\pi_t^\Omega = \delta_S \Lambda_t [\gamma T_t^{\Omega, h} + (1 - \gamma) T_t^{\Omega, l}] - cQ_t. \quad (4)$$

While the seller has to bear the costs of production cQ_t already in period t , he receives the expected transfer $\Lambda_t ET_t^\Omega$ only in the following period which is therefore discounted by δ_S .

Under open account, when deciding on the revenue-contingent transfers $T_t^{\Omega, h}$ and $T_t^{\Omega, l}$ the seller faces two challenges. First, he must ensure that the (patient) buyer's liquidity constraint is fulfilled for both possible revenue realizations. Formally, the following constraints must hold:

$$\mathcal{R}(Q_t, r^l) - T_t^{\Omega, l} \geq 0, \quad (\text{LC}_t^l)$$

$$\mathcal{R}(Q_t, r^h) - T_t^{\Omega, h} \geq 0. \quad (\text{LC}_t^h)$$

Since a buyer can foresee her bankruptcy when making the transfer and the respective liquidity

²⁴In Appendix A.3, we discuss the alternative scenario where the seller can directly observe the buyer's intention of not paying which makes court usage a decision variable for the seller. In this case, the seller's belief updating process under Ω -terms is identical to A-terms. Still, our central result prevails that a stage contract on Ω -terms cannot separate buyer types and, as a consequence, we see trade volume growth over the course of transactions. Moreover, we are able to account for the observations of [Macaulay \(1963\)](#) who documents that business relationships often die once courts are used to enforce contract terms.

constraint does not hold, she will instead keep the revenue for herself and accept that the relationship is discontinued. This also implies that it is optimal for the seller to offer a contract with revenue-contingent transfers.

Second, it is not enough to merely account for the participation and liquidity constraints to guarantee that the patient buyer does not deviate. In addition, she must be incentivized by the expected payoffs of future transactions to pay the transfer instead of seizing the period's entire revenue and accept being re-matched. To maintain tractability, we assume that buyers are unaware of the seller's belief formation process and expect the terms of future contracts C_k , with $k > t$, to be identical to those of the contract signed in period t . This implies that the buyer conditions her behavior on the same information set under both, A- and Ω -terms. Formally, the revenue state-contingent incentive constraints for a buyer of type $j \in \{M, B\}$ are:

$$-T_t^{\Omega,l} + \frac{\delta_j}{1-\delta_j}[\gamma R(Q_t) - ET_t^{\Omega}] \geq 0, \quad (\text{IC}_{j,t}^{\Omega,l})$$

$$-T_t^{\Omega,h} + \frac{\delta_j}{1-\delta_j}[\gamma R(Q_t) - ET_t^{\Omega}] \geq 0. \quad (\text{IC}_{j,t}^{\Omega,h})$$

Note that the incentive constraints are never fulfilled for the myopic buyer for any $T_t > 0$ and she will deviate whenever contracts are not enforced. The following Lemma 2 derives conditions that ensure buyers to behave according to the strategy profile, while maximizing the seller's stage game payoffs.

Lemma 2. *Under Ω -terms, the seller sets transfers $T_t^{\Omega,l} = \mathcal{R}(Q_t.r^l) \approx 0$ and $T_t^{\Omega,h} = \delta_B \gamma / (1 - \delta_B(1 - \gamma)) R(Q_t)$. Thereby, he rules out the buyer bankruptcy risk, makes the patient buyer indifferent between paying and not paying the agreed upon transfer in any revenue state and maximizes his own payoffs.*

Acknowledging the results of Lemma 2, the seller chooses the trade volume in period t by maximizing the following variant of (4):

$$Q_t^{\Omega} \equiv \arg \max_{Q_t} \delta_S \Lambda_t \mathcal{T} R(Q_t) - cQ_t, \quad \text{where } \mathcal{T} = \frac{\delta_B \gamma^2}{1 - \delta_B(1 - \gamma)}.$$

The optimal trade volume Q_t^{Ω} and the corresponding stage game payoff π_t^{Ω} in the t th transaction with a buyer on open account terms can be calculated as:

$$Q_t^{\Omega} = \left(\frac{\delta_S \mathcal{T} \Lambda_t}{c} \right)^{\frac{1}{\alpha}}, \quad \pi_t^{\Omega} = Q_t^{\Omega} \frac{c\alpha}{1 - \alpha}.$$

We define the trade volume and stage payoffs at the full information limit as $Q^{\Omega} \equiv \lim_{t \rightarrow \infty} Q_t^{\Omega} =$

$(\delta_S \mathcal{T}/c)^{1/\alpha}$ and $\bar{\pi}^\Omega \equiv \lim_{t \rightarrow \infty} \pi_t^\Omega = Q^\Omega c \alpha / (1 - \alpha)$, respectively.²⁵

The seller's ex-ante expected payoff from a trade relationship on open account terms, Π^Ω , can be obtained from solving the following dynamic programming problem for V_0^Ω :

$$\forall t \geq 0: \quad V_t^\Omega = \pi_t^\Omega + \delta_S (\Lambda_t V_{t+1}^\Omega + (1 - \Lambda_t) V_0^\Omega). \quad (5)$$

In Appendix A.1, we derive the following solution to this problem:

$$\Pi^\Omega = \frac{1 - \delta_S \lambda}{1 - \delta_S \lambda - \delta_S \theta_0 (1 - \lambda)} \bar{\pi}^\Omega \sum_{t=0}^{\infty} \delta_S^t \Lambda_t^{\frac{1}{\alpha}} (1 - \theta_0 (1 - \lambda^t)). \quad (6)$$

We summarize our findings on the open account equilibrium in Proposition 2.

Proposition 2. *Suppose that payments are only possible on Ω -terms. Then the seller proposes a pooling contract to the buyer and updates his belief as prescribed by θ_t^Ω as the relationship proceeds. Based on this belief, the trade volume Q_t^Ω (the expected stage payoffs π_t^Ω) increase gradually with the age of the relationship and converge to the full information level Q^Ω ($\bar{\pi}^\Omega$). The ex-ante expected payoffs of the seller are Π^Ω .*

3.3 Discussion

A comparison of the results of Sections 3.1 and 3.2 reveals important differences between cash in advance and open account payment terms. On the one side, they can be summarized as features related to the *learning process* about the buyer, and to the *risks of relationship breakdown* on the other side.

First, consider the learning process about the buyer in a new relationship. Under cash in advance terms, the seller optimally offers a separating stage contract that immediately reveals the buyer's type. In contrast, immediate separation is not possible under Ω -terms where the payoff-maximizing stage contract pools both types. In this case, type information is acquired only gradually over time through the Bayesian updating process. Type separation under A-terms translates into a comparably high trade volume Q^A from the first transaction while trade volumes under Ω -terms grow over time and converge to the belief-free level Q^Ω as the relationship matures. These patterns have immediate repercussions on the evolution of stage payoffs. Under A-terms, the expected stage payoffs jump from $(1 - \theta_0) \bar{\pi}^A$ to $\bar{\pi}^A$ immediately and permanently after the first successful transaction with the same buyer. In contrast, under Ω -terms they increase at a

²⁵For later use, note that the expected stage payoffs under belief θ_t^Ω can be rewritten as an expression that is proportional to the stage payoffs at the full information limit, i.e. $\pi_t^\Omega = \Lambda_t^{\frac{1}{\alpha}} \bar{\pi}^\Omega$.

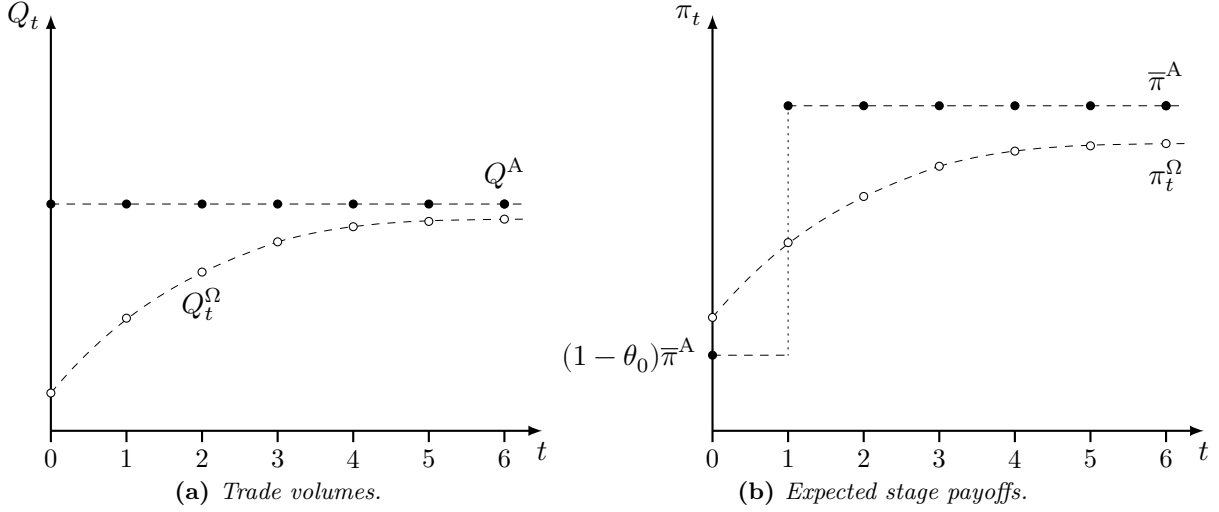


Figure 2: Trade volumes and expected stage payoffs (at the contracting stage).

strictly slower rate up to $\bar{\pi}^\Omega$ – the payoffs at the full information limit. Note that these results do not rely on the assumption of a fully myopic buyer. In Appendix A.4, we show that as long as the discount factors of both types differ sufficiently these results prevail.

Figure 2 illustrates the evolution of trade volumes and the seller’s expected stage payoffs over the course of a trade relationship. It shows the payoff expectation as formed at the beginning of the contracting stage in the t th transaction with the same buyer. Note that $Q_t^\Omega < Q^A$ and $\pi_t^\Omega < \bar{\pi}^A$ also for $t \rightarrow \infty$ due to the timing of the transfer payment.²⁶

Second, let us compare the risks of transaction failure across payment terms. Under the considered strategy profile, transaction failure directly corresponds to the breakdown of the trade relationship with a buyer. While under A-terms transaction failure is triggered by buyer characteristics (i.e., her type and/or liquidity status) under Ω -terms the institutional environment is decisive. Under the latter, a transaction can be unsuccessful only if contracts are not enforced which induces transfer *non-payment* in a match with a myopic buyer. In contrast, A-terms do not involve any payment risk for the seller since the transfer is made already before production and shipment. However, the transaction can still be unsuccessful as A-terms cause *non-participation* of the myopic buyer. Moreover, while low revenue realizations can cause relationship breakdown under A-terms due to buyer illiquidity this never occurs under Ω -terms. Here, the optimal

²⁶Moreover, note that $\lim_{\delta_B \rightarrow 1} \lim_{\delta_S \rightarrow 1} Q^\Omega = Q^A$ and $\lim_{\delta_B \rightarrow 1} \lim_{\delta_S \rightarrow 1} \bar{\pi}^\Omega = \bar{\pi}^A$, i.e. the trade volumes and stage payoffs at the full information limit under A- and Ω -terms converge as both, the seller and the patient buyer become very patient. Figure 2b depicts the situation where at $t = 0$ the expected stage payoff is larger under Ω - than under A-terms. The reverse scenario can also occur in equilibrium.

transfer conditions on the size of the realized revenue which eliminates liquidity concerns.

Ex-ante to contracting, the probability of transaction failure in period t for both payment types is given as $P_t^A = 1 - \gamma(1 - \theta_t)$ and $P_t^\Omega = \theta_t(1 - \lambda)$, respectively. Evidently, $P_t^\Omega < P_t^A$ holds and the seller can benefit from a smaller failure risk under Ω -terms the stronger contracting institutions are. Consequently, when deciding whether or not to provide trade credit to a new buyer the seller has to weigh the relationship stability-enhancing advantages of trade credit with the associated, comparably slow learning process about the buyer and the corresponding moderate growth of stage payoffs on the equilibrium path. In the following section, we study how the seller can manage this *trade-off between relationship stability and stage payoff growth* efficiently.

4 Dynamically optimal payment contracts

4.1 Main results

We now study the seller's optimal choice of payment contracts when he can separately decide between A- and Ω -terms – and hence about the provision of trade credit – in every period of the repeated game, i.e. $F_t \in \mathcal{F}$ for all $t \geq 0$. This will give us an understanding of how the inter-temporal trade-off identified in Section 3 determines optimal payment contract choice in the dynamic context.

Definition The sequence F that maximizes the seller's ex-ante expected payoffs from the trade relationship is called the *dynamically optimal sequence of payment contracts* (DOSPC).

Determining the DOSPC from a direct comparison of all available sequences is impossible since this set contains infinitely many elements as a consequence of the infinite time horizon of the game. However, simple parameter refinements allow us to endogenously reduce the set of possibly optimal sequences to three elements.

Proposition 3. *For all parametrizations of the model satisfying the constraints $\alpha > \underline{\alpha} \in (0, 1)$ and $\delta_B > \underline{\delta}_B \in (0, 1)$ there exists a unique $\underline{\delta}_S \in (0, 1)$ such that for all $\delta_S > \underline{\delta}_S$ we have $F \in \{(A, \dots), (\Omega, \dots), (A, \Omega, \Omega, \dots)\} \equiv \mathcal{F}^D$ as the DOSPC.²⁷*

The parameter constraints in Proposition 3 address three distinct incentive problems. The first addresses the seller's motivation to switch between payment terms over the course of a trade

²⁷The parameter thresholds $\underline{\alpha}$, $\underline{\delta}_S$, and $\underline{\delta}_B$ are defined in the Appendix in equations (A.9) and (A.10).

relationship. We show that in the initial transaction of a new relationship both, A- and Ω -terms, can be optimal. Hence, switches away from either payment mode must be considered. On the one side, observe that any relationship that starts on A-terms reaches the full information limit after the first successful transaction. Consequently, either the sequence (A, \dots) or $(A, \Omega, \Omega, \dots)$ must be optimal in this case. On the other side, whenever the trade relationship starts on Ω -terms switches to A-terms in later periods are never optimal. Intuitively, this is the case because the informational gains under Ω -terms relative to those under A-terms are smallest in the initial transaction. Hence, whenever Ω -terms payoff-dominate in the initial transaction for the seller, they also do so in later periods. Note that a necessary requirement for any sequence other than (A, \dots) to be optimal is that the seller is sufficiently patient, as payment under Ω -terms occurs only in the following period.

A second set of incentive constraints relates to the non-shipment deviation of the seller under A-terms. While Lemma 1 rules out non-shipment for sequence $F = (A, \dots)$ in Proposition 3 we derive additional, equivalent conditions for $F = (A, \Omega, \Omega, \dots)$. The corresponding lower bound on parameter α corresponds to an upper bound on the product's price elasticity of demand (for details, see Section 3.1). It can be interpreted as a restriction on the set of export markets for which our model provides unique predictions. In an empirical context, this speaks to the findings by [Imbs and Mejean \(2015\)](#) who show that trade price elasticities are highly heterogeneous across sectors in OECD countries.²⁸ Incentivizing product shipment in the initial transaction for sequence $(A, \Omega, \Omega, \dots)$ additionally requires sufficient buyer patience ($\delta_B > \underline{\delta}_B$) since the seller's continuation payoff under Ω -terms depend positively on the patient buyer's discount factor.

A final set of constraints deals with the seller's incentive to save the patient buyer from bankruptcy when the latter is hit by a liquidity shock under A-terms. The results differ between the sequences (A, \dots) and $(A, \Omega, \Omega, \dots)$. We find, that with the possibility to switch payment contracts over time it is never optimal for the seller to save the buyer from bankruptcy when sequence (A, \dots) is the DOSPC. In contrast, when the seller chooses sequence $(A, \Omega, \Omega, \dots)$ either option can be optimal in equilibrium (see the discussion of Corollary 1).

Summing up, Proposition 3 uncovers that when the trade partners are patient enough and when final consumer demand is sufficiently price-inelastic the trade-off between relationship

²⁸Using data from 16 OECD countries, [Imbs and Mejean \(2015\)](#) estimate trade elasticities for 56 ISIC sectors for which they document price elasticities ranging from -2.2 to -29. In the context of their data, our results imply that while the predictive power of Proposition 3 is high for relatively price-inelastic sectors such as the "dairy products" industry it is not as strong for sectors with high demand elasticity such as the "crude petroleum" industry. For further details, see Section II.B and Figure 2 of their paper.

stability and information acquisition outlined in Section 3.3 is sufficient to reduce the set of feasible DOSPCs to \mathcal{F}^D . The following Corollary 1 goes one step further by showing how the seller can resolve the trade-off efficiently and identifies unique conditions under which either sequence is dynamically optimal.

Corollary 1. (a) *Under the conditions of Proposition 3 there exists a unique belief threshold $\underline{\theta}_0 \in (0, 1)$ such that the DOSPC is $F = (A, \dots)$ if $\theta_0 < \underline{\theta}_0$. For both sequences $F \in \{(A, \Omega, \Omega, \dots), (\Omega, \dots)\}$ there exist parameter values $\theta_0 \in (\underline{\theta}_0, 1)$ under which either sequence is optimal. For $\theta_0 \rightarrow 1$, the DOSPC is $F = (\Omega, \dots)$.*

(b) *When in addition $\alpha > \bar{\alpha} \in [\underline{\alpha}, 1)$ holds, there exists a unique $\bar{\theta}_0$ with $0 < \underline{\theta}_0 < \bar{\theta}_0 < 1$ such that the DOSPC is determined as follows:*

- $F = (A, \dots)$ if $\theta_0 < \underline{\theta}_0$,
- $F = (A, \Omega, \Omega, \dots)$ if $\theta_0 \in (\underline{\theta}_0, \bar{\theta}_0)$,
- $F = (\Omega, \dots)$ if $\theta_0 > \bar{\theta}_0$.

Figure 3 provides a graphical summary of the results in Corollary 1(b).²⁹ It shows the seller's ex-ante expected payoffs resulting from any of the payment sequences in \mathcal{F}^D as a function of the seller's initial belief that the buyer is myopic, θ_0 . For given $\theta_0 \in (0, 1)$, the seller chooses the payment sequence which gives him the highest expected payoffs (as indicated by the solid line segments). Note that $\Pi^{A\Omega}$ (respectively, $\Pi^{A\Omega, s}$) denotes the seller's payoff under sequence $(A, \Omega, \Omega, \dots)$ when letting (respectively, not letting) the buyer go bankrupt after a liquidity shock in the initial transaction. We find that for both – new and established relationships that survive the initial transaction – Ω -terms and therefore the provision of seller trade credit is more likely optimal the higher belief θ_0 , and correspondingly, the larger the population share of myopic buyers. We elaborate on the reasons for this pattern in the following.

²⁹The additional constraint on α in Corollary 1(b) ensures the concavity of Π^Ω in θ_0 . Due to the complex series expression of Π^Ω – see equation (6) – we rely on a combination of element-wise analytical comparative statics and a numerical simulation for the payoff series as a whole to proof this. Requiring $\alpha > \bar{\alpha}$ ensures the uniqueness of $\bar{\theta}_0$. Note that there also exist model parametrizations for which $\bar{\theta}_0 < \underline{\theta}_0$, implying some $F \in \{(A, \dots), (\Omega, \dots)\}$ as DOSPC.

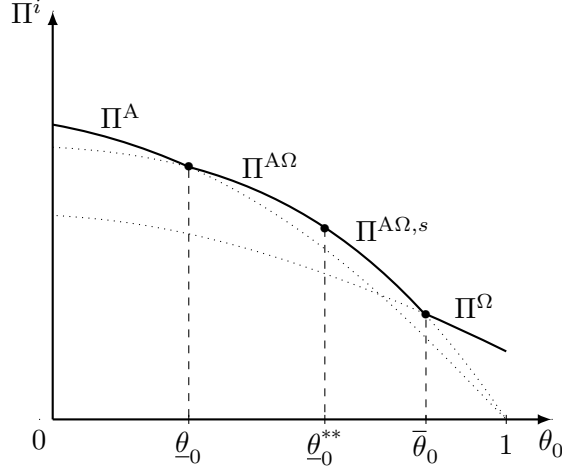


Figure 3: *Ex-ante expected payoff functions under the conditions of Corollary 1(b).*

Consider first the situation in a newly matched buyer-seller relationship. Given \mathcal{F}^D , the design of C_0 determines how the inter-temporal trade-off between relationship stability and payoff growth is resolved optimally. Corollary 1 shows that the mitigation of relationship breakdown risks is more likely prioritized to acquiring new information about the buyer the higher the initial belief θ_0 of drawing a myopic buyer. If θ_0 is large then conducting an initial transaction on A-terms is unlikely successful since only a small share of patient buyers will accept such a contract. This reduces the ex-ante expected payoffs associated with sequences that include A-terms and makes their optimality less likely. When the seller's belief is moderate and sequence $(A, \Omega, \Omega, \dots)$ is optimal, the trade-off drives further micro-adjustments on how this sequence is implemented by the seller. While for relatively low beliefs, $\theta_0 \in (\underline{\theta}_0, \underline{\theta}_0^{**})$, letting the buyer go bankrupt after a low-revenue shock in the initial transaction is optimal for the seller, for higher values, $\theta_0 \in (\underline{\theta}_0^{**}, \bar{\theta}_0)$, he prefers making an ex-post transfer to save the buyer from bankruptcy.

In order to understand the rationale for varying payment terms over time we can focus on the situation where A-terms are used initially. While the expected stage payoffs in any subsequent transaction are larger under A-terms (i.e., $\bar{\pi}^A > \bar{\pi}^\Omega$), continuing the relationship on A-terms can retain the risk of losing a certainly patient buyer due to liquidity problems. Corollary 1 predicts that switching to Ω -terms after the initial transaction is preferable to obtaining high stage payoffs under full information when the likelihood of finding another patient buyer is low (i.e., when $\theta_0 > \underline{\theta}_0$). In this situation, the seller rather accepts lower stage payoffs and offers trade credit instead of risking to lose the patient buyer. Conversely, when the probability of

finding a patient buyer upon relationship breakdown is high (i.e., when $\theta_0 < \underline{\theta}_0$) the seller does not find it threatful to loose his current buyer and continues business on A-terms throughout.

4.2 Discussion

Our model proposes a novel, dynamic mechanism to explain the substantial provision of trade credit by sellers and its availability to buyers engaged in international trade. It predicts that sellers are more prone to provide trade credit to their business partners the harder it is for them to find a reliable, patient buyer in the destination market and the more established the trade relationship with a particular buyer becomes. The reason is that compared to A-terms, under Ω -terms the stability of the trade relationships is not threatened by potential buyer liquidity problems which is particularly valuable when finding a reliable buyer is difficult. Stated differently, providing trade credit allows the seller to insure the trade relationship against breakdown due to unfavorable changes in buyer revenues. Whenever the seller increases trade credit provision over time this originates from a learning effect about the buyer's type and eliminates the costs of illiquidity-induced relationship breakdown.

The analysis shows that payment types can be interpreted as distinct *contract enforcement technologies*. While under Ω -terms enforcement is ensured by publicly available institutions, under A-terms it is ensured privately through the design of the contract terms which are only acceptable to reliable, patient buyers. For new trade relationships, our theory predicts that whenever the share of patient buyers is small then relying entirely on buyer selection to ensure payment (i.e., choosing A-terms for the initial transaction) is inefficient as any relationship with a myopic buyer fails immediately. In contrast, the “softer” screening under Ω -terms also allows these buyers to take up possibly productive trade relationships which has a stabilizing effect on the expected payoff stream of the seller. Overall, we show that acknowledging the screening properties of payment contracts allows to derive unambiguous recommendations on how a seller can efficiently resolve the corresponding trade-off between relationship stability and stage payoff growth.

5 Model extensions

In the following, we introduce and discuss the results of key extensions to our model. We focus on an intuitive summary of results and relegate the detailed analysis and formal derivations to the Online Appendix.

5.1 Trade credit insurance

The provision of trade finance through banks and insurance firms is an important, additional driver for the growth of firms' trade volumes (cf. [Amiti and Weinstein, 2011](#)). In the following, we discuss how the availability of trade credit insurance impacts dynamically optimal payment contract choice. In our model, this means that instead of taking the risk of buyer non-payment in an open account transaction himself, the seller can rule it out by employing trade credit insurance ($F_t = \text{I}$).

Following [Niepmann and Schmidt-Eisenlohr \(2017\)](#), we assume that the insurance is available from a perfectly competitive insurance market, in which the cost of insurance depends positively on the size of the insured transfer and inversely on the payment probability. The insurer creates value for the seller by engaging in buyer screening itself, thereby reducing the share of myopic buyers in the population and – vice versa – increasing the probability of buyer payment.³⁰ We augment the above strategy profile by assuming that the trade relationship fails whenever the insurance has to cover for buyer non-payment.

Optimal spot contract design with insurance is largely identical when compared to the open account scenario discussed in Section 3.2. The results of Lemma 2 directly apply and merely trade volumes are adjusted upwards, which is a benefit generated from the insurer's screening activity. In the dynamic context, the seller has available one additional payment term option in every transaction, such that $F_t \in \mathcal{F}^+ \equiv \{\text{A}, \Omega, \text{I}\}$. We obtain the following result on how the availability of insurance affects the set of feasible DOSPCs.

Proposition 4. *Let $F_t \in \mathcal{F}^+$ for all $t \geq 0$. Under the conditions of Proposition 3, it holds that some $F \in \mathcal{F}^D \cup (\text{I}, \Omega, \Omega, \dots) \equiv \mathcal{F}^{D+}$ is the DOSPC.*

Proposition 4 establishes that $F = (\text{I}, \Omega, \Omega, \dots)$ is the only additional sequence that can become dynamically optimal. This is because, first, I-terms are payoff-dominated by Ω -terms at the full information limit and after the initial play of I-terms and, second, the informational benefit from insurer screening is largest in the initial period. Finally, we show that whenever the insurer is sufficiently cost- and/or screening-efficient there exist model configurations in which using the payment sequence $F = (\text{I}, \Omega, \Omega, \dots)$ is in fact dynamically optimal.

³⁰This assumption is endorsed by the fact that trade credit insurers such as Euler Hermes and AIG advertise their insurance services with their expertise in monitoring the reliability of transaction counterparts.

5.2 Private observability of revenue shocks

Next, we summarize our results for the scenario where the realized level of revenue, r_t , is observed privately by the buyer. We allow the buyer to make a non-verifiable revenue report \hat{r}_t to the seller and adjust the revenue realization stage of the game as follows.

1. **Revenue realization.** The level of the revenue shifter $r_{t-1} \in \{r^l, r^h\}$ is realized and privately learned by the buyer. The buyer decides on a non-verifiable revenue report $\hat{r}_{t-1} \in \{r^l, r^h\}$ to the seller. The product shipped in the previous period generates revenue $R(Q_{t-1}, r_{t-1})$ to the buyer from the sale to final consumers.

Under A-terms, the buyer's report is irrelevant for optimal contract design. Since at the contracting and the payment stage both – buyer and seller – do not know the realized revenue level any report is irrelevant for contract design and relationship continuation. Consequently, the analysis does not change when compared to Section 3.

Under Ω -terms, the seller has two options for optimal contract design (cf. [Troya-Martinez, 2013, 2017](#)). On the one side, the contract may contain report-contingent transfers and ensure truthful reporting by punishing low reports adequately. On the other side, it can be optimal to propose a “flat” contract in which the transfer size is independent of reported revenues. A principal challenge in designing the report-contingent contract is to eliminate the buyer's incentive to under-report high revenues strategically. While we find that it is optimal to set transfers and trade volumes as in the public information case the seller addresses the under-reporting problem by suspending trade when low revenues are reported. The length of trade suspension is set to make the patient buyer indifferent between possible reports. It turns out that a high revenue report acts as a credible signal of the patient buyer's type which structurally impacts the seller's dynamic programming problem when compared to Section 3.2. Alternatively, when setting a flat transfer the seller ignores the buyer's liquidity constraint and sets the transfer such that the payment incentive constraint of the patient buyer binds. Comparing the seller's ex-ante expected payoffs of both scenarios gives the following result.

Proposition 5. *Under private information, in any transaction the seller finds it optimal to request a revenue report-independent transfer. Under Ω -terms, incentivizing the buyer to report revenues truthfully is never payoff-maximizing for the seller.*

Proposition 5 implies that the trade-off between relationship stability and stage payoff growth outlined in Section 3.3 applies also to the private information scenario. Without truthtelling

incentivization, the seller’s learning process under Ω -terms is identical to the public information case leading to slower information acquisition as compared to cash in advance.

As a corollary, note that under private information it is optimal to employ the relationship stability-enhancing advantages of Ω -terms only temporarily on the learning path. When the buyer has acquired sufficient type information through repeated interaction, A-terms payoff-dominate Ω -terms. The reason is that the flat stage contract under Ω -terms causes a residual buyer bankruptcy risk. Due to this, the larger stage payoffs under A-terms at the full information limit imply that these are overall more profitable in established relationships when revenue information is private. We conclude that seller trade credit provision in established relationships is more likely when he has reliable buyer revenue information available.

6 Testable predictions

Our analysis rationalizes the empirical patterns on relationship stability and the usage of payment contracts from [Antràs and Foley \(2015\)](#) and [Garcia-Marin et al. \(2020\)](#) as summarized in the introduction. At the same time, we further qualify their empirical results by showing how they rely on the institutional properties of the destination market as well as on the information exchange between trade partners. We summarize the key predictions of our model in the following.

Prediction 1. *A trade relationship (irrespective of its age) is more stable and more likely survives from one transaction to the next when payment is conducted on Ω -terms as compared to A-terms. With a better quality of contract enforcement institutions in the destination market, relationship stability increases under Ω -terms and is unaffected under A-terms.*

In our model, the higher relationship stability under Ω -terms originates from the fact that only under these terms the likelihood of buyer contract compliance benefits from institutional enforcement, and from the repayment flexibility that Ω -terms give the buyer with respect to revenue shocks (as, e.g., implied by variations in final consumer demand). Thereby, we show how shocks and relationship default systematically interact with the choice of payment terms and provide a theoretical micro-foundation to the reduced-form analysis of [Antràs and Foley \(2015\)](#). Relatedly, we provide an argument why even in the absence of a large macroeconomic shock (affecting contract compliance under both, A- and Ω -terms) one should expect larger relationship

discontinuation rates under A-terms.³¹ We find that optimal contract design attenuates the impacts of unanticipated shocks under Ω -terms but does not do so under A-terms.

Building on these patterns, Prediction 1 also underscores that better contract enforcement institutions increase the relationship stability under Ω -terms by constraining the non-payment opportunities for buyers. In contrast, better institutions have no such effect under A-terms. The reason is that advance payment enables the seller to efficiently screen buyers for their reliability and thereby makes institutional contract enforcement redundant. This differential effect of institutional quality remains to be tested in future empirical work.

For a given seller with initial belief θ_0 the model predicts a unique DOSPC. Across individual sellers the ex-ante assessment of the buyer pool is likely heterogeneous and, e.g., does depend on the seller’s experience in the destination market (cf. [Araujo et al., 2016](#)). When the initial beliefs of sellers in an industry are sufficiently dispersed and – in model terms – some sellers do have “moderate” and fixed initial beliefs with $\theta_0 \in (\underline{\theta}_0, \bar{\theta}_0)$, then the model provides the following industry-level predictions.³²

Prediction 2. *When sellers can verify buyer revenue shocks, at the industry level the relative usage of Ω -terms to A-terms increases with the age of trade relationships. When shocks are non-verifiable, the usage of Ω -terms does not increase with relationship age.*

When revenue shocks are public information, in our model the main rationale to increase trade credit provision over time is to strengthen the resilience of relationships to revenue shocks. While this leads to qualitatively comparable predictions on payment term transitions as in [Antràs and Foley \(2015\)](#) the mechanism that underlies the choice dynamics in our model is fundamentally different: In the mentioned paper transitions are generated from the differential efficiency of the banking system in the seller’s and the buyer’s economy. In contrast, we show that the prediction remains valid when abstracting from specific properties of the financial system and institutional differences between countries. We argue that the outlined transitions are a direct consequence of optimal contract design when buyer revenue information is available to the seller.

The transition dynamics described above find empirical support in the transaction-level trade data analyzed in the mentioned papers which underscores the practical relevance of the public

³¹Motivated by the global financial crisis in 2008, the analytical focus of the dynamic model in [Antràs and Foley \(2015\)](#) is on the impact of large macro-level shocks on relationship stability under different payment modes. While demand shocks in their framework reduce seller stage payoffs proportionally and cause relationship breakdown under either payment mode, our findings at the contractual level suggest that the seller’s ability to condition transfer payments on shock outcomes under Ω -terms makes trade relationships systematically more stable under these terms.

³²Prediction 2 follows from combining the theoretical results of Corollary 1 and Section 5.2.

information case of our model. For the markets studied there, our model suggests that sellers are well-aware of the revenue situation of buyers as, e.g., implied by the demand fluctuations of consumers in the local buyer economy. Our model extension in Section 5.2 points out that when sellers cannot verify the buyer’s revenue situation they lose important flexibility to design an incentive-compatible repayment scheme under Ω -terms which makes providing trade credit less attractive. For this case, the model predicts that in established trade relationships sellers will never find it optimal to offer trade credit to their buyers. While the prediction on how information availability and payment term selection in trade relationships interrelate is clear cut in our model, a direct empirical test of Prediction 2 is difficult. Even though controlling for information transmission between firms may be impossible with observational trade data, an experimental setting appears to be a promising avenue to bring our informational predictions to an empirical test.

7 Conclusion

In this paper, we have used external evidence on the usage of payment terms in inter-firm trade relationships to motivate a theoretical analysis on how sellers can employ payment contracts to improve the efficiency of buyer-seller cooperation. We have developed a relational contracting model in which trade volumes and payment terms of transactions are determined endogenously, and buyer payment compliance as well as the enforcement of formal contracts are uncertain. We have shown that pre- and post-shipment payment terms inhibit structurally different learning opportunities for the seller, allowing to address and improve the efficiency of trade relationships. Deciding on whether or not to provide trade credit requires the seller to prioritize between the stability and the profitability of the exchange relationship with a buyer. We have shown that the seller can resolve this trade-off in an optimal way by assessing the distribution of buyer types, based on which new trade relationships are formed.

While it is reassuring that our model can rationalize important empirical evidence on the dynamics of firm payment contract choice (cf. [Antràs and Foley, 2015](#)), the results also suggest that the generality of the usage patterns documented in their work is limited. We have found that only if the seller can obtain reliable information on the revenues that the seller makes from final consumers can it be optimal for him to increase the provision of trade credit over time. Also beyond the topic of payment contracts, this qualifying finding points at the important role that the verifiability of information plays for the structure and evolution of trade patterns and

relationships. While reliable measures on the information transmission between trade partners may be difficult to obtain from observational data, an experimental research setup in the field or the laboratory can offer a fruitful approach to bring our predictions to an empirical test.

While for the largest part of this paper the analysis has focused on the non-intermediated payment modes of cash in advance and open account, trade finance products provided by banks and insurance firms are also of practical relevance (cf. [Niepmann and Schmidt-Eisenlohr, 2017](#)). Our paper incorporates external forms of trade finance into the discussion by analyzing and identifying the impact of trade credit insurance on the dynamically optimal choice of payment contracts. While we show that the main mechanisms of our model are robust to the availability of such an insurance, a promising avenue for future research is to further explore the micro-foundations of other relevant types of external trade finance such as letters of credit and documentary collections in a dynamic contracting framework.

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A Theoretical appendix

A.1 Proofs and further derivations

Proof of Lemma 1

At the Production and Shipment stage (6) of any period the seller will not deviate from the contract if and only if (IC_S) holds. The seller's incentive constraint ensures that making the effort to produce the contracted output plus the continuation payoff from the current relationship with a patient buyer results in a higher payoff than deviating by not producing and shipping the agreed quantity Q^A . In this latter case the current relationship breaks down and one with a new buyer is started in the following period. Plugging explicit values for V_0^A and V_1^A into (IC_S) and simplifying gives:

$$-cQ^A + \delta_S \frac{(1 - \theta_0 + \gamma\theta_0(1 - \delta_S))\bar{\pi}^A}{(1 - \delta_S)(1 - \gamma\theta_0\delta_S)} \geq \delta_S \frac{(1 - \theta_0)\bar{\pi}^A}{(1 - \delta_S)(1 - \gamma\theta_0\delta_S)}. \quad (\text{A.1})$$

Observing that $cQ^A = \bar{\pi}^A(1 - \alpha)/\alpha$ we can simplify (A.1) to:

$$\delta_S \geq \frac{1 - \alpha}{\gamma\theta_0} \equiv \tilde{\delta}_S. \quad (\text{A.2})$$

For an equilibrium to exist we need to ensure that $\tilde{\delta}_S < 1$. This is the case whenever:

$$\alpha > 1 - \gamma\theta_0 \equiv \tilde{\alpha} \in (0, 1) \quad (\text{A.3})$$

holds. In this situation, the non-production deviation of the seller can be ruled if he is patient enough, i.e. when $\delta_S \geq \tilde{\delta}_S$ holds. ■

Proof of Lemma 2

In the following, we determine the transfer levels $\{T_t^{\Omega,l}, T_t^{\Omega,h}\}$ that maximize the seller's stage payoffs (and thereby also his ex-ante expected payoffs). In general, the seller chooses $\{Q_t^\Omega, T_t^{\Omega,l}, T_t^{\Omega,h}\}$ such that the stage payoffs in (4) are maximized, subject to (LC_t^l), (LC_t^h), (IC_{B,t}^{Ω,l}), and (IC_{B,t}^{Ω,h}). Clearly, the liquidity constraints ensure that (PC_{B,t}^Ω) holds as well.

First, note that the seller's stage payoffs increase in both $T_t^{\Omega,l}$ and $T_t^{\Omega,h}$. We can start by requiring that (LC_t^l) binds and set $T_t^{\Omega,l} = R(Q_t, r^l) \approx 0$. This simplifies (IC_{B,t}^{Ω,h}) to:

$$-T_t^{\Omega,h} + \frac{\delta_B \gamma}{1 - \delta_B(1 - \gamma)} R(Q_t) \geq 0. \quad (\text{A.4})$$

Observe that the maximal value of $T_t^{\Omega,h}$ for which both, (A.4) and (LC_t^h), hold is the point where (A.4) binds with equality. Hence, the seller will set $T_t^{\Omega,h} = \delta_B \gamma / (1 - \delta_B(1 - \gamma)) R(Q_t)$ to extract the maximal amount of rents.

A comparison of (IC_{B,t}^{Ω,l}), and (IC_{B,t}^{Ω,h}) reveals that $T_t^{\Omega,h} \geq T_t^{\Omega,l}$ must hold in order for all constraints of the maximization problem to be satisfied. This is always the case. ■

A rationale for avoiding buyer bankruptcy under cash in advance

Alternative to the case discussed in Section 3.1 where the seller lets the patient buyer go bankrupt after a low revenue shock, he can decide to repay the transfer $T_t^A = \delta_B R(Q^A, r_E) = \bar{\pi}^A / \alpha$ to the buyer and thereby save her from bankruptcy. When repaying the buyer, the seller's expected payoff at the point when the shock occurs can be obtained from the following programming problem:

$$\begin{aligned} V_0^{A,r} &= -\alpha^{-1} \bar{\pi}^A + \bar{\pi}^A + \delta_S [\gamma V_1^{A,r} + (1 - \gamma) V_0^{A,r}], \\ V_1^{A,r} &= \bar{\pi}^A + \delta_S [\gamma V_1^{A,r} + (1 - \gamma) V_0^{A,r}]. \end{aligned}$$

Note that if the seller repays in one period he repays in all periods where a shock occurs since the problem is fully stationary. Solving the problem for $V_0^{A,r}$ gives:

$$\Pi^{A,r} = \frac{1 - \alpha^{-1}(1 - \delta_S \gamma)}{(1 - \delta_S)} \bar{\pi}^A.$$

Hence, in any period under the payment sequence (A,...) the seller prefers to let the patient buyer go bankrupt instead of keeping him in the relationship by repaying the transfer if and only if:

$$\Pi^A > \Pi^{A,r} \quad \Leftrightarrow \quad \theta_0 < \frac{1}{\alpha + \delta_S \gamma} \equiv \underline{\theta}_0^*.$$

Intuitively, when there are not too many myopic buyers in the population re-matching to a new one is more profitable for the seller than keeping the current patient buyer as maintaining the buyer's liquidity is costly.

Derivation of the ex-ante expected payoffs Π^Ω

This appendix complements the analysis of the main text by providing a non-recursive expression of the seller's ex-ante expected payoffs under open account terms. We proceed in two steps. First, we rewrite the period t -version of equation (5) by repeatedly substituting in the value functions of all subsequent periods. Second, we solve the resulting equation for period $t = 0$. By substituting in, we can rewrite (5) to:

$$V_t^\Omega = \bar{\pi}^\Omega \left[\Lambda_t^{\frac{1}{\alpha}} + \sum_{i=t+1}^{\infty} \delta_S^{i-t} \Lambda_i^{\frac{1}{\alpha}} \prod_{j=t}^{i-1} \Lambda_j \right] + V_0^\Omega \left[\delta_S (1 - \Lambda_t) + \sum_{i=t}^{\infty} \delta_S^{i-t+2} (1 - \Lambda_{i+1}) \prod_{j=t}^i \Lambda_j \right]. \quad (\text{A.5})$$

Observing that $\prod_{j=t}^i \Lambda_j = (1 - \theta_0(1 - \lambda^{i+1})) / (1 - \theta_0(1 - \lambda^t))$, we can simplify (A.5) to:

$$V_t^\Omega = \frac{1}{1 - \theta_0(1 - \lambda^t)} \left[\bar{\pi}^\Omega \sum_{i=t}^{\infty} \delta_S^{i-t} \Lambda_i^{\frac{1}{\alpha}} (1 - \theta_0(1 - \lambda^i)) + \delta_S V_0^\Omega \left(\frac{\theta_0 \lambda^t (1 - \lambda)}{1 - \lambda \delta_S} \right) \right]. \quad (\text{A.6})$$

Now suppose that $t = 0$. Solving the resulting version of (A.6) for V_0^Ω gives:

$$\Pi^\Omega = \frac{1 - \lambda \delta_S}{1 - \delta_S(\theta_0 + (1 - \theta_0)\lambda)} \bar{\pi}^\Omega \sum_{t=0}^{\infty} \delta_S^t \Lambda_t^{\frac{1}{\alpha}} (1 - \theta_0(1 - \lambda^t)).$$

Proof of Proposition 3

For the proof, we re-express the value functions in (2) and (5) to introduce additional notation allowing us to distinguish more explicitly between the current period belief θ_t , $t \geq 0$, and the initial period belief θ_0 . For payment contract type $i \in \mathcal{F}$ we denote the corresponding value function applicable in period t of the trade relationship as $V_t^i(\theta_t, \theta_0)$ in the following. We have:

$$\begin{aligned} V_t^A(\theta_t, \theta_0) &= (1 - \theta_t)\bar{\pi}^A + \delta_S [\gamma(1 - \theta_t)V_{t+1}(0, \theta_0) + (1 - \gamma(1 - \theta_t))V_{t+1}(\theta_0, \theta_0)], \\ V_t^\Omega(\theta_t, \theta_0) &= \pi_t^\Omega + \delta_S [(1 - \theta_t(1 - \lambda))V_{t+1}(\theta_{t+1}^\Omega, \theta_0) + \theta_t(1 - \lambda)V_{t+1}(\theta_0, \theta_0)], \end{aligned} \quad (\text{A.7})$$

where $V_t(\theta_t, \theta_0) \in \{V_t^A(\theta_t, \theta_0), V_t^\Omega(\theta_t, \theta_0)\}$. When the seller is interested in setting the DOSPC, for every belief θ_t in any period $t \geq 0$ he sets $F_t \in \mathcal{F}$ such that $V_t(\theta_t, \theta_0) = \max\{V_t^A(\theta_t, \theta_0), V_t^\Omega(\theta_t, \theta_0)\}$. In the following steps, we derive conditions ensuring that \mathcal{F}^D represents the full set of possible DOSPCs.

Step 1: For limiting initial beliefs, $\theta_0 \rightarrow 0$ and $\theta_0 \rightarrow 1$, we show that only $F_t = (A, \dots)$ and $F_t = (\Omega, \dots)$, respectively, can be dynamically optimal.

First, consider the situation where $\theta_0 \rightarrow 1$. We get $\lim_{\theta_0 \rightarrow 1} V_t^\Omega(\theta_t, \theta_0) = \lambda^{\frac{1}{\alpha}} \bar{\pi}^\Omega / (1 - \delta_S) > \lim_{\theta_0 \rightarrow 1} V_t^A(\theta_t, \theta_0) = 0$. Since the value function expressions are independent of θ_t , it follows that $F_t = (\Omega, \dots)$ is optimal in this case. Next, consider the situation where $\theta_0 \rightarrow 0$. This gives:

$$\lim_{\theta_0 \rightarrow 0} V_t^\Omega(\theta_t, \theta_0) = \left(\frac{\delta_S \gamma}{1 - \delta_B(1 - \gamma)} \right)^{\frac{1}{\alpha}} \frac{\bar{\pi}^A}{1 - \delta_S} < \lim_{\theta_0 \rightarrow 0} V_t^A(\theta_t, \theta_0) = \frac{\bar{\pi}^A}{1 - \delta_S}.$$

Again, by the independence of the expressions of θ_t , it follows that $F_t = (A, \dots)$ must be optimal.

Step 2: We show that if the seller is sufficiently patient the only additional payment sequence that can become dynamically optimal is $F_t = (A, \Omega, \Omega, \dots)$.

From Step 1, we know that both, A- and Ω -terms can be optimal in the initial period. First, let us consider the case where A-terms are chosen initially ($F_0 = A$). Then, due to the separating nature of the optimal stage contract under these terms the game reaches the full information limit in the following period given that the relationship continues. Since at this limit the game reaches an absorbing state the payment contract that is optimal in $t = 1$ is also optimal in all further periods. As a consequence, the only payment contract sequences that can become optimal when $F_0 = A$ are (A, \dots) and $(A, \Omega, \Omega, \dots)$. At the contracting stage in $t = 1$, the seller chooses the payment terms $F_1 \in \{A, \Omega\}$ by comparing the following value functions:

$$V_1^A(0, \theta_0) = \frac{(1 - \delta_S \theta_0) \bar{\pi}^A}{(1 - \delta_S)(1 - \delta_S \gamma \theta_0)} \quad \text{and} \quad V_1^\Omega(0, \theta_0) = \left(\frac{\delta_S \gamma}{1 - \delta_B(1 - \gamma)} \right)^{\frac{1}{\alpha}} \frac{\bar{\pi}^A}{1 - \delta_S},$$

and will prefer Ω -terms over A-terms in all periods $t > 0$ if and only if:

$$V_1^\Omega(0, \theta_0) > V_1^A(0, \theta_0) \quad \Leftrightarrow \quad \theta_0 > \frac{1 - \left(\frac{\delta_S \gamma}{1 - \delta_B(1 - \gamma)} \right)^{\frac{1}{\alpha}}}{\delta_S \left(1 - \gamma \left(\frac{\delta_S \gamma}{1 - \delta_B(1 - \gamma)} \right)^{\frac{1}{\alpha}} \right)} \equiv \underline{\theta}_0.$$

Clearly, $\underline{\theta}_0 > 0$. Moreover, since $\partial \underline{\theta}_0 / \partial \delta_S < 0$ and $\lim_{\delta_S \rightarrow 1} \underline{\theta}_0 < 1$, there exists $\delta'_S \in (0, 1)$ such that $\underline{\theta}_0 \in (0, 1)$ holds for all $\delta_S > \delta'_S$.

Second, consider the case where Ω -terms are chosen initially ($F_0 = \Omega$), in which case the seller's belief is updated according to Bayes' rule when the initial transaction is successful and $\theta_1 = \theta_1^\Omega$. In the following, we show that whenever it is optimal to choose Ω -terms initially, it is never optimal to switch to A-terms in a later transaction. This establishes that the DOSPC is $F = (\Omega, \dots)$ in this case.

For the following arguments we first need to establish the comparative statics of the value functions with respect to the current period belief θ_t . Observe that the flow payoffs in both value functions in (A.7) are decreasing in θ_t . From this it directly follows that $\partial V_t^A(\theta_t, \theta_0)/\partial \theta_t < 0$ and $\partial V_t^\Omega(\theta_t, \theta_0)/\partial \theta_t < 0$. Moreover, the flow payoffs under A-terms and (due to the immediate buyer separation under A-terms) also $V_t^A(\theta_t, \theta_0)$ are linear in θ_t and, hence, $\partial^2 V_t^A(\theta_t, \theta_0)/\partial \theta_t^2 = 0$. In contrast, observe that:

$$\frac{\partial^2 V_t^\Omega(\theta_t, \theta_0)}{\partial \theta_t^2} = \frac{(1-\alpha)(1-\lambda)^2 \pi_t^\Omega}{\alpha^2 \Lambda_t^2} - 2(1-\lambda)\delta_S \frac{\partial V_{t+1}(\theta_{t+1}^\Omega, \theta_0)}{\partial \theta_t} + \delta_S \Lambda_t \frac{\partial^2 V_{t+1}(\theta_{t+1}^\Omega, \theta_0)}{\partial \theta_t^2}, \quad (\text{A.8})$$

where $\text{sgn}(\partial V_{t+1}(\theta_{t+1}^\Omega, \theta_0)/\partial \theta_t) = \text{sgn}(\partial V_{t+1}(\theta_{t+1}^\Omega, \theta_0)/\partial \theta_{t+1}) = -1$ since $\partial \theta_{t+1}^\Omega/\partial \theta_t > 0$. Moreover, we conclude that $\partial^2 V_{t+1}(\theta_{t+1}^\Omega, \theta_0)/\partial \theta_t^2 \geq 0$ using a case distinction: When A-terms are chosen in $t+1$, we have $\partial^2 V_{t+1}^A(\theta_{t+1}^\Omega, \theta_0)/\partial \theta_t^2 = 0$. When Ω -terms are chosen in $t+1$, it follows from $\partial \theta_{t+1}^\Omega/\partial \theta_t > 0$ and $\partial^2 \theta_{t+1}^\Omega/\partial \theta_t^2 > 0$ that $\text{sgn}(\partial^2 V_{t+1}^\Omega(\theta_{t+1}^\Omega, \theta_0)/\partial \theta_t^2) = \text{sgn}(\partial^2 V_{t+1}^\Omega(\theta_{t+1}^\Omega, \theta_0)/\partial \theta_{t+1}^2)$. Also note that at $\theta_t = 0$, we have:

$$\frac{\partial^2 V_t^\Omega(0, \theta_0)}{\partial \theta_t^2} = \frac{1}{1-\delta_S} \left[\frac{(1-\alpha)(1-\lambda)^2 \pi^\Omega}{\alpha^2} - 2(1-\lambda)\delta_S \frac{\partial V_{t+1}^\Omega(0, \theta_0)}{\partial \theta_t} \right] > 0.$$

Since the first two addends in (A.8) are positive for all $\theta_t \in [0, 1)$ it follows from the above observations that $\partial^2 V_{t+1}(\theta_{t+1}^\Omega, \theta_0)/\partial \theta_t^2 > 0$ in the present case. Hence, $\partial^2 V_t^\Omega(\theta_t, \theta_0)/\partial \theta_t^2 > 0$ holds.

From the limit properties derived in Step 1 it follows, that there exists a neighborhood of initial beliefs around the limit belief $\theta_0 \rightarrow 1$ for which $V_0^\Omega(\theta_0, \theta_0) > V_0^A(\theta_0, \theta_0)$ holds, i.e. Ω -terms are chosen initially. Consider now any such level of the initial belief θ_0 . In this situation, the seller evaluates the comparatively small learning gains available under Ω -terms (and as prescribed by updating rule θ_1^Ω) as preferable to the type-separation outcome under A-terms (in which case $\theta_1 = 0$). Together with the facts that $V_t^A(\theta_t, \theta_0)$ decreases linearly in θ_t and that $V_t^\Omega(\theta_t, \theta_0)$ is decreasing and strictly convex in θ_t it follows that $V_t^\Omega(\theta_t, \theta_0) > V_t^A(\theta_t, \theta_0)$ holds also for all $t > 0$ in this situation. Hence, $F = (\Omega, \dots)$ must be optimal. As an intermediate result, it follows that $F \in \mathcal{F}^D$ for all $\delta_S > \delta'_S$.

Step 3: Managing the buyer bankruptcy risk for sequences $F = (A, \dots)$ and $F = (A, \Omega, \Omega, \dots)$.

Whenever a contract C_t is accepted on A-terms in the context of sequences $F = (A, \dots)$ or $F = (A, \Omega, \Omega, \dots)$ the seller learns that the buyer is patient and therefore may want to save her from bankruptcy when $r_t = r^l$. In the following, we show that when the seller is sufficiently patient and can freely select the payment terms of every transaction it is never optimal to save the buyer under sequence (A, \dots) . This stands in contrast to the seller's choice for sequence $(A, \Omega, \Omega, \dots)$ where saving the buyer can be optimal when θ_0 is high.

First, let us consider the scenario where $F = (A, \dots)$ is optimal. We have shown in this Appendix that the seller prefers re-matching to a new buyer instead of saving the current buyer from bankruptcy if and only if $\theta_0 < \underline{\theta}_0^* = 1/(\alpha + \delta_S \gamma)$. Acknowledging the results of Step 2, the seller lets the buyer go bankrupt for all relevant model parametrizations if and only if $\underline{\theta}_0^* > \underline{\theta}_0$. Noting that $\partial \underline{\theta}_0^* / \partial \delta_S < 0$, $\partial \underline{\theta}_0 / \partial \delta_S < 0$ and $\lim_{\delta_S \rightarrow 1} \underline{\theta}_0^* > \lim_{\delta_S \rightarrow 1} \underline{\theta}_0$ we conclude that there exists $\delta_S^r \in [0, 1)$ such that $\underline{\theta}_0^* > \underline{\theta}_0$ for all $\delta_S > \delta_S^r$.

Next, let us continue with the case where $F = (A, \Omega, \Omega, \dots)$. Under the assumption of letting the buyer go bankrupt when $r_0 = r^l$, we can derive the seller's ex-ante expected payoffs from solving the following recursion for $V_0^{A\Omega}$:

$$V_0^{A\Omega} = (1 - \theta_0)\bar{\pi}^A + \delta_S [\gamma(1 - \theta_0)V_1^{A\Omega} + (1 - \gamma(1 - \theta_0))V_0^{A\Omega}], \quad V_1^{A\Omega} = \frac{\bar{\pi}^\Omega}{1 - \delta_S}.$$

The solution is:

$$\Pi^{A\Omega} = \frac{(1 - \theta_0)(\delta_S \gamma \bar{\pi}^\Omega + (1 - \delta_S)\bar{\pi}^A)}{(1 - \delta_S)(1 - \delta_S(1 - \gamma(1 - \theta_0)))}.$$

Suppose now that $r_0 = r^l$ and consider the seller's decision at the beginning of period $t = 1$ whether or not to let the buyer go bankrupt. When saving the buyer, the seller's current period expected payoffs are:

$$\Pi^{A\Omega, r} = -\frac{\bar{\pi}^A}{\alpha} + \frac{\bar{\pi}^\Omega}{1 - \delta_S},$$

and the seller prefers to re-match to a new buyer if and only if:

$$\begin{aligned} \Pi^{A\Omega} > \Pi^{A\Omega, r} &\Leftrightarrow \bar{\pi}^A \left(\frac{1 - \theta_0}{1 - \delta_S(1 - \gamma(1 - \theta_0))} + \frac{1}{\alpha} \right) > \frac{\bar{\pi}^\Omega}{1 - \delta_S(1 - \gamma(1 - \theta_0))} \\ &\Leftrightarrow \theta_0 < \frac{1}{\alpha + \delta_S \gamma} \left[\alpha \left(1 - \left(\frac{\delta_S \gamma}{1 - \delta_S(1 - \gamma)} \right)^{\frac{1}{\alpha}} \right) + 1 - \delta_S(1 - \gamma) \right] \equiv \underline{\theta}_0^{**}. \end{aligned}$$

Let us now compare the thresholds $\underline{\theta}_0^{**}$ and $\underline{\theta}_0$. We have $\partial \underline{\theta}_0 / \partial \delta_S < 0$, $\lim_{\delta_S \rightarrow 0} \underline{\theta}_0 = \infty$, $\lim_{\delta_S \rightarrow 1} \underline{\theta}_0 = (1 - \tilde{x}) / (1 - \gamma \tilde{x}) \in (0, 1)$ as well as $\partial \underline{\theta}_0^{**} / \partial \delta_S < 0$, $\lim_{\delta_S \rightarrow 0} \underline{\theta}_0^{**} = (1 + \alpha) / \alpha > 1$ and

$$\lim_{\delta_S \rightarrow 1} \underline{\theta}_0^{**} = \frac{\alpha(1 - \tilde{x}) + \gamma}{\alpha + \gamma} \in (0, 1), \quad \text{where} \quad \tilde{x} = \left(\frac{\gamma}{1 - \delta_S(1 - \gamma)} \right)^{\frac{1}{\alpha}} \in (0, 1).$$

Moreover observing that:

$$\lim_{\delta_S \rightarrow 1} \underline{\theta}_0^{**} > \lim_{\delta_S \rightarrow 1} \underline{\theta}_0 \Leftrightarrow \hat{x} \equiv \alpha(\tilde{x} - 1) + 1 - \gamma > 0,$$

noting that $\partial \hat{x} / \partial \alpha < 0$, and $\lim_{\alpha \rightarrow 1} \hat{x} = \delta_B(1 - \gamma)\gamma / (1 - \delta_B(1 - \gamma)) > 0$ we can safely conclude that there exists a unique $\delta_S^{rr} \in (0, 1)$ such that $\underline{\theta}_0^{**} > \underline{\theta}_0$ for all $\delta_S > \delta_S^{rr}$. In this situation, whenever the sequence $F = (A, \Omega, \Omega, \dots)$ is employed the seller does not save an illiquid patient buyer from bankruptcy in the initial transaction when his initial belief of facing a myopic type is relatively low (i.e., when $\theta_0 \in (\underline{\theta}_0, \underline{\theta}_0^{**})$). In contrast, when the belief is high ($\theta_0 > \underline{\theta}_0^{**}$) the seller prefers to save the buyer after a successful initial transaction. The trade-off at work in this decision is fully equivalent to that of the sequence $F = (A, \dots)$ discussed in Section 3.1.

For later use, let us note that the seller's ex-ante expected payoff at $t = 0$ for sequence

$(A, \Omega, \Omega, \dots)$ conditional saving the patient buyer after a liquidity shock in the initial transaction are:

$$\Pi^{A\Omega, s} = \frac{1 - \theta_0}{1 - \delta_S \theta_0} \left[\left(1 - \frac{\delta_S(1 - \gamma)}{\alpha} \right) \bar{\pi}^A + \frac{\delta_S}{1 - \delta_S} \bar{\pi}^\Omega \right].$$

Step 4: The non-shipment deviation for sequence $F = (A, \Omega, \Omega, \dots)$.

Remains to rule out the non-shipment deviation for the seller under the payment sequence $F = (A, \Omega, \Omega, \dots)$ (analogy to Lemma 1). A deviation by the seller by not procuring the product in the initial transaction on A-terms is ruled out if and only if:

$$-cQ^A + \delta_S V_1^{A\Omega} \geq \delta_S V_0^{A\Omega} \quad \Leftrightarrow \quad \Gamma_1 \equiv \left(\frac{\delta_S \gamma}{1 - \delta_B(1 - \gamma)} \right)^{\frac{1}{\alpha}} - (1 - \theta_0) \geq \frac{(1 - \alpha)(1 - \delta_S(1 - \gamma(1 - \theta_0)))}{\alpha \delta_S} \equiv \Gamma_2.$$

We want to derive parameter requirements such that $\Gamma_1 \geq \Gamma_2$ holds. First, note that $\partial \Gamma_2 / \partial \alpha < 0$, $\partial^2 \Gamma_2 / \partial \alpha^2 > 0$, $\lim_{\alpha \rightarrow 0} \Gamma_2 = \infty$ and $\lim_{\alpha \rightarrow 1} \Gamma_2 = 0$. Second, note that $\partial \Gamma_1 / \partial \alpha > 0$ and $\lim_{\alpha \rightarrow 0} \Gamma_1 = -(1 - \theta_0)$. Hence there exists a unique $\tilde{\alpha}^o \in (0, 1)$ such that $\Gamma_1 \geq \Gamma_2$ for all $\alpha > \tilde{\alpha}^o$ if and only if:

$$\lim_{\alpha \rightarrow 1} \Gamma_1 > 0 \quad \Leftrightarrow \quad \delta_S > \gamma^{-1}(1 - \theta_0)(1 - \delta_B(1 - \gamma)) \equiv \tilde{\delta}_S^o.$$

We need to ensure that $\tilde{\delta}_S^o \in (0, 1)$. This is the case if and only if:

$$\delta_B > \frac{1 - \theta_0 - \gamma}{(1 - \theta_0)(1 - \gamma)} \equiv \underline{\delta}_B \in (0, 1). \quad (\text{A.9})$$

We conclude that the non-shipment deviation under the sequence $F = (A, \Omega, \Omega, \dots)$ is ruled out whenever $\alpha > \tilde{\alpha}^o$, $\delta_S > \tilde{\delta}_S^o$ and $\delta_B > \underline{\delta}_B$ hold.

Step 5: Summary of the parameter constraints.

Let us summarize all the parameter requirements that we derived above and in Lemma 1 which allow us to conclude that $F \in \mathcal{F}^D$. Besides $\delta_B > \underline{\delta}_B$, the constraints are:

$$\begin{aligned} \alpha &> \max\{\tilde{\alpha}, \tilde{\alpha}^o\} \equiv \underline{\alpha} \in (0, 1), \\ \delta_S &> \max\{\tilde{\delta}_S, \tilde{\delta}_S^o, \delta'_S, \delta_S^r, \delta_S^{rr}\} \equiv \underline{\delta}_S \in (0, 1). \quad \blacksquare \end{aligned} \quad (\text{A.10})$$

Proof of Corollary 1

We begin by deriving essential comparative statics of the ex-ante expected payoff functions. First, let us compare the limit properties with respect to the initial belief θ_0 . Observe that $\lim_{\theta_0 \rightarrow 1} \Pi^{A\Omega} = \lim_{\theta_0 \rightarrow 1} \Pi^{A\Omega, s} = \lim_{\theta_0 \rightarrow 1} \Pi^A = 0 < \lim_{\theta_0 \rightarrow 1} \Pi^\Omega = \lambda^{\frac{1}{\alpha}} \bar{\pi}^\Omega / (1 - \delta_S)$. Moreover, we have:

$$\lim_{\theta_0 \rightarrow 0} \Pi^{A\Omega} = \frac{\gamma \delta_S \bar{\pi}^\Omega + (1 - \delta_S) \bar{\pi}^A}{(1 - \delta_S)(1 - \delta_S(1 - \gamma))}, \quad \lim_{\theta_0 \rightarrow 0} \Pi^A = \frac{\bar{\pi}^A}{1 - \delta_S}, \quad \lim_{\theta_0 \rightarrow 0} \Pi^\Omega = \frac{\bar{\pi}^\Omega}{1 - \delta_S},$$

for which holds $\lim_{\theta_0 \rightarrow 0} \Pi^A > \lim_{\theta_0 \rightarrow 0} \Pi^{A\Omega} > \lim_{\theta_0 \rightarrow 0} \Pi^\Omega$. Next, we derive essential functional properties of Π^A , $\Pi^{A\Omega}$, $\Pi^{A\Omega,s}$, and Π^Ω . We get:

$$\begin{aligned}\frac{\partial \Pi^A}{\partial \theta_0} &= -\frac{(1-\delta_S\gamma)\bar{\pi}^A}{(1-\delta_S)(1-\delta_S\gamma\theta_0)^2} < 0, & \frac{\partial^2 \Pi^A}{\partial \theta_0^2} &= -\frac{2\delta_S\gamma(1-\delta_S\gamma)\bar{\pi}^A}{(1-\delta_S)(1-\delta_S\gamma\theta_0)^3} < 0, \\ \frac{\partial \Pi^{A\Omega}}{\partial \theta_0} &= -\frac{(1-\delta_S)\bar{\pi}^A + \delta_S\gamma\bar{\pi}^\Omega}{(1-\delta_S + \delta_S\gamma(1-\theta_0))^2} < 0, & \frac{\partial^2 \Pi^{A\Omega}}{\partial \theta_0^2} &= -\frac{2\delta_S\gamma[(1-\delta_S)\bar{\pi}^A + \delta_S\gamma\bar{\pi}^\Omega]}{(1-\delta_S + \delta_S\gamma(1-\theta_0))^3} < 0, \\ \frac{\partial \Pi^{A\Omega,s}}{\partial \theta_0} &= \frac{-(1-\delta_S)}{(1-\delta_S\theta_0)^2} \left[\frac{\alpha - \delta_S(1-\gamma)}{\alpha} \bar{\pi}^A + \frac{\delta_S}{1-\delta_S} \bar{\pi}^\Omega \right] < 0, \\ \frac{\partial^2 \Pi^{A\Omega,s}}{\partial \theta_0^2} &= \frac{-2\delta_S(1-\delta_S)}{(1-\delta_S\theta_0)^3} \left[\frac{\alpha - \delta_S(1-\gamma)}{\alpha} \bar{\pi}^A + \frac{\delta_S}{1-\delta_S} \bar{\pi}^\Omega \right] < 0.\end{aligned}$$

From these arguments, part (a) of the Corollary follows: On the one side, note that for sufficiently small (respectively high) values of θ_0 , $F = (A, \dots)$ (respectively $F = (\Omega, \dots)$) is payoff-maximizing for the seller. As established in the proof of Proposition 3, also observe that:

$$\Pi^{A\Omega} > \Pi^A \quad \Leftrightarrow \quad \theta_0 > \underline{\theta}_0 \in (0, 1).$$

From this we can also conclude that (Ω, \dots) is never optimal for any $\theta_0 < \underline{\theta}_0$. Clearly, due to the limit properties of the payoff functions for $\theta_0 \rightarrow 1$, only (Ω, \dots) can be optimal in this case.

For part (b) of the Corollary, we need to establish an additional regularity condition to ensure that Π^Ω is decreasing and concave in θ_0 as well. These conditions ensure existence of a unique $\bar{\theta}_0 \in (\underline{\theta}_0, 1)$ such that $\max\{\Pi^{A\Omega}, \Pi^{A\Omega,s}\} > \max\{\Pi^A, \Pi^\Omega\}$ for all $\theta_0 \in (\underline{\theta}_0, \bar{\theta}_0)$ and $\Pi^\Omega > \max\{\Pi^A, \Pi^{A\Omega}, \Pi^{A\Omega,s}\}$ for all $\theta_0 > \bar{\theta}_0$. Due to the complex geometric series expression in (6) we proceed showing concavity of Π^Ω in two steps. First, we analytically derive two parameter conditions on every element of the payoff series that alone ensure the desired functional property of Π^Ω . Since these constraints turn out overly restrictive, in a second step we show in a numerical simulation that one of the two constraints does not bind when looking at the payoff series as a whole. Overall, we argue that only the constraint $\alpha > \bar{\alpha}$ stated in the Corollary is necessary to ensure concavity.

To proceed, let us define $\Pi^\Omega = \sum_{t=0}^{\infty} \Pi_t^\Omega$, where:

$$\Pi_t^\Omega \equiv \frac{(1-\lambda\delta_S)(1-\theta_0(1-\lambda^t))}{1-\delta_S(\theta_0 + (1-\theta_0)\lambda)} \delta_S^t \Lambda_t^{\frac{1}{\alpha}} \bar{\pi}^\Omega.$$

We have:

$$\frac{\partial \Pi_t^\Omega}{\partial \theta_0} < 0 \quad \Leftrightarrow \quad (1-\lambda)\lambda^t(1-\delta_S\lambda - \delta_S\theta_0(1-\lambda)) + \alpha(1-\delta_S - \lambda^t(1-\delta_S\lambda))(1-\theta_0(1-\lambda^{t+1})) > 0,$$

which holds for every element of the payoff series and every value of α if and only if:

$$\xi \equiv \delta_S(1+\lambda) - 1 < 0. \tag{A.11}$$

Moreover, we have:

$$\begin{aligned} \frac{\partial^2 \Pi_t^\Omega}{\partial \theta_0^2} < 0 &\Leftrightarrow K \equiv \frac{1-\alpha}{\alpha} \Delta - 2\delta_S(1-\lambda)[E + \alpha Z] < 0, \\ \text{where } \Delta &\equiv \frac{(1-\delta_S\lambda - \delta_S\theta_0(1-\lambda))^2(1-\lambda)\lambda^t}{(1-\theta_0(1-\lambda^{t+1}))^2(1-\theta_0(1-\lambda^t))} > 0, \quad E \equiv \frac{(1-\delta_S\lambda - \delta_S\theta_0(1-\lambda))(1-\lambda)\lambda^t}{(1-\theta_0(1-\lambda^{t+1}))} > 0, \\ \text{and } Z &\equiv 1 - \delta_S - \lambda^t(1 - \delta_S\lambda). \end{aligned}$$

When $\xi < 0$ holds, we have $Z > 0$ and hence $\partial K / \partial \alpha < 0$ with $\lim_{\alpha \rightarrow 1} K < 0$ and $\lim_{\alpha \rightarrow 0} K = \infty$. This implies existence of a unique $\alpha^* \in (0, 1)$ such that Π_t^Ω is concave for all $\alpha > \alpha^*$. By definition, it follows that Π^Ω is decreasing and concave under conditions (A.11) and $\alpha > \alpha^*$ as well.

In the next step, we show by simulation that constraint (A.11) is a relict that results from considering single payoff series elements in isolation and that disappears when numerically approximating the derivative of the full payoff series. To proceed, let us define:

$$\Pi^{\Omega:k:l} \equiv \sum_{t=0}^k \frac{\partial^l \Pi_t^\Omega}{\partial \theta_0^l},$$

which is the l th derivative of Π^Ω when considering the first k elements of the payoff series.

Figure A.1 illustrates that the constraint $\xi < 0$ (representing a joint upper bound on parameters δ_S and λ) loses all its relevance when more and more elements of the payoff series are included. The figure depicts in color the parameter combinations for which the derivatives of Π^Ω are negative. As k increases the upper bound below which this property of the derivatives holds moves to the North-East corner of the respective figure indicating that $\partial^l \Pi^\Omega / \partial \theta_0^l < 0$, $l = 1, 2$, also for large values of δ_S and λ . Note that we conducted the simulation over the entire value ranges of parameters θ_0 and α and the result are qualitatively unvaried throughout.

Moreover, note from Figure A.1b that for Π^Ω to be concave the seller must be sufficiently patient, i.e. δ_S must be larger than $\underline{\xi}$. Additional simulations show that – in the figure – $\underline{\xi}$ moves to the left with α increasing and when $\alpha \rightarrow 1$ the constraint vanishes. This is consistent with the analytical property derived for $\partial^2 \Pi_t^\Omega / \partial \theta_0^2$ and reinforces our claim that for sufficiently high values of α the payoff function Π^Ω is in fact concave.

In sum, we conclude that whenever $\alpha > \max\{\underline{\alpha}, \alpha^*\} \equiv \bar{\alpha}$ part (b) of the Corollary applies and the parameter thresholds $\underline{\theta}_0$ and $\bar{\theta}_0$ uniquely pin down the DOSPC. ■

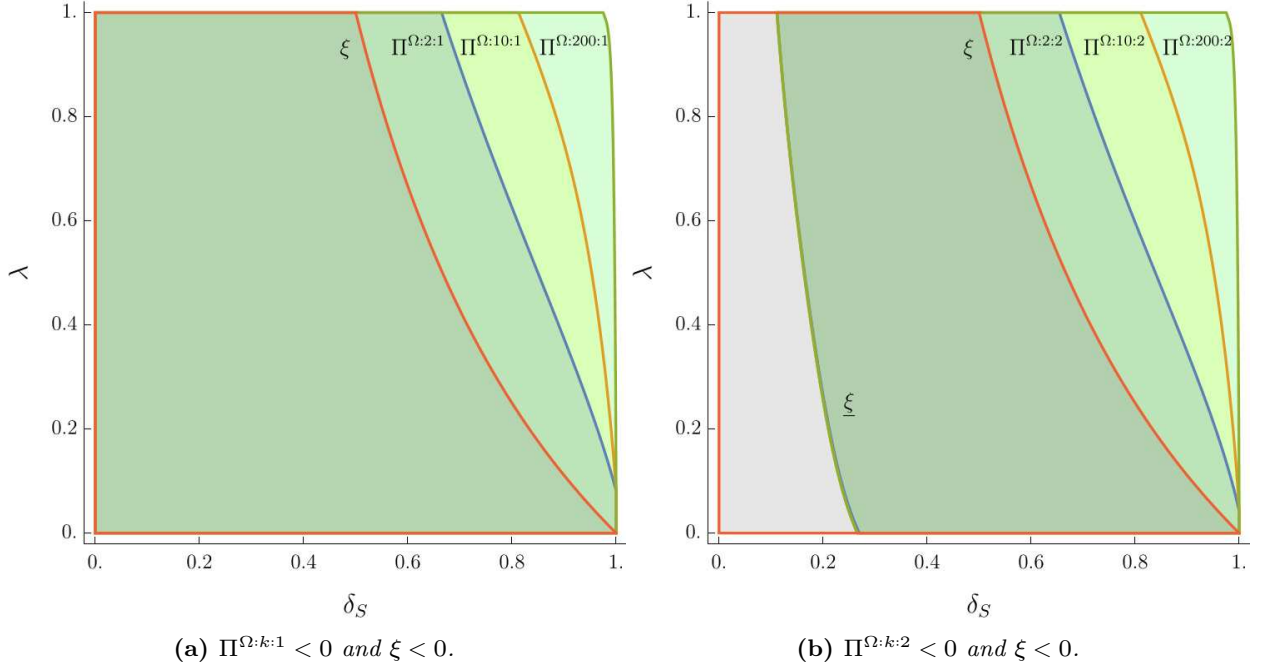


Figure A.1: Numerical simulation results for $\Pi^{\Omega:k:l}$ ($\theta_0 = .7$, $\alpha = .8$).

A.2 Generalization of the revenue shock distribution

In this Appendix, we generalize the model to account for revenue shocks of arbitrary size and assume that $r_t \in \{r^h, r^l\}$ with $r^h > r^l > 0$. As in the main text, we denote by $\gamma \in (0, 1)$ the probability that the revenue level is high, i.e. $r_t = r^h$. Assuming larger values of $r^l > 0$ makes the analysis of both, the cash in advance and the open account payment scenario, more involved. Under A-terms, depending on the parametrization of the revenue distribution, additional transfer strategies can be optimal for the seller and require further case distinctions in Lemma 1. Under Ω -terms, the seller now finds it optimal to request a non-zero transfer from the seller in the low revenue state which requires us to account for additional non-payment incentives of the buyer (implying adjustments to Lemma 2). We discuss the changes to the analysis of Section 3 in the following.

Cash in advance terms

While designing a contract that avoids the risk of buyer bankruptcy in the low revenue state altogether is never optimal when $r^l \rightarrow 0$, the situation changes when r^l is larger and we need to distinguish two cases. On the one side, just as in the main text the seller may want to set the transfer to $T_t^{A,h} = \delta_B R(Q_t, r_E)$ such that $(PC_{B,t}^A)$ binds and extract all rents from the patient buyer. In this situation, the seller accepts that the buyer goes bankrupt when the low revenue state is realized. Alternatively, he can set the transfer to $T_t^{A,l} = R(Q_t, r^l) < T_t^{A,h}$ such that the liquidity constraint in the low revenue state binds. This ensures that the trade relationship with the patient buyer is maintained in all revenue states.

Since revenue shocks are i.i.d. and the seller's learning about the buyer type does not depend on the transfer size, the seller's optimal decision between $T_t^{A,h}$ and $T_t^{A,l}$ does not vary over transactions. Hence, we can obtain the optimal transfer decision from comparing the seller's ex-ante expected payoffs when the transfer is fixed to either $T^{A,h}$ or $T^{A,l}$ for the entire relationship (the time index is dropped). In the following, we call the seller's choice $T^A \in \{T^{A,l}, T^{A,h}\}$ his *transfer strategy* under A-terms. For a given transfer strategy, the seller sets to trade volume by maximizing (1), and we denote the corresponding trade volumes by $Q^{A,h}$ and $Q^{A,l}$, respectively.

The following Lemma A.1 gives a unique condition on the revenue state distribution determining which of the two transfer levels is optimal for the seller and summarizes the corresponding trade volumes and profits.

Lemma A.1. *Suppose that $\delta_B \geq r^l/r_E$. Then there exists a unique value*

$$\hat{r} = \frac{\gamma}{\frac{1}{\delta_B} \left(\frac{1-\gamma\theta_0\delta_S}{1-\theta_0\delta_S} \right)^\alpha - 1 + \gamma} \in (0, 1)$$

such that setting the transfer to $T^{A,h} = \delta_B R(Q^{A,h}, r_E)$ in all transactions maximizes the seller's ex-ante expected payoffs if and only if $r^l \leq r^h \hat{r}$, and setting it to $T^{A,l} = R(Q^{A,l}, r^l)$ in all transactions does so otherwise. Since any spot contract under A-terms is separating, trade volumes do not vary over time and are given as:

$$Q^A = \begin{cases} (r_E \delta_B / c)^{\frac{1}{\alpha}} & \equiv Q^{A,h} \quad \text{if } r^l \leq r^h \hat{r}, \\ (r^l / c)^{\frac{1}{\alpha}} & \equiv Q^{A,l} \quad \text{if } r^l > r^h \hat{r}. \end{cases} \quad (\text{A.12})$$

The corresponding seller stage payoffs, conditional on contract acceptance, are:

$$\bar{\pi}^A = \begin{cases} (r_E \delta_B)^{\frac{1}{\alpha}} c^{\frac{\alpha-1}{\alpha}} \alpha / (1-\alpha) \equiv \bar{\pi}^{A,h} & \text{if } r^l \leq r^h \hat{r}, \\ (r^l)^{\frac{1}{\alpha}} c^{\frac{\alpha-1}{\alpha}} \alpha / (1-\alpha) \equiv \bar{\pi}^{A,l} & \text{if } r^l > r^h \hat{r}. \end{cases} \quad (\text{A.13})$$

Moreover, the seller's ex-ante expected payoffs are:

$$\Pi^A = \begin{cases} \frac{(1-\theta_0)\bar{\pi}^{A,h}}{(1-\delta_S)(1-\gamma\theta_0\delta_S)} \equiv \Pi^{A,h} & \text{if } r^l \leq r^h \hat{r}, \\ \frac{(1-\theta_0)\bar{\pi}^{A,l}}{(1-\delta_S)(1-\gamma\theta_0\delta_S)} \equiv \Pi^{A,l} & \text{if } r^l > r^h \hat{r}. \end{cases} \quad (\text{A.14})$$

Proof The expressions in (A.12) and (A.13) are obtained from solving the maximization problem in (1) for the respective transfer strategy $T^A \in \{T^{A,l}, T^{A,h}\}$. For the case where $T^A = T^{A,h}$, the seller's ex-ante expected payoffs from conducting an infinite sequence of transactions on A-terms can be derived from solving the following dynamic programming problem for $V_0^{A,h}$:

$$\begin{aligned} V_0^{A,h} &= (1-\theta_0) [\bar{\pi}^{A,h} + \delta_S V_1^{A,h}] + \theta_0 \delta_S V_0^{A,h}, \\ V_1^{A,h} &= \gamma [\bar{\pi}^{A,h} + \delta_S V_1^{A,h}] + (1-\gamma) V_0^{A,h}. \end{aligned}$$

Alternatively, in the situation where $T^A = T^{A,l}$ the ex-ante expected payoffs are derived from the following problem:

$$\begin{aligned} V_0^{A,l} &= (1-\theta_0) [\bar{\pi}^{A,l} + \delta_S V_1^{A,l}] + \theta_0 \delta_S V_0^{A,l}, \\ V_1^{A,l} &= \bar{\pi}^{A,l} + \delta_S V_1^{A,l}. \end{aligned}$$

The solutions to the respective programming problem are given in (A.14). Moreover, note that

the seller prefers to set $T^{A,h}$ instead of $T^{A,l}$ if and only if $\Delta\Pi \equiv \Pi^{A,h} - \Pi^{A,l} > 0$, which is equivalent to $r^l \leq r^h \hat{r}$. An important requirement for $\hat{r} \in (0, 1)$ is $\delta_B \geq r^l/r_E$. Otherwise, setting the transfer to T^l is profit-dominant for the seller and under no revenue shock distribution will he find it optimal to set $T^{A,h}$. ■

The Lemma shows that even though setting the smaller transfer $T^{A,l}$ implies smaller optimal trade volumes ($Q^{A,l} < Q^{A,h}$) and, correspondingly, smaller stage payoffs ($\bar{\pi}^{A,l} < \bar{\pi}^{A,h}$) doing so can be optimal for the seller. When the size of the negative revenue shock in the r^l -state is not sufficiently pronounced (i.e., when $r^l > r^h \hat{r}$ holds) the seller prioritizes relationship stability over full rent-extraction which he implements by choosing the smaller transfer level $T^{A,l}$.

Equivalently to Lemma 1, the following result rules out the non-shipment deviation by the seller. Since continuation payoffs depend on the chosen transfer strategy, each transfer scenario features distinct parameter thresholds to rule out the deviation. In Lemma A.2, we use the index $i \in \{l, h\}$ to refer to the low and high transfer strategy, respectively.

Lemma A.2. *Consider transfer strategy $i \in \{l, h\}$. Suppose that $\alpha > \tilde{\alpha}^i \in (0, 1)$ holds. Then there exists a repeated game equilibrium that maximizes the seller's ex-ante expected payoffs under cash in advance terms, Π^A , for all $\delta_S \geq \tilde{\delta}_S^i \in (0, 1)$.*

Proof At the Production and Shipment stage of any period the seller will not deviate from the contract if and only if:

$$-cQ^{A,i} + \delta_S V_1^{A,i} \geq \delta_S V_0^{A,i}, \quad i = l, h. \quad (\text{A.15})$$

Equation (A.15) follows from the same logic as (IC_S). Plugging explicit values for $V_0^{A,i}$ and $V_1^{A,i}$ into (A.15) and simplifying gives:

$$-cQ^{A,h} + \delta_S \frac{(1 - \theta_0 + \gamma\theta_0(1 - \delta_S))\bar{\pi}^{A,h}}{(1 - \delta_S)(1 - \gamma\theta_0\delta_S)} \geq \delta_S \frac{(1 - \theta_0)\bar{\pi}^{A,h}}{(1 - \delta_S)(1 - \gamma\theta_0\delta_S)} \quad \text{for } i = h, \quad (\text{A.16})$$

$$\text{and } -cQ^{A,l} + \delta_S \frac{\bar{\pi}^{A,l}}{1 - \delta_S} \geq \delta_S \frac{(1 - \theta_0)\bar{\pi}^{A,l}}{(1 - \delta_S)(1 - \theta_0\delta_S)} \quad \text{for } i = l. \quad (\text{A.17})$$

Observing that $cQ^{A,i} = \bar{\pi}^{A,i}(1 - \alpha)/\alpha$, $i = l, h$, we can simplify (A.16) to:

$$\delta_S \geq \frac{1 - \alpha}{\gamma\theta_0} \equiv \tilde{\delta}_S^h.$$

For an equilibrium to exist we need to ensure that $\tilde{\delta}_S^h < 1$. This is the case whenever $\alpha > 1 - \gamma\theta_0 \equiv \tilde{\alpha}^h \in (0, 1)$ holds. In this situation, the non-production deviation of the seller can be ruled if he is patient enough, i.e. when $\delta_S \geq \tilde{\delta}_S^h$ holds. Moreover, we can simplify (A.17) to:

$$\delta_S \geq \frac{1 - \alpha}{\theta_0} \equiv \tilde{\delta}_S^l,$$

and ensure that $\tilde{\delta}_S^l < 1$ by imposing that $\alpha > 1 - \theta_0 \equiv \tilde{\alpha}^l \in (0, 1)$ holds. ■

Under the conditions of Lemmas A.1 and A.2, Proposition 1 applies analogously for both transfer strategies discussed in this extension.

Open account terms

The seller's set of participation, liquidity, and incentive constraints remains structurally fully equivalent to the expressions in the main text. As a consequence, the pooling nature of the optimal spot contract – and hence the belief formation and updating process – remain the same. The size of revenue state-contingent transfers and thus the optimal trade volumes change, however. We summarize the principal changes under the generalized revenue shock distribution in the following Lemma A.3. It is the equivalent to Lemma 2 and ensures that the buyer behaves according to the strategy profile, while maximizing the seller's stage game payoffs.

Lemma A.3. *Suppose that $\delta_B \geq r^l/r_E \in (0, 1)$. Then under Ω -terms, the seller sets transfers $T_t^{\Omega, l} = R(Q_t, r^l)$ and $T_t^{\Omega, h} = \delta_B \gamma / (1 - \delta_B(1 - \gamma)) R(Q_t, r^h)$. Thereby, he rules out the buyer bankruptcy risk, makes the patient buyer indifferent between paying and not paying the agreed upon transfer in any revenue state and maximizes his own payoffs.*

Proof The proof of Lemma 2 applies. In addition, to ensure that $T_t^{\Omega, h} \geq T_t^{\Omega, l}$ holds (which is used to incentivize buyer payment in any revenue state) we plug the explicit transfer levels into the expression which – after simplification – gives $\delta_B \geq r^l/r_E$. ■

Note that the generalized revenue shock distribution additionally requires that the patient buyer has a discount factor above a positive threshold level, i.e. $\delta_B \geq r^l/r_E$. This accounts for the additional non-payment deviation that becomes available to the buyer when $T^{\Omega, l} > 0$.

Acknowledging the results of Lemma A.3, the seller chooses the trade volume in period t by maximizing:

$$Q_t^\Omega \equiv \arg \max_{Q_t} \delta_S \Lambda_t \left[\frac{\delta_B \gamma^2}{1 - \delta_B(1 - \gamma)} R(Q_t, r^h) + (1 - \gamma) R(Q_t, r^l) \right] - c Q_t.$$

The optimal trade volume Q_t^Ω and the corresponding stage game payoff π_t^Ω in the t th transaction with a buyer on open account terms can be calculated as:

$$Q_t^\Omega = \left(\frac{\delta_S \mathcal{T}'}{c} \Lambda_t \right)^{\frac{1}{\alpha}}, \quad \pi_t^\Omega = Q_t^\Omega \frac{c\alpha}{1 - \alpha}, \quad \text{where } \mathcal{T}' = \frac{\delta_B \gamma^2}{1 - \delta_B(1 - \gamma)} r^h + (1 - \gamma) r^l.$$

The derivation of the seller's ex-ante expected payoffs is fully analogous to the main text. Moreover, Proposition 2 applies analogously.

A.3 Court usage and relationship stability

In this Appendix, we investigate the situation where the seller can observe when institutions (i.e. courts) are used to enforce contract compliance by the buyer. This scenario is equivalent to a situation in which the seller decides to resort to courts in case of buyer non-payment. Since under A-terms only patient buyers accept the stage contract who – by construction – always comply with the contract terms, the analysis will not be affected in this payment scenario.

The situation changes under Ω -terms, however. While the buyer's participation and incentive constraints remain unvaried and therefore Lemma 2 applicable, the updating process of the seller's belief θ_t , trade volumes, stage payoffs, and the corresponding dynamic programming problem are subject to change. At the end of the first transaction with a buyer, the seller will

know with certainty whether he is in a match with a patient or myopic buyer. The reason is that whenever a transaction with a myopic buyer is successful, it must be the case that buyer payment is enforced by court (she would never pay voluntarily). Contrarily, non-payment by the buyer will only occur if the buyer is myopic.

Hence, whenever an initial transaction is successful without the usage of courts (which happens if and only if the buyer is patient) the seller updates his belief from $\theta_0 = \hat{\theta}$ to $\theta_1 = 0$. Correspondingly, trade volumes and stage payoffs grow from Q_0^Ω and π_0^Ω in the first transaction to Q^Ω and $\bar{\pi}^\Omega$ in the second transaction, respectively. Consistent with the findings by [Macaulay \(1963\)](#), we assume in the following that the seller discontinues the trade relationship once courts are used to enforce the transfer payment by the buyer. This gives rise to the following dynamic programming problem for the seller:

$$\begin{aligned} V_0^{\Omega,c} &= \pi_0^\Omega + \delta_S \left[(1 - \theta_0) V_1^{\Omega,c} + \theta_0 V_0^{\Omega,c} \right], \\ V_1^{\Omega,c} &= \bar{\pi}^\Omega + \delta_S V_1^{\Omega,c}, \end{aligned}$$

which we can solve for $V_0^{\Omega,c}$ to obtain the seller's ex-ante expected payoffs:

$$\Pi^{\Omega,c} = \frac{\bar{\pi}^\Omega}{1 - \delta_S} - \frac{\bar{\pi}^\Omega - \pi_0^\Omega}{1 - \delta_S \theta_0}.$$

While under the varied model assumptions the belief updating process by the seller is the same under A- and Ω -terms and all information about the buyer is revealed until the end of the initial transaction, the qualitative predictions on trade volume growth and relationship stability of the main text remain valid. Since also under the varied assumptions the stage contract under Ω -terms cannot separate buyer types, just as in our baseline model, we see trade volume growth over time (while in contrast, trade volumes on A-terms do not vary over transactions). However, a difference is that due to the additional observability of court usage, the trade volume at the full information limit is reached already after the initial transaction.

Moreover, just as in the main text scenario the probability of relationship failure in any period is larger under A-terms than it is under Ω -terms. Under Ω -terms, a relationship fails after the initial transaction if and only if the buyer is myopic. Under A-terms, relationship breakdown additionally occurs when the patient buyer suffers bankruptcy (which does not occur under Ω -terms in equilibrium). Summing up, we find that our main results are qualitatively robust to assuming that the business relationship dies whenever courts are used to enforce the stage contract.

A.4 Generalizing the myopic buyer type

In this Appendix, we study the consequences of relaxing the assumption of a fully myopic impatient buyer for our results. More specifically, we generalize the analysis of Section 3 to the situation where the myopic buyer can possess any discount factor $\delta_M \in [0, \delta_B)$.

Cash in advance terms

As outlined in the main text, when $\delta_M = 0$ the seller always offers a separating contract to buyers that only the patient type accepts. The reason is that a pooling contract would require

$T_t = 0$, which is never incentive compatible for the seller. However, this may differ when $\delta_M > 0$ in which case contracts with positive transfers that ensure $(PC_{M,t}^A)$ to hold are feasible.

To derive the pooling equilibrium under cash in advance let us note that the role of the liquidity constraints does not change when compared to Section 3.1, implying that either buyer type suffers bankruptcy when hit by a low revenue shock (as in the main text, we assume that θ_0 is sufficiently low such that buyer bankruptcy is incentive-compatible for the seller).

Under pooling, it is optimal for the seller to set the transfer such that $(PC_{M,t}^A)$ binds with equality. Hence, $T_t^{A,p} = \delta_M R(Q_t, r_E)$. We use $T_t^{A,p}$ for the maximization problem in (1) to determine optimal trade volumes and the corresponding stage payoffs for the pooling case:

$$Q^{A,p} = \left(\frac{\gamma \delta_M}{c} \right)^{\frac{1}{\alpha}}, \quad \bar{\pi}^{A,p} \equiv \pi_t^{A,p} = Q^{A,p} \frac{c\alpha}{1-\alpha}.$$

Since trade volumes are the same in any transaction and both revenue realizations imply the same payoff for the seller with any buyer, his ex-ante expected payoffs under pooling are $\Pi^{A,p} = \bar{\pi}^{A,p} / (1 - \delta_S)$.

Observe that (IC_S) is never satisfied under pooling and after receiving the transfer $T_t^{A,p}$ the seller has no incentive to produce and ship the product. Anticipating the seller's commitment problem, the buyer never accepts a cash in advance contract on pooling terms. We summarize our findings in the following Lemma.

Lemma A.4. *When using A-terms, for any $\delta_M \in [0, \delta_B)$ it is payoff-maximizing for the seller to offer a stage contract $\{Q^A, T_t^A, A\}$ that separates buyer types. A pooling contract is never optimal and the main text analysis applies for any value of δ_M .*

Open account terms

When δ_M is sufficiently large (i.e., sufficiently close to δ_B) it may be profitable for the seller to set transfers such that payment is incentive compatible for the myopic buyer. Such a policy change may be a profitable for the seller as it eliminates the risk of non-payment by the myopic buyer which we discuss in Section 3.2.

Suppose that the seller designs a contract such that the myopic buyer is incentivized to repay the trade credit. In this case, the myopic buyer's participation constraint is identical to $(PC_{B,t}^\Omega)$ from the main text. The determination of the optimal transfer strategy follows the same steps as in Lemma 2 with the exception that the transfer in the high revenue state is set such that $(IC_{M,t}^{\Omega,h})$ instead of $(IC_{B,t}^{\Omega,h})$ binds with equality, which gives $\hat{T}_t^{\Omega,h} = \delta_M \gamma / (1 - \delta_M(1 - \gamma)) R(Q_t)$. Moreover, $\hat{T}_t^{\Omega,l} = T_t^{\Omega,l}$.

Acknowledging this transfer strategy, the seller chooses the trade volume in period t by maximizing:

$$\hat{Q}_t^\Omega \equiv \arg \max_{Q_t} \delta_S \hat{\Lambda}_t \hat{\mathcal{T}} R(Q_t) - cQ_t, \quad \text{where} \quad \hat{\mathcal{T}} = \frac{\delta_M \gamma^2}{1 - \delta_M(1 - \gamma)}.$$

Since $\hat{\Lambda}_t = 1$ in this case, the optimal trade volume \hat{Q}_t^Ω and the corresponding stage game payoff

$\hat{\pi}^\Omega$ are the same in every transaction under this transfer strategy and given as:

$$\hat{Q}^\Omega = \left(\frac{\delta_S \hat{\mathcal{T}}}{c} \right)^{\frac{1}{\alpha}}, \quad \hat{\pi}^\Omega = \hat{Q}^\Omega \frac{c\alpha}{1-\alpha},$$

yielding $\hat{\Pi}^\Omega = \hat{\pi}^\Omega / (1 - \delta_S)$ as the seller's ex-ante expected payoffs. Note that whether or not this transfer strategy is optimal it sustains the finding from the main text that the optimal contract under open account terms pools buyer types.

When we compare the seller's outcome from this alternative transfer strategy to the outcomes in the main text scenario we obtain the following result.

Lemma A.5. *There exists a unique $\delta_M^* \in (0, \delta_B)$ such that $\{T_t^{\Omega,l}, T_t^{\Omega,h}\}$ is the optimal transfer strategy for the seller for all $\delta_M < \delta_M^*$. Otherwise, $\{\hat{T}_t^{\Omega,l}, \hat{T}_t^{\Omega,h}\}$ is the optimal transfer strategy.*

Proof The result is obtained from comparing $\hat{\Pi}^\Omega$ and Π^Ω . First, note that Π^Ω is independent of δ_M . Moreover, observing that $\partial \hat{\Pi}^\Omega / \partial \delta_M > 0$, $\Pi^\Omega > \lim_{\delta_M \rightarrow 0} \hat{\Pi}^\Omega$, and $\Pi^\Omega < \lim_{\delta_M \rightarrow \delta_B} \hat{\Pi}^\Omega$ completes the proof. ■

Online Appendix for

Optimal Payment Contracts in Trade Relationships

— Christian Fischer-Thöne —

In parts S.1 and S.2 of this Online Appendix we derive the results of our most central model extensions summarized in Section 5. Moreover, in part S.3 we investigate the consequences for model outcomes when the buyer has a positive outside option to the trade relationship.

S.1 Trade credit insurance

As summarized in Section 5.1, instead of taking the risk of buyer non-payment in an open account transaction in period t himself, in this extension the seller can rule it out by employing a trade credit insurance ($F_t = I$). We assume that such an insurance is available to the seller from a perfectly competitive insurance market and that the insurance fee I_t for the transaction in period t can be separated into a fixed and a variable component which is given by:

$$I_t = m + \delta_S(1 - \Lambda_t^I)ET_t,$$

where the fixed (and time-invariant) component $m > 0$ covers setup and monitoring costs that the insurer incurs for managing the transaction. The second addend represents the variable component that depends on the size of the insured expected transfer, ET_t .³³ It is weighted by the probability of non-payment $1 - \Lambda_t^I$, where Λ_t^I denotes the payment probability when in the t th transaction of a trade relationship is conducted under insurance. Moreover, because potential payment default occurs only in $t + 1$ the variable component is discounted. For analytical simplicity we assume the insurer's discount factor is equal to that of the seller, δ_S . Finally, because the insurer has a vital interest that the buyer does not default on the contract it will engage in buyer screening itself before granting a credit insurance.³⁴ We model this aspect by assuming that initially using a trade credit insurance reduces the proportion of myopic types in the population to $\hat{\theta}^I = \phi\hat{\theta}$, where $\phi \in (0, 1)$ is an inverse measure of the insurer's ability to screen out myopic types. Hence, the seller's belief to face a myopic buyer in the t th transaction on insurance terms is determined via Bayes' rule as $\theta_t^I = \hat{\theta}^I \lambda^t / [1 - \hat{\theta}^I(1 - \lambda^t)]$, and the probability of payment in t is given as $\Lambda_t^I = 1 - \theta_t^I(1 - \lambda)$.³⁵

³³We assume that in case of buyer non-payment, the insurance reimburses the seller the factually forgone transfer, i.e. the insurer pays out $T_t^{\Omega, h}$ when $r_t = 1$, and $T_t^{\Omega, l}$ otherwise, which is consistent with perfect competition assumption for the insurance market.

³⁴Our specification of the insurance fee follows the formalization of the letter of credit contract by [Niepmann and Schmidt-Eisenlohr \(2017\)](#). Its size follows from the perfect competition assumption for the insurance market which implies that the insurer makes zero profits. Since the introduction of banks as additional strategic players would render our dynamic model intractable we refrain from discussing the details of other forms of trade finance such as documentary collections and letters of credit in this paper and focus our study on the impact of the insurance on the seller's payment contract choices.

³⁵In addition to having a superior ability to screen buyers, the insurance firm may be more proficient than the seller in enforcing the contract in court (e.g., due to an specialized legal department). In the model, such an ability can be introduced by assuming a higher value of the contract enforcement parameter λ under insurance. For a given belief θ_t^I a stronger enforcement ability of the insurer then implies a smaller insurance fee I_t in a perfectly competitive insurance market, which further increases the attractiveness for the seller to use trade credit insurance. In our analysis, we focus on the buyer selection channel.

The optimal spot contract with insurance

We employ the same strategy profile as in the baseline scenario. In addition, we assume that the seller terminates the trade relationship and matches with a new buyer whenever the buyer does make the transfer and the insurance repays instead. The participation constraints of the two buyer types under insurance are the same as in the open account scenario. Also, the incentive constraints for the patient buyer to conduct payment are the same as under open account leading the seller to request the same transfer profile from the buyer (i.e. Lemma 2 applies directly). The optimal trade volume in period t , Q_t^I , is hence determined by maximizing the following stage payoff function:

$$Q_t^I \equiv \arg \max_{Q_t} \delta_S \mathcal{T}R(Q_t) - cQ_t - I_t = \arg \max_{Q_t} \delta_S \Lambda_t^I \mathcal{T}R(Q_t) - cQ_t - m,$$

where the second equality holds since the insured expected transfer is $ET_t = \mathcal{T}R(Q_t)$.

Observe that even though the insurance eliminates the risk of non-payment, the probability of payment Λ_t^I still indirectly affects the seller's maximization problem through the variable fee component. The optimal trade volume Q_t^I and the corresponding stage payoffs π_t^I are:

$$Q_t^I = \left(\frac{\delta_S \mathcal{T} \Lambda_t^I}{c} \right)^{\frac{1}{\alpha}}, \quad \pi_t^I = Q_t^I \frac{c\alpha}{1-\alpha} - m.$$

Dynamically optimal payment contracts with insurance

In any period t , the seller can now freely choose not only between cash in advance and open account terms but can alternatively decide to use a trade credit insurance, i.e. $F_t \in \mathcal{F}^+ \equiv \{A, \Omega, I\}$. In the following, we study how the availability of insurance affects the set of feasible dynamically optimal payment contract sequences. In fact, under the parameter restrictions of Proposition 3 the set of possible DOSPCs is extended by one unique element in the presence of insurance terms. The following Proposition S.1 is the more detailed analogue to Proposition 4 of the main text.

Proposition S.1. *Let $F_t \in \mathcal{F}^+$ for all $t \geq 0$. Under the conditions of Proposition 3, it holds that some $F \in \mathcal{F}^D \cup (I, \Omega, \Omega, \dots) \equiv \mathcal{F}^{D+}$ is the DOSPC. The seller's ex-ante expected payoffs for the sequence $F = (I, \Omega, \Omega, \dots)$ are given by:*

$$\Pi^{I\Omega} = \frac{1 - \delta_S \lambda}{1 - \delta_S \lambda - \delta_S \theta_0^I (1 - \lambda)} \left[-m + \bar{\pi}^\Omega \sum_{t=0}^{\infty} \delta_S^t (\Lambda_t^I)^{\frac{1}{\alpha}} (1 - \theta_0^I (1 - \lambda^t)) \right].$$

Proof First, note that I-terms cannot follow on A-terms because at the full information limit I-terms are dominated by Ω -terms. The reason is that when A-terms are used before the game reaches the full information limit and by playing Ω -terms instead of I-terms the seller can save the fixed costs of the insurance, m , in this case.

Second, note that I-terms cannot follow on Ω -terms. To see this, let us rewrite the belief under payment contract $j \in \{\Omega, I\}$ for period $t+1$ as $\theta_{t+1}^j = \theta_t^j \lambda / (1 - \theta_t^j (1 - \lambda))$. Note that θ_{t+1}^j is an increasing and strictly convex function in θ_t^j . Consequently, the incentive to employ insurance is largest in the initial period since it implies the largest informational gain from the

insurer's screening activity. Hence, whenever trade credit insurance is used it will be employed in the initial transaction.

Note also, that insurance will not be used for more than the initial period. The reason is that in any further transaction with the same buyer the seller can benefit from the insurer's screening technology also under Ω -terms. However, by not using the insurance he can save the fixed insurance costs m in the subsequent periods.

Remains to establish that A-terms cannot follow on an initial period on I-terms. Since the value functions V_t^I and V_t^Ω are structurally equivalent, the comparative statics of V_t^Ω w.r.t. θ_t derived in Step 2 of the proof of Proposition 3 apply analogously to V_t^I . This directly implies that the seller will never find it optimal to switch to A-terms after an initial transaction on I-terms.

Consequently, the only sequence of payment contracts that can become dynamically optimal and includes insurance terms is $F = (I, \Omega, \Omega, \dots)$. The corresponding ex-ante expected payoffs are obtained from the following program:

$$\begin{aligned} V_0^{\text{I}\Omega} &= \pi_0^I + \delta_S (\Lambda_0^I V_1^{\text{I}\Omega} + (1 - \Lambda_0^I) V_0^{\text{I}\Omega}), \\ \forall t > 0 : \quad V_t^{\text{I}\Omega} &= \pi_t^I + m + \delta_S (\Lambda_t^I V_{t+1}^{\text{I}\Omega} + (1 - \Lambda_t^I) V_t^{\text{I}\Omega}). \end{aligned} \tag{S.1}$$

Solving (S.1) for $V_0^{\text{I}\Omega}$ by using the same steps as in the derivation of Π^Ω gives:

$$\Pi^{\text{I}\Omega} = \frac{1 - \delta_S \lambda}{1 - \delta_S \lambda - \delta_S \theta_0^I (1 - \lambda)} \left[-m + \bar{\pi}^\Omega \sum_{t=0}^{\infty} \delta_S^t (\Lambda_t^I)^{\frac{1}{\alpha}} (1 - \theta_0^I (1 - \lambda^t)) \right]. \blacksquare$$

The proof of Proposition S.1 establishes that $F = (I, \Omega, \Omega, \dots)$ is the only additional sequence that can become dynamically optimal. This is because, first, I-terms are payoff-dominated by Ω -terms at the full information limit and after the initial play of I-terms and, second, the informational benefit from insurer screening is largest in the initial period. The proof argues that the parameter requirements imposed in Proposition 3 are sufficient to establish that \mathcal{F}^{D+} is the full set of feasible DOSPCs when insurance becomes available. Acknowledging that some $F \in \mathcal{F}^{D+}$ is optimal, the following Corollary S.1 gives conditions under which insuring the initial open account transaction is payoff-maximizing for the seller.

Corollary S.1. *Suppose that the parameter constraints of Corollary 1(b) are satisfied. Then for any level of insurer screening efficiency $\phi \in (0, 1)$ there exist threshold levels $\bar{m} > 0$ and $\hat{\theta}_0 \in (0, 1)$ such that for all $m < \bar{m}$ and all $\theta_0 > \hat{\theta}_0$ the sequence $F = (I, \Omega, \Omega, \dots)$ is the DOSPC. If $m > \bar{m}$, then $F \in \mathcal{F}^D$.*

Proof As argued in the proof of Proposition S.1, the comparative statics of V_t^Ω w.r.t. θ_t also apply to V_t^I . As a consequence, we have that $\Pi^{\text{I}\Omega}$ decreases monotonically in θ_0 . Next, let us compare the limit properties of Π^Ω and $\Pi^{\text{I}\Omega}$ w.r.t. θ_0 . First, note that $\lim_{\theta_0 \rightarrow 0} \Pi^{\text{I}\Omega} = -m + \bar{\pi}^\Omega / (1 - \delta_S) < \lim_{\theta_0 \rightarrow 0} \Pi^\Omega$. Since both, Π^Ω and $\Pi^{\text{I}\Omega}$ are monotonically decreasing and continuous in θ_0 , whenever:

$$\begin{aligned} \lim_{\theta_0 \rightarrow 1} \Pi^{\text{I}\Omega} &> \lim_{\theta_0 \rightarrow 1} \Pi^\Omega \\ \Leftrightarrow \quad m &< \bar{\pi}^\Omega \left[\frac{\lambda^{\frac{1}{\alpha}} (1 - \delta_S \lambda - \delta_S \phi (1 - \lambda))}{(1 - \delta_S)(1 - \delta_S \lambda)} - \sum_{t=0}^{\infty} \delta_S^t \left(\frac{1 - \phi(1 - \lambda^{t+1})}{1 - \phi(1 - \lambda^t)} \right)^{\frac{1}{\alpha}} (1 - \phi(1 - \lambda^t)) \right] \equiv \bar{m}, \end{aligned}$$

then there exists a $\hat{\theta}'_0 \in (0, 1)$ at which $\Pi^{\text{I}\Omega} = \Pi^\Omega$, and $\Pi^{\text{I}\Omega} > \Pi^\Omega$ if and only if $\theta_0 > \hat{\theta}'_0$. Noting from Corollary 1 that for $\theta_0 \rightarrow 1$ the sequence (Ω, \dots) payoff-dominates (A, \dots) and $(\text{A}, \Omega, \Omega, \dots)$, we can infer that there must exist $\hat{\theta}_0 \in [\hat{\theta}'_0, 1)$ such that for all $\theta_0 > \hat{\theta}_0$ we have that $\Pi^{\text{I}\Omega} > \max\{\Pi^\Omega, \Pi^{\text{A}\Omega}, \Pi^{\text{A}}\}$. ■

Corollary S.1 shows that no matter how efficient the insurer is in screening the population of buyers there always exists an upper bound of insurance fixed costs $\bar{m} > 0$ below which the seller finds it optimal to use $F = (\text{I}, \Omega, \Omega, \dots)$, provided that the marginal impact of the insurer's screening activity is high enough (i.e. the share of myopic buyers in the population is large enough). Conversely, when the fixed costs of the insurer are too large (i.e., when $m > \bar{m}$) insurance is never optimal for the seller and the set of possible DOSPCs reduces to \mathcal{F}^D .

Figure S.1 illustrates the model for the situation where $m < \bar{m}$. In the depicted case, the belief thresholds are ordered such that all possible DOSPCs can be optimal across the θ_0 -space. Note, that there also exist model parametrizations for which $\hat{\theta}_0 < \underline{\theta}_0$ holds. In this case, some $F \in \{(\text{A}, \dots), (\text{I}, \Omega, \Omega, \dots)\}$ is the DOSPC.

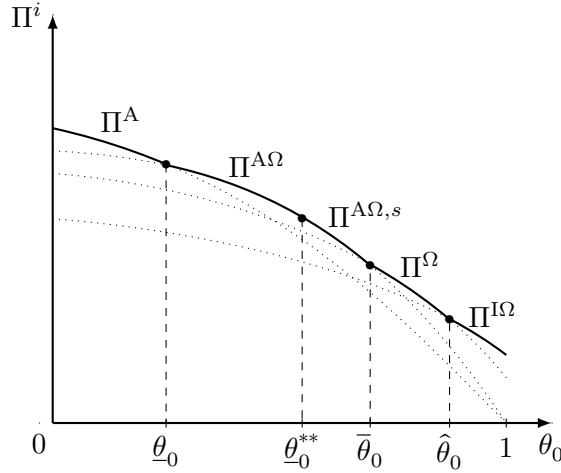


Figure S.1: *Ex-ante expected payoff functions with insurance when $\hat{\theta}_0 > \bar{\theta}_0$.*

S.2 Private observability of revenue shocks

In this Appendix, we derive the formal results for our model variant in which revenue shocks are privately observable to the buyer. An intuitive summary of results is contained in Section 5.2.

Report-dependent transfers with truthtelling incentivization under Ω -terms

We first consider the scenario where the seller offers report-contingent transfers to the buyer. For now, assume that the seller assigns the same transfers to reported revenues levels as those chosen for the respective levels in the public information case.³⁶ This implies that the prescribed

³⁶We show below that the optimal transfers under private information are identical to those of the public information case.

transfer when reported revenues are high ($\hat{r}_t = r^h$) is larger than when the revenue report is low ($\hat{r}_t = r^l$). In this situation, the myopic buyer always reports low since it gives her larger stage payoffs also in the situation where contracts are enforced and deviation is not possible. For the patient buyer, on the one side it is never optimal to over-report when $r_t = r^l$ since $T_t^{\Omega,h} > T_t^{\Omega,l}$ leads to immediate bankruptcy which is not optimal given positive continuation payoffs under truthtelling. Conversely, when $r_t = r^h$ the buyer has an incentive to under-report, since the lower transfer when $\hat{r}_t = r^l$ ensures her a higher stage payoff.

The seller can counter the under-reporting problem under private information by incentivizing the patient buyer to tell the truth (such that she reports $\hat{r}_t = r_t$ in all periods) by (temporarily) suspending trade when $\hat{r}_t = r^l$. The length of trade suspension is chosen such that the buyer is indifferent between possible reports (cf. [Troya-Martinez, 2017](#)). As outlined above, the myopic buyer can never be incentivized to report high revenues truthfully. As a consequence, a high report of the buyer is a *credible signal* of her patient type effectuating an update of the seller's belief to $\theta_{t+1} = 0$ in the following period. Note that such signal enhances the buyer's continuation payoff only if the realized revenue is indeed high since the corresponding transfer would lead to her bankruptcy otherwise (this eliminates any incentive for strategic over-reporting).

Before we set up the seller's dynamic programming problem in which we incorporate the above observations, let us first derive the optimal stage contract with report-dependent transfers that ensures truthtelling. Compared to the public information case the payment probability is adjusted in order to account for the reporting behavior of buyers outlined above. In period t , the seller chooses $\{Q_t, T_t^{\Omega,h}, T_t^{\Omega,l}, T(l)\}$ to maximize the following stage payoff function:

$$\pi_t^{\Omega,s} = \delta_S \left[(1 - \theta_t) \gamma T_t^{\Omega,h} + [(1 - \gamma)(1 - \theta_t) + \theta_t \lambda] T_t^{\Omega,l} \right] - cQ_t. \quad (\text{S.2})$$

$T(l) \geq 0$ denotes the number of trade suspension periods following on a low revenue report. Evidently, trade suspension in the high revenue state reduces seller payoffs while not increasing the buyer's incentive to report truthfully. Hence, we do not need to further consider this possibility in the following.

While the maximization problem is subject to the same participation and liquidity constraints as in the public information case the buyer's incentive constraints are adjusted as follows:

$$u_t^l \equiv -T_t^{\Omega,l} + \frac{\delta_B^{T(l)+1}}{1 - \delta_B} [\gamma R(Q_t) - ET_t^{\Omega}] \geq 0, \quad (\text{IC}_{B,t}^{\Omega,l})$$

$$u_t^h \equiv -T_t^{\Omega,h} + \frac{\delta_B}{1 - \delta_B} [\gamma R(Q_t) - ET_t^{\Omega}] \geq 0. \quad (\text{IC}_{B,t}^{\Omega,h})$$

Finally, to ensure truthtelling we need $u_t^l = u_t^h$ as an additional constraint to the maximization problem.³⁷

The derivation of the optimal equilibrium transfers follows the exact same steps as in Lemma 2, which applies one-to-one here. We can plug the resulting transfer payments $T_t^{\Omega,l} = r^l R(Q_t) \approx 0$ and $T_t^{\Omega,h} = \delta_B \gamma / (1 - \delta_B(1 - \gamma)) R(Q_t)$ into the truthtelling constraint, which implies that trade with a buyer is suspended permanently whenever $\hat{r}_t = r^l$, i.e. $T(l) \rightarrow \infty$.

Using the equilibrium transfer payments the seller chooses the trade volume in period t by

³⁷We assume that the trade relationship with the suspended buyer ends permanently when the seller decides to engage in a new trade relationship during periods of trade suspension.

maximizing the following variant of (S.2):

$$Q_t^{\Omega,s} \equiv \arg \max_{Q_t} \delta_S (1 - \theta_t) \mathcal{T} R(Q_t) - c Q_t.$$

The optimal trade volume $Q_t^{\Omega,s}$ and the corresponding stage game payoff $\pi_t^{\Omega,s}$ in the t th transaction with a buyer on open account terms can be calculated as:

$$Q_t^{\Omega,s} = \left(\frac{\delta_S \mathcal{T} (1 - \theta_t)}{c} \right)^{\frac{1}{\alpha}}, \quad \pi_t^{\Omega,s} = Q_t^{\Omega,s} \frac{c\alpha}{1 - \alpha}.$$

We denote the stage payoffs at the full information limit by $\bar{\pi}^{\Omega,s}$ in the following.

For the remainder of the paragraph, suppose that the seller is restricted to Ω -terms with report-dependent transfers. Accounting for the possibility of type signalling under private information outlined above and conditional on the optimality of the trade suspension punishment, the seller's dynamic programming problem looks as follows in this situation:

$$\begin{aligned} V_0^{\Omega,s} &= \pi_0^{\Omega,s} + \delta_S \left[(1 - \gamma(1 - \theta_0)) V_0^{\Omega,s} + \gamma(1 - \theta_0) V_1^{\Omega,s} \right], \\ V_1^{\Omega,s} &= \bar{\pi}^{\Omega,s} + \delta_S \left((1 - \gamma) V_0^{\Omega,s} + \gamma V_1^{\Omega,s} \right), \end{aligned}$$

where re-matching (due to a low revenue report) occurs in equilibrium when the buyer is myopic, or, when the patient buyer faces a low revenue realization. Solving the problem for $V_0^{\Omega,s}$ gives the seller's ex-ante expected payoffs:

$$\Pi^{\Omega,s} = \frac{(1 - \delta_S \gamma) \pi_0^{\Omega,s} + \delta_S \gamma (1 - \theta_0) \bar{\pi}^{\Omega,s}}{(1 - \delta_S)(1 - \gamma \theta_0 \delta_S)}.$$

Report-independent transfers under Ω -terms

Alternatively to establishing truthtelling, the seller can ignore the buyer's revenue report and offer a contract with a transfer that depends only on the trade volume (a "flat contract" with regard to the reported revenue). In principle, the seller here has two options. First, he can set the transfer at a lower level such that the patient buyer does not suffer a risk of bankruptcy in either revenue state. Since this strategy is not profitable for the seller (it requires $T_t = 0$ in all periods) we will not consider it further. Alternatively, the seller can ignore the liquidity constraints and set the transfer such that the patient buyer's incentive constraint ($\text{IC}_{B,t}^{\Omega}$) binds with equality (($\text{PC}_{B,t}^{\Omega}$) is also satisfied in this case):

$$-T_t^{\Omega,f} + \frac{\delta_B}{1 - \delta_B} [\gamma R(Q_t) - T_t^{\Omega,f}] \geq 0. \quad (\text{IC}_{B,t}^{\Omega})$$

This implies $T_t^{\Omega,f} = \delta_B \gamma R(Q_t)$. Acknowledging this transfer, the seller chooses the trade volume in period t by maximizing the following stage payoff function:

$$\pi_t^{\Omega,f} = \delta_S \gamma \Lambda_t T_t^{\Omega,f} - c Q_t.$$

The payment probability is adjusted to $\gamma \Lambda_t$ to account for the fact that payment of the transfer $T_t^{\Omega,f}$ only occurs when revenues are high (no revenue is generated otherwise, and therefore no transfer is possible). In this situation, non-payment occurs only if the buyer is myopic and contracts are not enforced.

The optimal trade volume $Q_t^{\Omega,f}$ and the corresponding stage game payoffs with a buyer under

belief θ_t can be calculated as:

$$Q_t^{\Omega,f} = \left(\frac{\delta_S \delta_B \gamma^2 \Lambda_t}{c} \right)^{\frac{1}{\alpha}}, \quad \pi_t^{\Omega,f} = Q_t^{\Omega,f} \frac{c\alpha}{1-\alpha}.$$

We denote the stage payoffs at the full information limit by $\bar{\pi}^{\Omega,f}$ in the following.

For the remainder of the paragraph, suppose that the seller is restricted to Ω -terms with report-independent transfers. Compared to the main text, the seller's dynamic programming problem needs to be adjusted by the fact that the relationship survives from one transaction to the next only if the revenue realization is high. Hence, we have:

$$\forall t \geq 0: \quad V_t^{\Omega,f} = \pi_t^{\Omega,f} + \delta_S \left(\gamma \Lambda_t V_{t+1}^{\Omega,f} + (1 - \gamma \Lambda_t) V_0^{\Omega,f} \right). \quad (\text{S.3})$$

Rewriting (S.3) in steps analogous to the main text, we get:

$$V_t^{\Omega,f} = \frac{1}{1 - \theta_0(1 - \lambda^t)} \left[\bar{\pi}^{\Omega,f} \sum_{i=t}^{\infty} \delta_S^{i-t} \Lambda_i^{\frac{1}{\alpha}} (1 - \theta_0(1 - \lambda^i)) + \delta_S V_0^{\Omega,f} \left(\frac{(1 - \gamma)(1 - \theta_t)}{1 - \delta_S \gamma} + \frac{\theta_t \lambda^t (1 - \gamma \lambda)}{1 - \delta_S \gamma \lambda} \right) \right]. \quad (\text{S.4})$$

We can solve the initial period version of (S.4) for $V_0^{\Omega,f}$ to obtain the ex-ante expected payoffs:

$$\Pi^{\Omega,f} = \frac{(1 - \lambda \delta_S \gamma)(1 - \delta_S \gamma)}{(1 - \delta_S \gamma(\theta_0 + (1 - \theta_0)\lambda))(1 - \delta_S)} \bar{\pi}^{\Omega,f} \sum_{t=0}^{\infty} \delta_S^t \Lambda_t^{\frac{1}{\alpha}} (1 - \theta_0(1 - \lambda^t)).$$

Optimal contract design with private information

In the following, we analyze dynamically optimal payment contract choice with private information. For any belief $\theta_t \in (0, 1)$, the seller may now want to choose either A-terms or Ω -terms with report-dependent or -independent transfers. We introduce the same notation for the value functions as in the proof of Proposition 3 to distinguish more explicitly between the seller's belief in period t , θ_t , and his initial belief θ_0 . This gives:

$$\begin{aligned} V_t^A(\theta_t, \theta_0) &= (1 - \theta_t) \bar{\pi}^A + \delta_S [\gamma(1 - \theta_t) V_{t+1}(0, \theta_0) + (1 - \gamma(1 - \theta_t)) V_{t+1}(\theta_0, \theta_0)], \\ V_t^{\Omega,s}(\theta_t, \theta_0) &= \pi_t^{\Omega,s} + \delta_S [\gamma(1 - \theta_t) V_{t+1}(0, \theta_0) + (1 - \gamma(1 - \theta_t)) V_{t+1}(\theta_0, \theta_0)], \\ V_t^{\Omega,f}(\theta_t, \theta_0) &= \pi_t^{\Omega,f} + \delta_S [\gamma \Lambda_t V_{t+1}(\theta_{t+1}^{\Omega}, \theta_0) + (1 - \gamma \Lambda_t) V_{t+1}(\theta_0, \theta_0)]. \end{aligned} \quad (\text{S.5})$$

While under A-terms and report-dependent transfers the belief is updated to $\theta_{t+1} = 0$ at the beginning of the following transaction, under report-independent transfers updating follows Bayes' rule and $\theta_{t+1} = \theta_{t+1}^{\Omega}$. A comparison of $V_t^{\Omega,s}(\theta_t, \theta_0)$ and $V_t^A(\theta_t, \theta_0)$ reveals that A-terms payoff-dominate the usage of Ω -terms with report-dependent transfers and truth-telling incentivization. This directly leads to Proposition 5.

This leaves us with two potentially optimal payment strategies under private information. The following Lemma S.1 provides a unique condition that pins down optimal payment contract choice for any period in a trade relationship.

Lemma S.1. *There exists a unique belief level $\theta^* \in (0, 1)$ such that it is optimal for the seller in period t (under belief θ_t) to conduct business on A-terms if and only if $\theta_t < \theta^*$, and to use Ω -terms with report-independent transfers otherwise. This implies that the DOSPC is $F \in$*

$\{(A, \dots), (\Omega, \dots, \Omega, A, A, \dots)\}$. There exist initial belief levels θ_0 such that either type of sequence can be optimal in equilibrium.

Proof First, observe that:

$$\lim_{\theta_t \rightarrow 1} V_t^{\Omega, f}(\theta_t, \theta_0) = \lim_{\theta_0 \rightarrow 1} V_t^{\Omega, f}(\theta_0, \theta_0) = \frac{(\delta_S \gamma \lambda)^{\frac{1}{\alpha}} \bar{\pi}^A}{1 - \delta_S} > \lim_{\theta_t \rightarrow 1} V_t^A(\theta_t, \theta_0) = 0.$$

Moreover:

$$\begin{aligned} V_t^A(0, \theta_0) &= \frac{1}{1 - \delta_S \gamma} \left[\bar{\pi}^A + \delta_S(1 - \gamma)V_{t+1}(\theta_0, \theta_0) \right], \quad \text{and} \\ V_t^{\Omega, f}(0, \theta_0) &= \frac{1}{1 - \delta_S \gamma} \left[(\delta_S \gamma)^{\frac{1}{\alpha}} \bar{\pi}^A + \delta_S(1 - \gamma)V_{t+1}(\theta_0, \theta_0) \right], \end{aligned}$$

from which it is easy to infer that $V_t^A(0, \theta_0) > V_t^{\Omega, f}(0, \theta_0)$ holds. Next, note from the proof of Proposition 3 that V_t^A decreases linearly in θ_t . Moreover, due to the analogous functional structure of $V_t^{\Omega, f}(\theta_t, \theta_0)$ in (S.5) and of $V_t^{\Omega}(\theta_t, \theta_0)$ in (A.7) it follows by the same line of argument as in the proof of Proposition 3 that $V_t^{\Omega, f}(\theta_t, \theta_0)$ decreases and is convex in θ_t .

As a consequence, we can conclude that there exists a unique $\theta^* \in (0, 1)$ such that $V_t^{\Omega, f} > V_t^A$ if and only if $\theta_t > \theta^*$. Note that θ^* is a function of θ_0 . From the limiting properties derived above it follows that there always exist values $\theta_0 \in (0, 1)$ such that both sequences, (A, \dots) and $(\Omega, \dots, \Omega, A, A, \dots)$, can be part of an optimal equilibrium. In sequence $(\Omega, \dots, \Omega, A, A, \dots)$, the period in which payment terms transition to A-terms is the first for which $\theta_t < \theta^*$ holds. ■

Figure S.2 summarizes the results of Lemma S.1 graphically. While the level of θ^* at which the two value functions intersect is θ_0 -specific, depending on whether $\theta_0 \leq \theta^*$ holds Ω -terms will be used in the initial periods of a trade relationship or not. It follows from the proof of Lemma S.1 that when θ_0 is close enough to the full information limit the seller will employ A-terms throughout, while Ω -terms will be used in the initial transactions if the share of myopic buyers is sufficiently large.

The figure depicts the situation where $\theta_0 > \theta^*$. In this case, after initial usage of Ω -terms the seller switches to A-terms beginning with the first period t in which $\theta_t^{\Omega} < \theta^*$ holds. The bullet points on the value functions indicate the steps of the belief updating process. In the plotted example, the seller's payment contract choice switches from Ω - to A-terms in period $t = 2$ of the trade relationship.

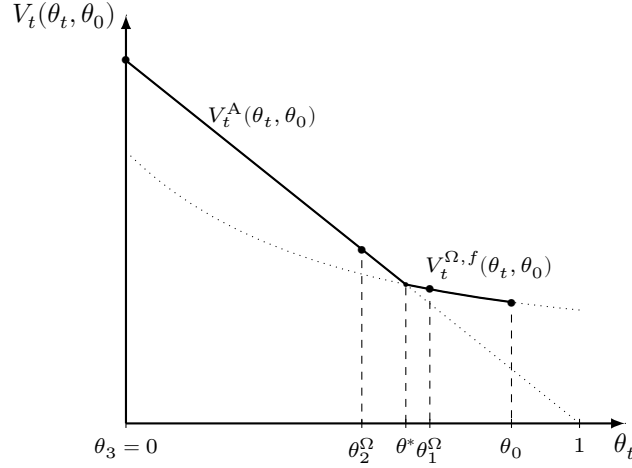


Figure S.2: Value functions and belief evolution under private information when $\theta_0 > \theta^*$.

S.3 Positive buyer outside option

In this Appendix, we extend the analysis of section 3 to the situation where the buyer has a constant per-period outside option $\omega > 0$ that she receives when deciding not to engage in trade with the seller. Consistent with the strategy profile outlined in the main text, we assume that the seller ends the trade relationship permanently whenever the buyer decides to take the outside option instead of engaging in trade. After outlining all the differences to the analysis of the main text for the situation when $\omega > 0$ we summarize our findings in Proposition S.2 at the end of this Appendix.

Cash in advance terms

First, consider the case where $F = (A, \dots)$. With the outside option available, the participation constraint of a buyer of type $j \in \{M, B\}$ in period t is:

$$\delta_j \mathcal{R}(Q_t, r_E) - T_t \geq \omega. \quad (\text{PC}_{j,t}^{A,\omega})$$

By the same logic as in the case of the main text where $\omega = 0$ the myopic buyer's participation constraint, $(\text{PC}_{M,t}^{A,\omega})$, cannot be fulfilled for any $T_t > 0$. Consequently, the myopic buyer will never accept any contract on A-terms and the seller offers a *separating contract* that only a patient buyer accepts. Buyer liquidity constraints are unaffected by the size of the outside option.

As a consequence, the seller sets the transfer to $T_t^{A,\omega} = \delta_B \mathcal{R}(Q_t, \gamma) - \omega$ such that $(\text{PC}_{B,t}^{A,\omega})$ binds and extract the maximal amount of rents from the patient buyer. Acknowledging this transfer strategy, the seller's trade volume choice solves the following maximization problem:

$$Q_t^{A,\omega} \equiv \arg \max_{Q_t} \pi_t^{A,\omega} = T_t^{A,\omega} - cQ_t,$$

which results in the following trade volume and stage payoffs:

$$Q^{A,\omega} = \left(\frac{\gamma \delta_B}{c} \right)^{\frac{1}{\alpha}}, \quad \bar{\pi}^{A,\omega} \equiv \pi_t^{A,\omega} = Q^{A,\omega} \frac{c\alpha}{1-\alpha} - \omega.$$

Since trade volume $Q^{A,\omega}$ and stage payoffs $\bar{\pi}^{A,\omega} = \bar{\pi}^A - \omega$ do not vary with belief θ_t a necessary and sufficient condition for seller participation in the trade relationship is $\omega < \bar{\pi}^A$ who otherwise would refrain from engaging in trade altogether. For the following, we assume that this condition holds. The dynamic programming problem is structurally identical to the one derived in the main text. The seller's ex-ante expected payoffs are adapted as follows:

$$\Pi^{A,\omega} = \frac{(1 - \theta_0)\bar{\pi}^{A,\omega}}{(1 - \delta_S)(1 - \gamma\theta_0\delta_S)}.$$

Equivalently to Lemma 1, the non-shipment deviation of the seller can be ruled out as summarized in the following Lemma S.2. For notational convenience we assume that $\omega \equiv w\bar{\pi}^A$ in the following, where $w \in [0, 1)$ needs to hold to satisfy seller trade participation.

Lemma S.2. *Suppose that $\alpha > \tilde{\alpha}^\omega \in (0, 1)$ and $\omega \in [0, \bar{\pi}^A]$. Then there exists a repeated game equilibrium that maximizes the seller's ex-ante expected payoffs under cash in advance terms, $\Pi^{A,\omega}$, for all $\delta_S \geq \tilde{\delta}_S^\omega \in (0, 1)$.*

Proof Equivalently to the proof of Lemma 1, at the Production and Shipment stage (6) of any period the seller will not deviate from the contract if and only if:

$$-cQ^{A,\omega} + \delta_S \frac{(1 - \theta_0 + \gamma\theta_0(1 - \delta_S))\bar{\pi}^{A,\omega}}{(1 - \delta_S)(1 - \gamma\theta_0\delta_S)} \geq \delta_S \frac{(1 - \theta_0)\bar{\pi}^{A,\omega}}{(1 - \delta_S)(1 - \gamma\theta_0\delta_S)}. \quad (\text{S.6})$$

Observing that $cQ^{A,\omega} = \alpha^{-1}(1 - \alpha)(1 + w)\bar{\pi}^{A,\omega}$ we can simplify (S.6) to:

$$\delta_S \geq \frac{1 - \alpha}{\gamma\theta_0} \frac{1 + w}{1 + (1 - \alpha)w} \equiv \tilde{\delta}_S^\omega.$$

For an equilibrium to exist we need to ensure that $\tilde{\delta}_S^\omega < 1$. This is the case whenever $\alpha > (1 - \gamma\theta_0)(1 + w)/(1 + w(1 - \gamma\theta_0)) \equiv \tilde{\alpha}^\omega \in (0, 1)$ holds. In this situation, the non-shipment deviation of the seller can be ruled if he is patient enough, i.e. when $\delta_S \geq \tilde{\delta}_S^\omega$ holds. ■

Note that $\partial\tilde{\delta}_S^\omega/\partial w > 0$, i.e. the minimum patience level of the seller necessary to sustain trade increases in the buyer's outside option. The reason is that with a higher outside option, the buyer only participates in trade when receiving a larger share of the revenue making it less attractive for the seller to obey the contract and indeed ship the product to the buyer. Asides, the results of Proposition 1 and the corresponding discussion hold analogously for the case where $\omega > 0$.

Open account terms

Next, consider the case where $F = (\Omega, \dots)$. In the presence of the buyer's outside option her participation constraints become:

$$\gamma R(Q_t) - ET_t^\Omega \geq \omega, \quad (\text{PC}_{B,t}^{\Omega,\omega})$$

$$\gamma R(Q_t) - \lambda ET_t^\Omega \geq \omega, \quad (\text{PC}_{M,t}^{\Omega,\omega})$$

where $(\text{PC}_{B,t}^{\Omega,\omega})$ is the participation constraint of the patient buyer and $(\text{PC}_{M,t}^{\Omega,\omega})$ that of the myopic buyer, respectively. Conditional on the outside option not being too large (we derive an explicit constraint below), the screening properties of open account payment terms and the belief

updating process remain unaffected when compared to the main text. As under A-terms, the liquidity constraints are unaffected in the presence of the outside option. However, the buyer's incentive constraints that ensure the payment of the transfer must be adapted in order to account for the outside option:

$$-T_t^{\Omega,l} + \frac{\delta_B}{1-\delta_B}[\gamma R(Q_t) - ET_t^{\Omega}] \geq \frac{\omega}{1-\delta_B}, \quad (\text{IC}_{B,t}^{\Omega,l,\omega})$$

$$-T_t^{\Omega,h} + \frac{\delta_B}{1-\delta_B}[\gamma R(Q_t) - ET_t^{\Omega}] \geq \frac{\omega}{1-\delta_B}. \quad (\text{IC}_{B,t}^{\Omega,h,\omega})$$

Equivalently to Lemma 2, the following Lemma S.3 derives the seller's optimal transfer strategy when $\omega \geq 0$. The Lemma also shows that an additional constraint on the size of the outside option is required to ensure seller participation in the trade relationship.

Lemma S.3. *Under Ω -terms, the seller participates in the trade relationship for all beliefs $\theta_t \in [0, \theta_0]$ if $\omega \in [0, \omega']$ and sets transfers $T_t^{\Omega,l,\omega} = 0$ and $T_t^{\Omega,h,\omega} = [\delta_B \gamma R(Q_t) - \omega] / (1 - \delta_B(1 - \gamma))$ in this situation. Thereby, he rules out the buyer bankruptcy risk, makes the patient buyer indifferent between paying and not paying the agreed upon transfer in any revenue state and maximizes his own payoffs.*

Proof As in Lemma 2, we require $(\text{LC}_{B,t}^{\Omega,l})$ to bind and set $T_t^{\Omega,l,\omega} = 0$. This allows us to rewrite $(\text{PC}_{B,t}^{\Omega,\omega})$ and $(\text{IC}_{B,t}^{\Omega,h,\omega})$ as:

$$T_t^{\Omega,h} \leq R(Q_t) - \frac{\omega}{\gamma} \equiv T^*, \quad (\text{PC}_{B,t}^{\Omega,\omega})$$

$$T_t^{\Omega,h} \leq \frac{\delta_B \gamma R(Q_t) - \omega}{1 - \delta_B(1 - \gamma)} \equiv T_t^{\Omega,h,\omega}. \quad (\text{IC}_{B,t}^{\Omega,h,\omega})$$

Note that $(\text{IC}_{B,t}^{\Omega,h,\omega})$ binds whenever $T^* > T_t^{\Omega,h,\omega} \Leftrightarrow \omega < \gamma R(Q_t) / (1 - \gamma)$ holds. Seller participation in trade requires $T_t^{\Omega,h} > 0$ (he would make a loss otherwise). In this context, it is also necessary that $T^* > 0 \Leftrightarrow \omega < \gamma R(Q_t)$ holds, which ensures that $T^* > T_t^{\Omega,h,\omega}$ on the equilibrium path. Consequently, $(\text{IC}_{B,t}^{\Omega,h,\omega})$ is indeed the binding constraint and $T_t^{\Omega,h} = T_t^{\Omega,h,\omega}$ in equilibrium.

Acknowledging the equilibrium transfers derived above, the seller sets $Q_t^{\Omega,\omega}$ to maximize:

$$Q_t^{\Omega,\omega} \equiv \arg \max_{Q_t} \pi_t^{\Omega,\omega} = \delta_S \Lambda_t \gamma T_t^{\Omega,h,\omega} - c Q_t.$$

This gives $Q_t^{\Omega,\omega} = Q_t^{\Omega}$ and:

$$\pi_t^{\Omega,\omega} = \pi_t^{\Omega} - \frac{\delta_S \Lambda_t \gamma}{1 - \delta_B(1 - \gamma)} \omega.$$

To achieve comparability to the main text outcomes, our aim is to constrain ω such that the seller finds it profitable to trade with the buyer in every period (i.e. for every belief θ_t). This is the case if and only if:

$$\forall t \geq 0 : \quad \pi_t^{\Omega,\omega} > 0 \quad \Leftrightarrow \quad \omega < \delta_B \gamma R(Q_t^{\Omega,\omega}) - \frac{1 - \delta_B(1 - \gamma)}{\delta_S \Lambda_t \gamma} c Q_t^{\Omega,\omega} \equiv \tilde{\omega}.$$

Since $\tilde{\omega} \in (0, \gamma R(Q_t^{\Omega,\omega}))$ and $\partial \tilde{\omega} / \partial \theta_t < 0$ a necessary and sufficient constraint to ensure seller participation in all periods is $\omega < \tilde{\omega}|_{t=0} \equiv \omega'$. ■

The seller's ex-ante expected payoffs are derived from a programming problem that is fully analogous to the main text and are given as:

$$\Pi^{\Omega, \omega} = \frac{1 - \delta_S \lambda}{1 - \delta_S \lambda - \delta_S \theta_0 (1 - \lambda)} \bar{\pi}^{\Omega, \omega} \sum_{t=0}^{\infty} \delta_S^t \Lambda_t^{\frac{1}{\alpha}} (1 - \theta_0 (1 - \lambda^t)),$$

where $\bar{\pi}^{\Omega, \omega} = \bar{\pi}^{\Omega} - \delta_S \gamma \omega / (1 - \delta_B (1 - \gamma))$. The results of Proposition 2 and the corresponding discussion hold analogously for the case where $\omega > 0$.

We finish the discussion of the non-zero buyer outside option by summarizing the results of the model extension in the following Proposition.

Proposition S.2. *Suppose that instead to engaging in trade with the seller the buyer can decide to obtain a per-period outside option $\omega \in [0, \omega']$. A larger outside option allows the buyer to keep a larger revenue share in every period due to smaller equilibrium transfer levels and to realize larger transaction payoffs. At the same time, the seller's learning process about the buyer's type and relationship stability remain unaffected which reinforces the importance of the trade-offs identified in section 3.3.*

Proof Note that $\bar{\pi}^A > \tilde{\omega}$, implying that $\omega < \omega'$ is a sufficient constraint on the outside option for both, Lemma S.2 and S.3 to be applicable. The remaining points follow from the discussion in the text above. ■