"A Solution to the Palm–3Com Spinoff Puzzles" *

Martin Cherkes, cherkes@princeton.edu
Princeton University

Charles M. Jones
Columbia Business School (published posthumously)

Chester S. Spatt, cspatt@andrew.cmu.edu
Tepper School of Business, Carnegie Mellon University
National Bureau of Economic Research

Abstract

This paper revisits the relative pricing of Palm and 3Com shares in 2000. We offer a simple rational explanation of the Palm/3Com price relationship before Palm's spinoff is completed. Lending fees and spinoff uncertainty are crucial to understanding the relative levels and co-movement of Palm and 3Com share prices. We use Palm's post-spinoff forward prices (calculated from the market prices of calls and puts) and model the spinoff uncertainty in valuing 3Com. Considering forward pricing and spinoff uncertainty resolves many of the observed pricing puzzles, including the sharp change in relative price behavior once the spinoff uncertainty is resolved after trading on May 8, 2000.

Keywords: Market efficiency, lending fees, spinoff uncertainty, forward pricing, options, arbitrage.
JEL Codes: G12, G14, G40.

This version: June 9, 2024

*We wish to thank Franklin Allen, Andrew Ang, Jonathan Berk, Patrick Bolton, Mark Broadie, Charles Calomiris, Joey Engelberg, Diego Garcia, Nicolae Gârleanu, Larry Glosten, David Goldreich, Carole Gresse, Lars Lochstoer, Christopher Polk, Jacob Sagi, Michael Schill, Robert Stambaugh, Paul Tetlock, and participants at presentations at BI Norwegian Business School, Carnegie Mellon, Columbia, Dauphine, Fudan U., IDC Herzliya, Lausanne, MIT, Oxford, Princeton, the Stockholm School of Economics, the University of Utah, the Vienna Graduate School of Finance, the American Finance Association meetings, the European Finance Association meetings, the Financial Intermediation Research Society, the NBER Behavioral Finance group, the Notre Dame Conference on Current Topics in Financial Regulation, the Q-Group, and the Tel Aviv Finance Conference for helpful comments. We dedicate this paper to the memory of Charles Jones.

"A Solution to the Palm–3Com Spinoff Puzzles" *

Abstract

This paper revisits the relative pricing of Palm and 3Com shares in 2000. We offer a simple rational explanation of the Palm/3Com price relationship before Palm's spinoff is completed. Lending fees and spinoff uncertainty are crucial to understanding the relative levels and co-movement of Palm and 3Com share prices. We use Palm's post-spinoff forward prices (calculated from the market prices of calls and puts) and model the spinoff uncertainty in valuing 3Com. Considering forward pricing and spinoff uncertainty resolves many of the observed pricing puzzles, including the sharp change in relative price behavior once the spinoff uncertainty is resolved after trading on May 8, 2000.

A Solution to the Palm-3Com Spinoff Puzzles

A bedrock principle of modern financial economics is the efficiency of market pricing and the absence of arbitrage (Ross (1976, 1978 and 2004)). However, in an important challenge to this paradigm, Lamont and Thaler (2003a, 2003b) claim and provide evidence suggesting that asset prices are sometimes extremely inefficient, offering traders opportunities to make large profits with almost no risk. Their most celebrated example is in the tech stock space, based on the spinoff of Palm from 3Com in 2000. After the carve-out of Palm and the IPO of 5% of its shares, 3Com still owned the remaining 95% of Palm. After extrapolating the market valuation of the traded Palm shares to the remaining 95% of Palm, the total stock market value of 3Com would be much lower than 3Com's holdings of Palm. In the Wall Street lingo of spinoffs, the "stub" or remaining value of 3Com without the value of Palm would be negative, and considerably so. Can a parent really be worth less than one of its subsidiaries, especially when the subsidiary is about to be spun off? At its most general level, Palm-3Com has been interpreted as an apparent violation of the law of one price, leading to questions about the ability of the marketplace to undertake basic valuation arithmetic. This can be seen in Lamont and Thaler's (2003b) paper title, "Can the Market Add and Subtract? Mispricing in Tech Stock Carve-outs."[1] In light of the striking nature of the Palm-3Com example and the wide attention paid to it,[2] a fully rational reconciliation of the evidence seems like a difficult challenge. However, this paper shows that a model with uncertainty associated with

[1]The 3Com-Palm example is one of several situations in which the value of the parent is nominally less than the value of the subsidiary (e.g., Lamont and Thaler (2003b), Cornell and Liu (2001), Schill and Zhou (2001) and Mitchell, Pulvino, and Stafford (2002)).

[2]This Palm-3Com situation was discussed contemporaneously in such outlets as the *New York Times* and *Wall Street Journal*, and the event has been subject to considerable academic study. Even now, more than two decades later, there are frequent references to the episode in the popular and academic press.

the spinoff, combined with shorting constraints, can indeed explain the relative levels and co-movements between Palm and 3Com share prices.

Lamont and Thaler (2003a, 2003b) claim that the price of 3Com should be at least 1.5 times the per-share price of Palm, because the spin-off would provide approximately 1.5 shares of Palm for every share of 3Com held (1.525 shares, to be precise). In Lamont and Thaler (2003b), they write:

> Since the price of 3Com's shares can never be less than zero (equity values are never negative), here the law of one price establishes a simple inequality: the price of 3Com must be at least 1.5 times the price of Palm. (p. 230)

In fact, they argue more stridently that (p. 231):

> We do not need to agree on a model of asset pricing to agree on the proposition that one share of 3Com should be worth at least 1.5 shares of Palm.

They claim that the observed relative pricing of Palm and 3Com is "ludicrous," because the "stub" value of a strongly profitable 3Com was negative $22 billion (!) at the close on the day of the Palm IPO. They conclude that there must be considerable irrationality present in the market. To explain why anyone would buy the overpriced security (Palm) they state:

> One needs investors who are (in our specific case) irrational, woefully uninformed, endowed with strange preferences, or for some other reason willing to hold overpriced assets. We shall refer to these conditions collectively as "irrational," but they could be anything that causes a downward-sloping demand curve for specific stocks (despite the presence of cheaper and nearly identical substitutes). (p. 231)

We disagree. Most of our analysis focuses on a large and important friction: the Palm shares owned by 3Com cannot be loaned. Lending would otherwise be very valuable in this case, based on the underlying short-sale constraints. We point out that after the IPO and before the "no action" period ends, there are two quite different types of Palm shares:

- Type 1-the 5% of Palm that has been floated and is freely traded and
- Type 2- the 95% of Palm shares that are still held by 3Com.

The Type 1 shares reflect the value of lending fees that an owner can collect from lending the Palm shares at high lending fees (at an annualized rate of up to 60%!). The Type 2 shares cannot be loaned, and their value should be equal to the PV of a prepaid forward on a Palm share at the spin-off date, assuming the spin-off goes through, averaged with the value of those shares if the spinoff is not completed.

The main generator of the apparent "puzzles" is the (inappropriate) use of valuation of the first type to value the second type of shares. Here, we provide both direct measurement of the cost of borrowing (through direct data on lending fees) and the PV of a prepaid forward on a Palm share. The latter is measured indirectly through estimates inferred from Palm's option (forward) prices. Additionally, our model framework shows that the co-movement between the share prices of Palm and 3Com and the relative share price levels should not follow the naïve 1.5:1 ratio but should reflect these frictions. Furthermore, these co-movements and relative price levels should change over time and especially with resolution of uncertainty about the spinoff in early May 2000. The observed relative valuation of Palm and 3Com and changes in the co-movement of Palm and 3Com at the resolution of uncertainty are consistent with our framework rather than being puzzling. In

contrast to the interesting title and conclusions of Lamont and Thaler (2003b), the evidence turns out to be consistent with very sophisticated capital markets.

1. A review of the Palm-3Com episode

At the end of 1999, 3Com, which was mainly a producer of computer networking equipment, began the process of spinning off its wholly-owned subsidiary Palm, Inc., and on March 2, 2000 about 23 million Palm shares (about 5% of the company—the Type 1 shares) were offered to the public in an initial public offering (IPO). Palm was mainly known for its handheld devices, especially the Palm Pilot (which was something akin to the iPhone of its era); in fact, Palm was planning a handheld device with a phone several years before Steve Jobs envisioned the iPhone. Thus, Palm's IPO attracted a great deal of interest from investors, and it is easy to see why many investors would be strongly optimistic about Palm's growth prospects. By the end of the first day of trading, Palm's closing share price was about $95, giving it a market value of $54 billion, while 3Com's closing price was about $81, making its market value $28 billion.

However, 3Com still owned 532 million Palm shares (the Type 2 shares) valued at approximately $50 billion (assuming that Type 1 and Type 2 shares are valued equally) implying that the value of 3Com's non-Palm assets (its "stub" value) was a staggering negative $22 billion at the close on March 2, the IPO date! 3Com had no debt, held more than $1 billion in cash, and had a substantially positive market value before acquiring Palm. Furthermore, 3Com ended up with a $5 billion market capitalization the day after Palm's spinoff was completed later that year. Obviously, the financial market recognized the considerable positive residual value in 3Com. How then can 3Com's stub value be negative on March 2, the IPO date? We argue that there is no paradox, once one recognizes that Palm shares held outside of 3Com are quite different from Palm shares held

inside of 3Com. Therefore, the market value of the free-floating Palm shares should not be applied mechanically to the remaining 95% of Palm shares still owned by 3Com.

The most obvious difference between the two types of Palm shares is in their ability to be loaned to potential short sellers. Once the IPO settles and shares are distributed to IPO purchasers, owners of floating Palm shares are free to lend their shares, while 3Com as majority owner cannot lend out its unregistered Palm shares.[3] The presence of a non-zero lending fee establishes the following no-arbitrage relationship between the spot price of a Palm share and its forward price on the expected spinoff date, which is very different from the equation proposed by Lamont and Thaler

Spot price of Palm = E[PV[Palm lending fees from now to the forward date]] + PV[forward price of Palm].

On the other hand, the share price of 3Com should be equal to the value of its non-Palm businesses (the "stub value") plus 1.5 times the present value of the forward price of Palm, as every share of 3Com contains approximately 1.5 shares of Palm, and the latter will be distributed to 3Com shareholders on the spinoff date. In other words, the valuation of a traded Palm share should include the capitalized value of the lending fees that are available to owners of Palm shares, while the valuation of the remaining shares (owned by 3Com) does not reflect those lending fees at all

[3] The Palm shares held by 3Com are not registered and thus are not fungible with Palm shares held by the public. Unless the shares are registered, 3Com cannot legally lend or sell to the public the shares that it owns. If it sought to do a follow-on offering of some or all of its Palm shares before a spinoff or register the shares in order to lend them out, 3Com would have to file an S-1 registration statement with the SEC and go through the entire registration process, which would be equivalent to the steps required for an IPO.

(Duffie, Gârleanu and Pedersen (2002)). This introduces a potentially large wedge between the valuation of 3Com's owned Palm shares and Palm's floating shares.[4]

This basic idea is present in a number of theoretical models. Generally, if investors have heterogeneous valuations or beliefs and short-selling is costly or difficult, asset prices differ from the frictionless benchmark. Examples of such models include Miller (1977), Harrison and Kreps (1978), Duffie, Gârleanu, and Pedersen (2002), and Scheinkman and Xiong (2003). In all of these disagreement models, prices are determined by optimists (agents with high valuations), as the shorting constraints imply that pessimists (agents with low valuations) are less able to offset the optimists' asset demands with a short position. Hong, Scheinkman, and Xiong (2006) note that all else equal, a small float (that is, when there are few shares available to trade) leads to a greater divergence in prices from the frictionless benchmark (see also Saffi and Siggurdsson (2011)). When shorting costs are explicit, the size of the divergence is correlated with the capitalized present value of these expected costs (see for example, Ofek and Richardson (2003), Jones and Lamont (2002), and Cremers and Weinbaum (2010)).

Throughout most of the paper, we work with a simple model where the costly shorting and uncertainty about the spinoff cause the apparent (but not actual) departures from efficient pricing. To correctly value 3Com in such a world, we must use the value of a Palm share that excludes the capitalized value of lending fees. Here, the importance of the spinoff date comes into focus. All

[4] The lending fees are substantial: our data show that annualized Palm lending fees were as high as 60%. This is unsurprising given the extremely small lendable supply of Palm shares due to the minuscule float of Palm shares between the IPO and the completion of the spinoff. D'Avolio (2002, p. 273) finds that in 2000, "less than 1% of stocks (roughly seven per month) on loan become extremely special, demanding negative rebate rates (i.e., loan fees in excess of the risk-free rate). Krispy Kreme Doughnuts … [is an example] … of such stocks, exhibiting [annualized] loan fees as high as 50% …." Additional data on the relationship between lending fees, put-call parity, and future stock returns can be found in Ofek and Richardson (2003); Jones and Lamont (2002) analyze historical lending fee data.

else equal, the capitalized value of non-zero lending fees depends on the spinoff date: a shorter time to the spinoff date translates into a smaller present value of earned lending fees, whereas a distant spinoff date translates into a larger present value of earned lending fees.

A simple example may be instructive. Assume a negative rebate rate of 28% per year on the Palm shares, with a spinoff date one year hence. This is equivalent to a 34% lending fee per year if the risk-free rate is 6%. If Palm's share price is $100, this reflects $28 of lending fees (ignoring compounding in this example) and an intrinsic value (alternatively, the value of a Palm share retained by 3Com) of $72. In addition, traded Palm shares are more volatile than Palm shares held by 3Com, because the traded Palm shares are grossed-up in value by the capitalized lending fees. The presence of lending fees also changes the co-movement of returns on Palm and 3Com. For example, if the share price of Palm changes by $1 and rebate rates do not change, the value of a 3Com share should increase by $0.72 * 1.5 = $1.08, not $1.50.

Now assume that the spinoff date is moved half a year closer without other changes. The capitalized wedge is much smaller: now about 14% of the value of a traded Palm share is due to the present value of lending fees. Furthermore, a $1 change in the Palm share price should increase the share price of 3Com by $0.86 * 1.5 = $1.29, closer to but still less than the first-blush expectation of $1.50.

As the example shows, the spinoff time is critical in assessing Palm's contribution to 3Com's valuation. If the spinoff date is sufficiently distant, the wedge between the prices of traded Palm shares and Palm shares held by 3Com can be arbitrarily large. As we show, this wedge is equivalent to the difference between shares purchased today and shares purchased today for forward delivery on the spinoff date (a "prepaid forward"). Thus, traded forwards can be used to gauge the market's

expectations about the date of the spinoff and the lending fees expected at various intervals in the future.[5] In this paper, we calculate forward prices at various dates using calls and puts to assess the market's expectations about the timing of the spinoff and future lending fees.

When we adjust in this manner the various paradoxes disappear. The correctly-calculated stub value is always positive (Section 4), and Palm's synthetic forward price behavior is consistent with observed lending fees and the significant uncertainty about the spinoff that is later resolved (Section 6). The apparent violations of put-call parity and the law of one price also disappear (Section 7). More importantly, we derive a novel theoretical relationship for the co-movement of the share prices of Palm and 3Com (Section 2) and then test it against data: Section 3 tests the Palm/3Com relationship and Section 5 compares the model-implied lending fees vs. actual lending fees. The empirical tests strongly support our theory.

We conclude that markets correctly priced the uncertainty associated with Palm's spinoff and the size of Palm's future lending fees. We also conclude that no-arbitrage relationships prescribed by classical finance theory were satisfied during the Palm-3Com episode. In the last section prior to the conclusion (Section 9), we discuss the single remaining puzzle: there must be investors who choose or are forced to hold traded Palm shares without lending them out. For these investors, it might appear that holding 3Com is a dominant strategy. However, holding Palm is rational if an

[5] Analogously, in commodity valuation analyses the forward price of a commodity does not reflect its use value prior to the expiration of the forward contract, while the spot price of a commodity reflects the value of the option to "use" the commodity in "stock-out" states prior to the expiration of the forward contract. The use value of a commodity can be interpreted as "convenience yield," as illustrated by the equilibrium analysis in Routledge, Seppi, and Spatt (2000). The lending fees for Palm reflect the overall "use" values for direct ownership of a share of Palm even prior to the date of spinoff, but these are not reflected in the implicit ownership of Palm through ownership of 3Com. Absent storage costs, this results in a downward sloping forward curve for commodities. See also the discussion of convenience yield in Cochrane (2003).

investor is sufficiently pessimistic about the likelihood of the spinoff and thus convergence between Palm and 3Com.

Of course, there is a possible "arbitrage" trade: 3Com states that it plans to spin off the rest of Palm by December 2000 at a rate of approximately 1.5 Palm shares for every 3Com share. At the first-day closing price of $95, 1.5 shares of Palm are worth 1.5 * 95= $143, while a 3Com share trades at $81.81. If an investor buys one share of 3Com and shorts 1.5 Palm shares, she can pocket the difference of over $61 and wait until the spinoff to cover the short position by returning 1.5 spinoff shares of Palm to the share lender.

But this discussion ignores two important factors: the cost to borrow Palm shares, and the uncertainty of the spinoff. We describe in the Appendix our unique dataset (provided by a major broker) showing that Palm lending fees were about 25% annualized between April 10 and May 9 and about 50% annualized after May 9. Separately, Mitchell, Pulvino, and Stafford (2002) locate 84 cases of spinoffs with "negative stub" values. In 30% of these cases, prices did not converge for some reason, such as cancellation of the spinoff, repurchase of subsidiary shares by the parent, or a takeover. Mitchell, Pulvino, and Stafford conclude that "… significant risk [is] faced by an arbitrageur attempting to profit from negative stub values …[as] the path to convergence can be long and bumpy... [T]he length of the interval over which convergence will occur is unknown. Increasing the length of the path reduces the arbitrageur's return… Increasing the volatility of the path increases the likelihood that the arbitrageur will be forced to terminate the negative-stub-value trade prematurely... If the arbitrageur is unable to maintain his short position, he will be

forced to terminate the trade" with the potential for substantial losses. These facts indicate that the proposed relative-value position can be costly and risky and is thus not an arbitrage trade.[6]

Overall, after considering the frictions and impediments to short-selling Palm, our empirical analyses suggest that the market approached the relative valuation of 3Com and Palm in a highly sophisticated manner.

2. Modeling the Palm/3Com price relationship when the spinoff is uncertain

2.1 Uncertainty about the spinoff date and its resolution on May 8

The Palm spinoff was contractually governed by the December 12, 1999 Master Separation and Distribution Agreement between 3Com Corp. and Palm Computing Inc. The agreement stated that 3Com's board (in its sole discretion) could expedite or delay the spinoff date. The board could also cancel the spinoff if it deems (in its sole discretion) that "… result [of Palm's spinoff and] the Distribution [of shares could have]… a material adverse effect on 3Com."[7] Among other conditions, the spinoff was dependent on a favorable IRS ruling that the company could distribute the remaining 532 million shares without incurring any tax liability. The IRS ruling was expected

[6] On the effects of a long and bumpy path to convergence for such a trade, see for example Kondor (2009).

[7] Section 4.3 of the agreement states: "3Com currently intends, following the consummation of the IPO, to complete the Distribution by December 1, 2000. 3Com shall, in its sole and absolute discretion, determine the date of the consummation of the Distribution and all terms of the Distribution. …3Com may … modify or change the terms of the Distribution, including, without limitation, by accelerating or delaying the timing of the consummation of all or part of the Distribution." Section 4.4 of the agreement states

"The following are conditions that must take place prior to the consummation of the Distribution. The conditions are for the sole benefit of 3Com and shall not give rise to or create any duty on the part of 3Com or the 3Com Board of Directors to waive or not waive any such condition.

(a) IRS Ruling. 3Com shall have obtained a private letter ruling from the Internal Revenue Service in form and substance satisfactory to 3Com (in its sole discretion) … [that] the transfer by the 3Com Group to the Palm Group of the property … will qualify as a reorganization under Sections368(a)(1)(D) and 355 of the Code;

(d) No Material Adverse Effect. No other events or developments shall have occurred subsequent to the IPO Closing Date that, in the judgment of the Board of Directors of 3Com, would result in the Distribution having a material adverse effect on 3Com or on the stockholders of 3Com."

in mid–September 2000, but the 3Com board could cancel the spinoff even if all stated conditions were met. For example, an offer from another firm to acquire 3Com could be treated as having a "material adverse effect" against the Distribution. Consequently, the spinoff was uncertain. Mitchell, Pulvino, and Stafford (2002) document that this was a common feature of the many carve-outs and spinoffs of that era.

The uncertainty was resolved in the after-hours of May 8 when 3Com unexpectedly announced that a positive Internal Revenue Service ruling occurred earlier than expected and that 3Com "will distribute on July 27th … months earlier than scheduled -- about 1.5 Palm shares for each 3Com share."[8]

2.2 The case of a known spinoff date

Let $F_{T,t}$ denote the time t prepaid forward price of a Palm share with delivery date T, let S_t denote the time t price of Palm, and let T^* be the (known) spinoff date. A buyer of a 3Com share pays up front for the 3Com stub plus the forward claim on 1.525 Palm shares. Thus, the time t value of 3Com is the value of the stub plus a prepaid date T^* forward on 1.525 Palm shares[9]

$$S_{3COM,t} = STUB_t + 1.525\ \mathrm{PV}\left[F_{T^*,t}\right] \quad (1)$$

For simplicity, we henceforth round the spinoff ratio to 1.5. Assume for simplicity a constant continuous risk-free rate R and continuous constant "lending fees" δ for all $t < T^*$.[10] Then:

[8] See "Stock Watch: Buyback, Palm Spinoff Plans Drive 3Com" by Nora Macaluso in E-Commerce Times on May 9, 2000.

[9] Compare to Lamont and Thaler (2003b), who argue that the value of a 3Com share should be $S_{3COM,t} = STUB_t + 1.5 * S_t$.

[10] In this article we use R=6.3% as the risk–free rate for reasons explained below.

$$F_{T^*,t} = S_t e^{(R-\delta)(T^*-t)} \quad (2)$$

And

$$PV\left[F_{T^*,t}\right] = S_t e^{-\delta(T^*-t)} \quad (3)$$

We can rewrite this to express the value of a lendable Palm share as the present value of the stream of lending fees up to T^* plus the PV of the T^* forward price

$$S_t = PV(\text{lending fees}_{[t,T^*]}) + PV\left[F_{T^*,t}\right] \quad (4)$$

From (3)

$$PV(\text{lending fees}_{[t,T^*]}) = S_t(1 - e^{-\delta(T-t)}) \quad (5)$$

Palm's contribution to the price of a share of 3Com is $1.5\ PV\left[F_{T^*,t}\right] = 1.5\ S_t e^{-\delta(T^*-t)}$ and (1) becomes

$$S_{3COM,t} = STUB_t + 1.5 S_t e^{-\delta(T^*-t)} \quad (6)$$

We rewrite the latter as

$$S_{3COM,t} = STUB_t + G(T^*, t, \delta) * S_t \quad (7)$$

where $G(T^*, t, \delta)$ measures the contribution of 1.5 3Com-held Palm shares to the valuation of one 3Com share. In this case $G(T^*, t, \delta) = 1.5\ e^{-\delta(T^*-t)}$, which may be quite different from G = 1.5 as claimed by Lamont and Thaler.

2.3 Uncertainty of the spinoff

To model the uncertainty about the spinoff time, we assume for simplicity that T^* is uniformly distributed between two dates, U(a, $a + z$), with a denoting the first possible spinoff date and with $a + z$ denoting the latest possible date of spinoff where $z \geq 0$.

Under uncertainty, equation (1) depends on the expected discounted forward price

$$S_{3COM} = STUB + 1.5E(\mathrm{PV}[\mathrm{F}_{\widetilde{T^*},t}]) \tag{8}$$

in this case with $\widetilde{T^*}$ uniformly distributed[11] over $[a, a + z]$. Integrating over possible stopping times, it can easily be shown that equation (7) continues to hold with

$$G(\delta, a, z) = 1.5\frac{e^{-\delta a}}{\delta z}(1 - e^{-\delta z}) \tag{9}$$

which implies that $\frac{\partial G}{\partial a}<0$ and $\frac{\partial G}{\partial z}<0$. That is, an increase in the time to the earliest possible distribution date a and/or an increase in the length of the spinoff interval measured by z reduces the impact of the Palm share price on S_{3COM}. Similar results can be calculated for other distribution date probability distributions.

Calculating synthetic Palm forwards. Beginning on March 16, 2000, there were active markets in Palm's puts and calls, with May, August, and November expiration dates. We utilize these options to calculate synthetic forwards for these dates.

[11] The tilde sign will be dropped whenever it does not cause ambiguity.

Let $C_t(X,T)$ and $P_t(X,T)$ be the time t value of a European call and put, respectively, with strike price X and maturity T.[12] From put-call parity, the forward price is

$$C(X,T) - P(X,T) = PV(F_T - X). \tag{10}$$

As noted earlier, we use $r = 0.063$ throughout. Solving for F_T

$$F_T = [C(X,T) - P(X,T)]e^{rT} + X. \tag{11}$$

To build a long position in the synthetic forward requires buying the call at the ask price and selling the corresponding put at the bid price. Therefore, the cost of creating a synthetic long forward is

$$F_T^A = [C^A(X,T) - P^B(X,T)]e^{rT} + X. \tag{12}$$

Analogously, the cost of creating a synthetic short forward is

$$F_T^B = [C^B(X,T) - P^A(X,T)]e^{rT} + X. \tag{13}$$

Finally, we define the midpoint between the cost of creating these two positions as:

$$F_T^{MID} = \frac{F_T^B + F_T^A}{2}. \tag{14}$$

3. Empirical verification of the predicted co-movement between Palm and 3Com

[12] Unless specified otherwise, t = 0 and is often omitted. The formula is derived for European options, but the available data are prices of American options, which bias the results against us. Also, Ofek and Richardson (2003) show that the value of the early exercise premium on listed options is typically less than 1% of the underlying share price.

Taking first differences of equation (7) to obtain stationary variables, the same co-movement expression holds in price changes

$$\Delta S_{3COM,t} = \Delta STUB_{\mathrm{t}} + \mathrm{G}(\mathrm{T}^{*}, \mathrm{t}, \delta) * \Delta \mathrm{S}_{\mathrm{t}} \, . \tag{15}$$

As before, $\mathrm{G}(\mathrm{T}^{*}, \mathrm{t}, \delta) < 1.5$ measures the contribution of 1.5 3Com-held Palm shares to the valuation of 3Com. OLS can estimate this relationship as long as innovations to the stub value are uncorrelated with innovations to the value of Palm. We confirm this condition by measuring the correlation between Palm and the 3Com stub in daily log price changes for the three months after the spinoff completion (from July 31 to October 31, 2000). We find that this correlation is statistically and economically indistinguishable from zero (ρ = 0.026, t = 0.206). These OLS regressions are always performed on a single day of intraday transaction price changes to ensure that the *G* function is constant (recall that all else equal, *G* should increase toward 1.5 with the passage of time). To adjust for non-synchronous trading effects, we regress the 3Com price change on the contemporaneous Palm price change along with a small number of leads and lags of the differenced Palm share price, and we report the sum of the slope coefficients as in Dimson (1979).

We measure co-movement between Palm and 3Com at different points in time. This yields an estimator of $\mathrm{G}(\mathrm{T}^{*}, \mathrm{t}, \delta)$ in equation (7), and equation (9) allows us to determine whether the estimates are consistent with plausible values of the parameters *a*, δ, and *z*. Over each interval we study, we find a good fit between our theory and the empirical observations.

3.1 Empirical estimation of $G(T^{*}, t, \delta)$ from March 2 data.

After the IPO was priced overnight, Palm shares started trading at 11:30 a.m. on March 2; we examine the minute-by-minute Palm and 3Com share prices between 11:30 a.m. and 4:00 p.m. that

first trading day. To be precise, we regress one-minute 3Com share price changes on the Palm share price change and three (one-minute) leads and lags of the differenced Palm share price. Summing the seven slope coefficients, we obtain the following co-movement estimates, with Newey-West standard errors (also based on three lags) in parentheses

$$\Delta S_{3COM,t} = \underset{(0.030)}{-0.019} + \underset{(0.15)}{0.44}\,\Delta S_{PALM,t}$$

That is, based on March 2 intraday data, our estimate of $G(\delta, a, z) = 0.44$. This is far from the frictionless 1.5, but is consistent with the parameter triplet $\delta = 0.35, a = 0.4$ years, and z = 7.95 years in equation (9), implying a long expected time to the spinoff and considerable uncertainty about the spinoff time. This also consistent with the evidence in the sample of spinoffs examined by Mitchell, Pulvino, and Stafford (2002), where the average time to convergence is 236 days, the maximum time to convergence is 2,796 days, and in 30% of cases there was no convergence at all.

We graph in Figure 1 the minute-by-minute Palm and 3Com prices between 11:30 a.m. and 4:30 p.m. on March 2. One can see that the markets for Palm and 3Com were in continuous minute-by-minute coordination, that the valuation process was orderly, and that Palm share price declines were contemporaneously reflected in 3Com share prices.

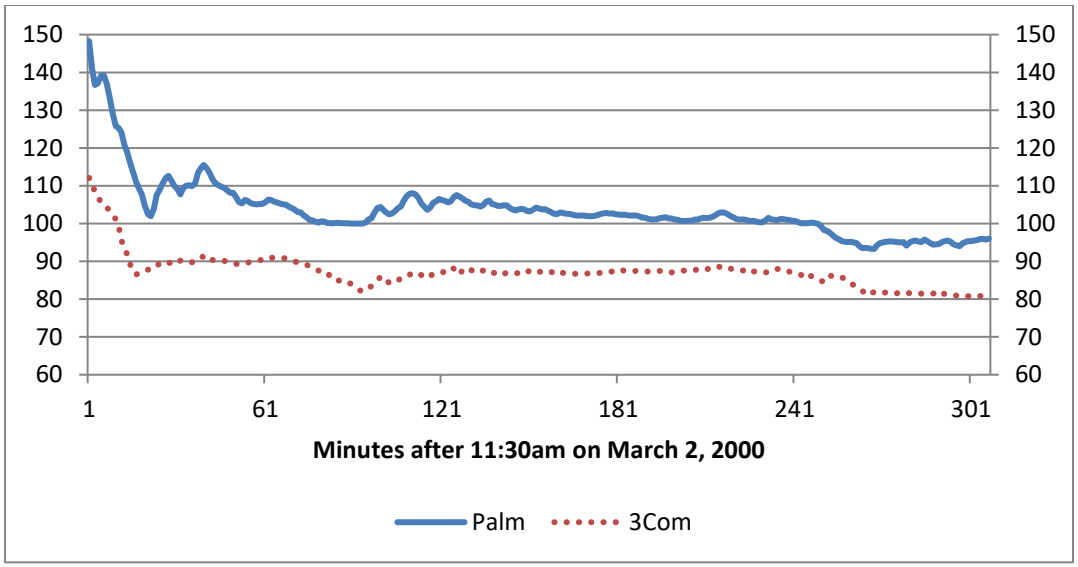


Figure 1: Minute-by-minute share prices of Palm and 3Com after trading opens at 11:30 a.m. on March 2, 2000. This illustrates that markets for Palm and 3Com were orderly and closely coordinated throughout March 2nd.

3.2 The resolution of uncertainty on May 8 and its impact on $G(T^*, t, \delta)$.

After trading closed on May 8, 3Com announced that it had received confirmation from the IRS that the spinoff would be a tax-free event and that it would spin off its shares of Palm on July 27, 2000, well before its original estimated spinoff date of December 2000.[13] The following day, 3Com's share price rose more than 10%, from $43.69 to $48.25. Palm's share price fell almost 10%, from $32.25 on May 8 to $29.13 at the close on May 9. As 3Com still owned 95% of Palm on May 9, how can we explain the opposite movement of Palm and 3Com prices on that date?

The May 8 announcement sharply changed the distribution of the spinoff time, and the uncertainty about the spinoff essentially disappeared. The market learned that a Palm share would earn lending fees only over a much shorter time interval, and thus the capitalized value of these expected lending fees dropped sharply. This implies that, all else equal, the value of a traded Palm share should have

[13] At the same time, 3Com declared a $1 billion open-market share repurchase. This could also influence 3Com's valuation.

and did fall sharply. The 3Com share price response is also sensible to the extent that 3Com shareholders desired a spinoff but had previously harbored significant doubts about whether a spinoff would be completed.

The May 8 announcement removed the uncertainty about the spinoff timing and shortened the expected spinoff time. A quicker spinoff explains why the share price of Palm went down: the expected total future lending fees from owning Palm shares suddenly shrank. In terms of our distributional assumptions, it changed the parameters of the $G(\delta,a,z)$ distribution. At that moment, the parameter a became 0.24 years and z went to zero. If markets are behaving sensibly, the co-movement of Palm and 3Com should also sharply increase after the announcement. For example, the May 9 parameter values ($a = 0.24$ years, $z = 0$, and $\delta = 0.35$) imply a slope coefficient of about 1.38, and this slope coefficient should rise gradually to 1.5 by the July 27 spinoff date.

To determine whether the co-movements between Palm and 3Com reflect this change in the expected spinoff time, we split our sample on May 8, 2000, and investigate the joint daily evolution of Palm's and 3Com's share prices before and after the spinoff announcement. During the March 2 to May 8 period, there is substantial uncertainty about the spinoff date and substantial lending fees on Palm shares, and thus we should expect a relatively small $G(T^*,t,\delta)$, as discussed above. Starting May 9, we should see a much higher $G(T^*,t,\delta)$.

Each day, we regress an error-correction model of 5-minute 3Com transaction price changes on contemporaneous Palm price changes and three leads and lags of Palm price changes, as in Stock and Watson (1993). Figure 2 below reports the average estimated co-movement for each week, with 95% confidence intervals that are based on the daily Newey-West standard errors. The solid line provides model-implied theoretical values for the slope coefficient each week. On May 9, the

theoretical value is 1.38 and increases gradually to 1.5 as the spinoff approaches. Prior to May 9, we calculate the single spinoff date that provides the best mean-squared error fit between the associated theoretical co-movement and the estimated slope using a 35% lending rate. Said another way, we set $z = 0$ and $\delta = 35\%$ and calculate the a (which turns out to imply a spinoff on October 27, 2001) that provides the best fit between $G(\delta,a,z)$ and the estimated slope coefficient for the entire pre-May 9 period.

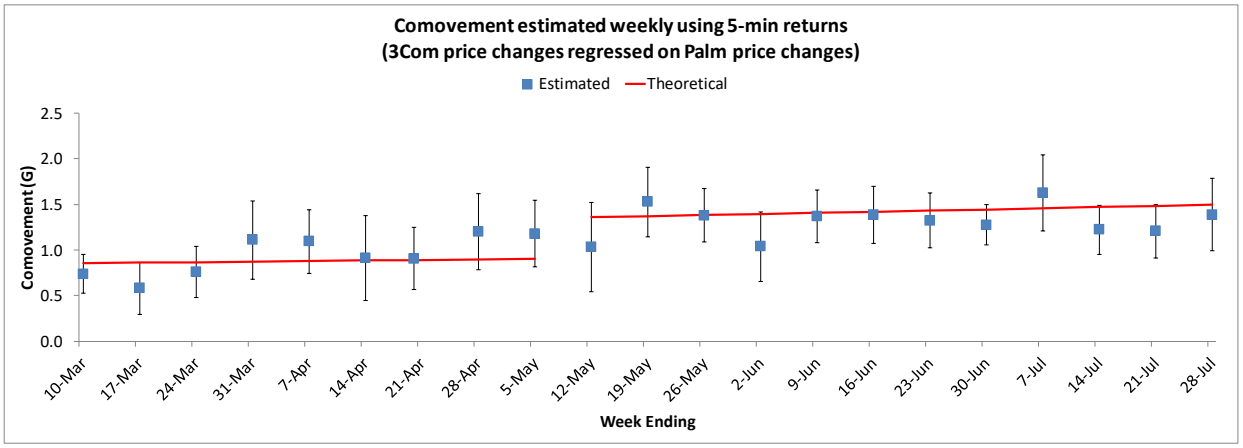


Figure 2. Daily regressions of $\Delta S_{3COM,t} = c + \beta_{-3}\Delta S_{PALM,t-3} + \beta_{-2}\Delta S_{PALM,t-2} + \ldots + \beta_{3}\Delta S_{PALM,t+3}$ using 5-minute transaction price changes. Reported coefficients are weekly averages of daily summed slopes $\beta_{-3} + \beta_{-2} + \beta_{-1} + \beta_0 + \beta_1 + \beta_2 + \beta_3$. Error bars represent 95% confidence intervals based on Newey-West standard errors. The graph illustrates that the co-movement slope increases significantly and shifts regime after May 8th.

Our estimates of $G(T^*,t,\delta)$ in Figure 2 over the whole time period show a distinct change after the announcement that the spinoff is to be moved up: the co-movement slope averages 0.90 before the May 8 announcement and 1.30 afterward. These are statistically different from each other (t = 4.57), indicating that the May 8 announcement represents an important co-movement regime-switch. We also test whether the average weekly estimated slope coefficient differs from the corresponding theoretical slope coefficient, both before and after the May 8 announcement, and we find that we cannot reject this joint null of equality before and after May 8, with a chi-squared

statistic of 29.71 ($p = 0.098$). We conclude that a rational Palm/3Com price relationship as derived above explains their joint share price behavior well.

4. Empirical analysis of 3Com's stub value

Equation (7) shows that 3Com's stub value, properly calculated, is equal to the price of 3Com minus 1.5 times Palm's price net of capitalized lending fees. Below we verify that this value is always positive.

4.1 March 16 data. For ease of comparison we start with March 16, 2000 data from Lamont and Thaler (2003b). Palm's closing share price on that date is $55.25, so the table below considers puts and calls on Palm for various expiration dates that are approximately at-the-money. The table is identical to their Table 6, with the last 3 columns added by us. Forward prices are based on a riskless rate of 6.30%. As Ofek, Richardson, and Whitelaw (2004) highlight, when at-the-money puts are substantially more expensive than at-the-money calls as in this case, this implies the presence of severe shorting constraints, which equivalently manifest themselves in the form of a high implied stock lending fee through the option expiration date.

Table 1

Expiration	Years	Call	Call	Put	Put	Synthetic Forward		
and strike	to expiry	Bid	Ask	Bid	Ask	Long	Short	Midpoint
May 55	0.17	5.75	7.25	10.63	12.63	**51.84**	**48.30**	**50.07**
Aug 55	0.42	9.25	10.75	17.25	19.25	**48.58**	**44.98**	**46.78**
Nov 55	0.67	10	11.5	21.63	23.63	**44.69**	**41.04**	**42.87**

The option prices are from the Lamont and Thaler (2003b) article and the last three columns (the implied forward prices) are calculated from these option prices.

First, we observe from the last column that longer-dated forward prices are substantially lower (see discussion in footnote 5 regarding downward sloping forward curves), as one would expect from $F_{T^*,t} = S_t * e^{(R-\delta)*(T^*-t)}$ when the lending fee δ is far from zero.

November 2000 is the longest option expiration available, so that is also the latest date for which one can easily calculate synthetic forward prices. Using November 2000 forward prices results in a conservative estimate of the 3Com stub value if the spinoff is actually expected later than November 2000, as was likely the case when the IPO occurred. Assuming a spinoff at the November option expiration (T^* = November 17, 2000), the value of the 3Com stub on March 16 equals $7.35 per share. A negative $22 billion 3Com stub only appears if the stub is calculated using Palm's spot price rather than using the appropriate post-spinoff prepaid forward price.

4.2 Calculating stub values for all dates

Figure 3 gives 3Com's stub value for the entire period from March 16 to July 27. To estimate 3Com's stub value for all dates between March 16 and July 27, we calculate $F_{T^*,t}$ for all $t < T^*$ assuming T^* = Nov 2000 during the period before May 9, and T^* = Aug 2000 during the period after May 8. Recall that T^* = Nov 2000 underestimates the stub value of 3Com if the spinoff is expected after this date and lending fees are expected to remain positive.

With a few exceptions (all of them before April 13, 2000) the value of the stub is positive and above $3.75 per share. Figure 3 shows that throughout this period, the value of Palm is never consistently larger than the combined value of Palm and 3Com.

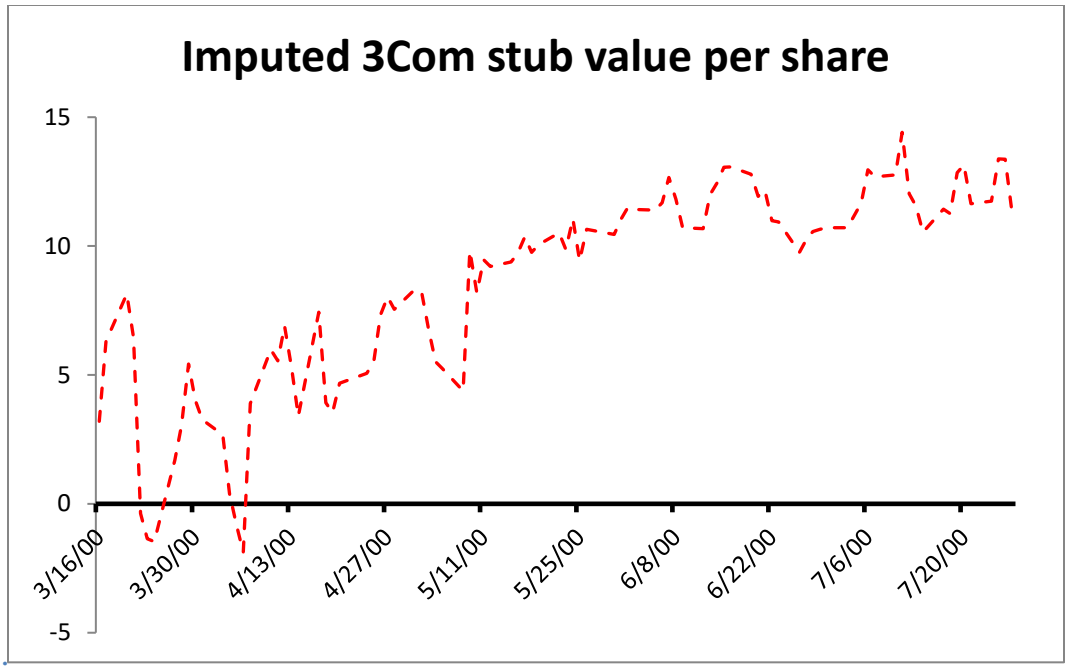


Figure 3. Estimates of 3Com stub value, calculated as the share price of 3Com less 1.5 times the PV of the synthetic forward price of Palm, based on a spinoff date of Nov 2000 before May 9 (Aug 2000 after that date). With a few exceptions early in the period, the stub value is positive.

5. Comparing the implied and the actual lending fees during the March–July period

Once implied forward prices are derived from put and call prices, forward-looking market estimates of future lending fees δ over a given interval can be derived from the equation $F_T = S_0 * e^{(0.063-\delta)*T}$.

Figure 4 graphs the implied lending fees. The graph employs November 2000 forwards for dates before May 9, with August 2000 forwards used thereafter. The average implied lending fee is 41.3% for the March 16 to May 8 period, and the average implied lending fee is 44% for the May 9 to July 27 period.

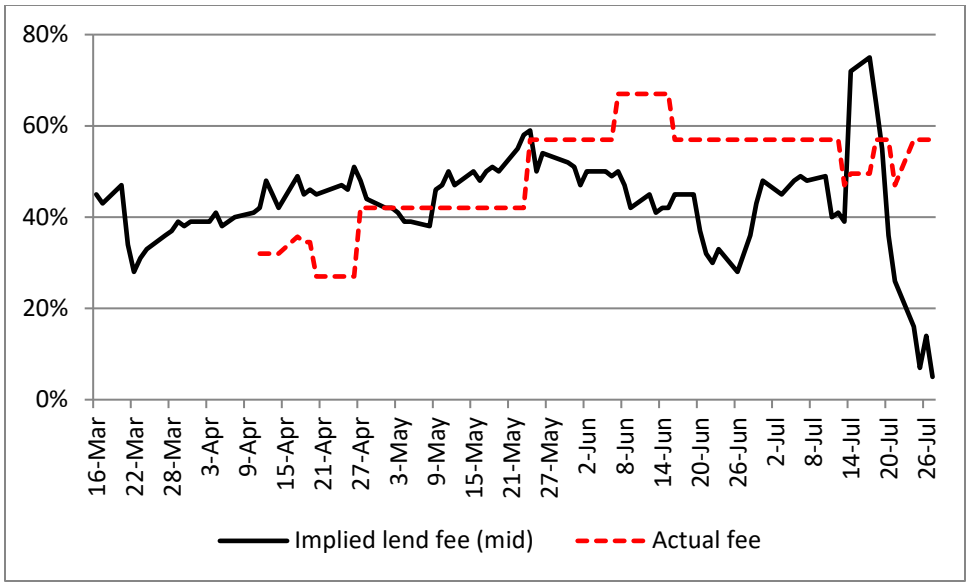


Figure 4. Annualized Palm lending fees implied by forward prices calculated on various dates. For the most part the implied lending fees from call and put prices are consistent with observed ex-post market lending rates.

Figure 4 also shows the lending fees charged on a sample of actual Palm share loans obtained from a large agency broker. More details on the lending sample are in the Appendix. Overall, the implied future lending fees are quite consistent with observed ex-post market lending rates. In fact, we cannot statistically reject the hypothesis that the difference between the two time series is a stationary mean-zero AR(1) process (mean difference = -0.0584, AR(1) coefficient = 0.025, Newey-West t-stat with 3 lags = 1.62).

6. Implied lending fees for the period from Aug 16, 2000 to Nov 17, 2000

From the no-arbitrage relationship $F_{Aug,t} * (e^{(0.063-\hat{\delta})*(\text{Nov}-Aug)} = F_{\text{Nov},t}$, we can estimate the lending fees expected for period from August 16, 2000 to November 17, 2000. Our theory predicts that if the markets expect the spinoff to occur after the end of November (which was the expectation prior to May 8), there will be positive implied lending fees for the August to November interval. On the other hand, if markets are certain that the spinoff will occur before August, and that lending fees will vanish thereafter, there should be zero implied lending fees for the August

to November interval. Implied forward prices reflect these expectations perfectly. The results are reported in Figure 5, which shows the annualized implied fee averaging about 28% before May 9, but averaging essentially zero (t = 1.03) once the July 27th spinoff date is announced, exactly as the theory would predict.

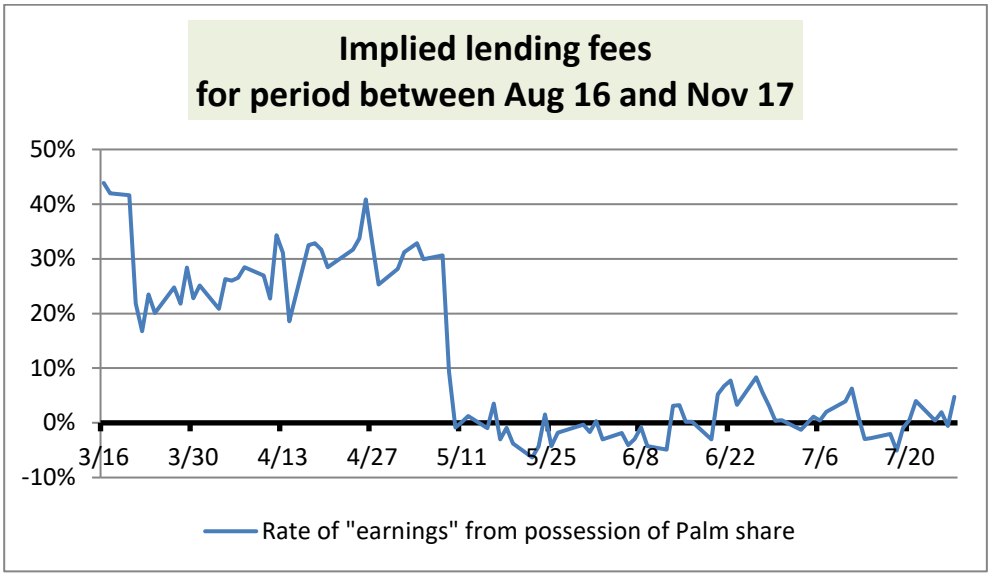


Figure 5. Palm lending fees implied from August 2000 and November 2000 forward prices as constructed from options prices. On May 8th 3Com announced that it would spin-off the remaining shares in Palm to its stockholders on July 27th. Prior to May 8th, the difference in August vs. November forward prices reflected a 30% lending fee (implied "dividend"), while starting on May 9th this "dividend" is estimated to be zero.

7. No violation of put-call parity, and no violations of LOOP

Put-call parity. Lamont and Thaler (2003b) state that on March 16, 2000, "[o]ptions on Palm display massive violations of put-call parity [for European options] and violate the weaker inequality [for American options] as well. Instead of observing at-the-money call prices that are greater than put prices, we find that puts were about twice as expensive as calls. [Also]…[o]n March 16 the price of the synthetic short was about $39.12[= PV of synthetic forward], far below

the actual trading price of Palm of $55.25. This constellation of prices is a significant violation of the law of one price because the synthetic security is worth 29 percent less than the actual security." (Lamont and Thaler, 2003b, p. 255). But this discussion disregards the fact that a Palm share allows the owner to earn the lending fee δ.

The lending fee can be viewed as a continuous dividend paid to the owner of the share, and the put-call parity relationship for at-the-money options on a dividend-paying stock is

$$S_0 * e^{-\delta T} - PV(S_0) = C(S_0, T) - P(S_0, T) \quad (16)$$

Because lending fees δ are much larger than the 6.3% riskless rate at the time (see Figure 4), puts should be much more expensive than calls, and there was no violation of put-call parity.

Law of one price (LOOP). Lamont and Thaler (2003b) suggest that the Law of One Price (LOOP) was violated by the 3Com-Palm data. To recapitulate, the law of one price requires that assets be fungible for the law to hold within the limits of transaction costs. As 3Com could not be delivered in lieu of a shorted Palm share until the spinoff had occurred, the law of one price is not violated. As the time of spinoff and its completion were both uncertain, the Palm-3Com case offers at most an attractive but risky opportunity.

In other markets, there are similar opportunities that appear to be arbitrage opportunities at first glance. For example, one can purchase silver half-dollar coins in bulk. A bag of 2,000 silver Kennedy half dollar coins contains approximately 295 ounces of pure silver. On April 25, 2012,

the cash asking price[14] for the $1,000 face value bag was $8,985.70, and the bid price was $8,425.20. On that day, the silver spot price was $30.56 per ounce, making the silver content of the bag of coins worth $9015.20 (= $30.56 * 295), higher than $8,985.70, the ask price for the whole bag.[15] Here the value of the underlying metals is greater than the value of the unrefined coins. But it does not mean that these two markets break the law of one price: these are two separate markets that serve different clienteles, and there is no way to arbitrage between them, as it takes $400-$600 to refine a bag of these coins into their constituent metals, silver, and copper.

The parallel with Palm and 3Com is straightforward: only 3Com management can "refine" the pre-spinoff 3Com share into two separate stocks. This "refinement" was in doubt on March 2, so a $95 price for Palm and a 3Com share at $81 did not violate the law of one price. Lamont and Thaler focus on notions of "fundamental value" or "intrinsic value," but the "fundamental value" or "intrinsic value" of 3Com or Palm is unobservable. Our analysis offers a number of fairly precise implications within these limits of arbitrage, all of which are borne out by the data.

8. The case of rational investors with access to two segmented markets

Lamont and Thaler (2003b) ponder who buys the expensive Palm shares when 1.5 shares of Palm plus the stub can be acquired cheaper by buying a share of 3Com. They rely on a different version of LOOP: two identical assets should trade at the same price in different markets when a buyer has costless access to both markets.

[14] Source: http://www.providentmetals.com/1000-face-value-40-silver-us-kennedy-half-dollars-1965-1970.html, visited April 25-2012. Note that it is in fact legal to melt silver U.S. coins, but it is currently illegal to melt pennies or nickels.
[15] In addition, a bag of these coins contains copper that was worth about $80 on that date.

But this version of LOOP requires careful calibration. Two apartments should sell for the same price if their size, view, exposure to sun, level of noise, and other characteristics are identical, but all these characteristics have to be matched precisely to get the LOOP result. Matching physical attributes is not enough: to take the classic New York City example, otherwise identical apartments may trade at a substantial price differential if one is in a co-op and the other is a condo, where transfers of the latter are generally much less restricted.[16] Matching of cash flows is not enough, as we have learned from "on-the-run" vs. "off-the-run" Treasury bond markets or closed-end funds trading at a discount.

Assets have a number of parameters that define their valuation, such as cash flows, trading costs, ownership structure, and agency issues. Prices in the two markets should be identical only if all parameters are carefully matched. This was not the case in the Palm-3Com story: outright ownership of Palm shares and indirect ownership of Palm shares via ownership of 3Com are not the same thing, and this important difference drives the two prices apart.

Kolasinski, Reed, and Ringgenberg (2013) document that the lending supply curve for shares is strongly upward sloping, so the observed lending fees in the Palm-3Com case are not surprising. However, some set of investors must ultimately hold the outstanding stock of Palm shares without lending them out. We know that many investors do not have access to the "lending technology." Brokers usually do not pass lending fees through to retail customers, and some institutional shareholders do not have a share lending program in place. For these investors, the question is whether it can be rational to buy the more-expensive Palm shares instead of buying Palm shares

[16]Schill, Voicu, and Miller (2007) use 1984-2002 sales data to estimate that co-operative apartments in New York City trade at a 9% discount on average to identical condominium apartments.

via 3Com. If these investors are sufficiently pessimistic about the spinoff and the prospects for convergence, or these investors attach large marginal utilities to divergence, an investment in Palm shares could be quite rational.

9. A fully rational equilibrium

In any potential Palm/3Com equilibrium, there must be a set of investors that holds Palm shares and does not lend them out. Duffie, Gârleanu, and Pedersen (2002) assert that all Palm shareholders wanted to lend them out, but could not due to search frictions, making it difficult to locate a counterparty. This could be part of the explanation, but we start from a slightly different institutional friction: that many investors do not have the ability or incentive to loan shares. Lamont and Thaler claim that it was irrational for such non-lending investors to purchase Palm directly, as purchasing Palm shares via ownership in 3Com was considerably cheaper. In this section, we show that non-lending rational investors would opt for a direct purchase of Palm shares under a reasonable set of expectations about the probability of the spinoff, the value of the stub, and the future cash flows of 3Com if the spinoff were cancelled.

Heterogeneous valuations can arise for a number of reasons. Many game theorists emphasize that agents need not have common priors and can "agree to disagree." For example, Morris (1995) writes that even if "prior beliefs are restricted by rationality or other assumptions, there is every reason to think there will still be heterogeneity." Of course, bounded rationality can also give rise to heterogeneity. Miller (1977) mentions a "badly informed minority" of over-optimistic investors, while Scheinkman and Xiong (2003) explicitly obtain differences of opinion via overconfidence.

In the Palm-3Com case, the question boils down to whether the investors who hold Palm have expectations which neutral observers would consider reasonable.

There was essentially no spinoff uncertainty after May 8. After that date, a rational investor that wanted to own Palm but was unable to lend would choose an ownership route based only on her valuation of the 3Com stub. Investors who were pessimistic about 3Com's stub would buy Palm shares directly; investors who had a high valuation of 3Com's stub would indirectly buy Palm shares by owning 3Com. Figure 6 shows the stub value at which such an investor would be indifferent between direct and indirect ownership of Palm. For example, on May 11, the breakeven stub value was $4.50 per share. If a non-lending Palm investor thought the stub was worth less than this amount, she would prefer to hold Palm shares directly. This breakeven valuation of the stub seems quite reasonable. 3Com ended up reporting net income from continuing operations (excluding non-recurring items) of $0.34 per share for the year ended June 2, 2000, so a $4.50 stub valuation represented a current year price-earnings ratio of 13.2.

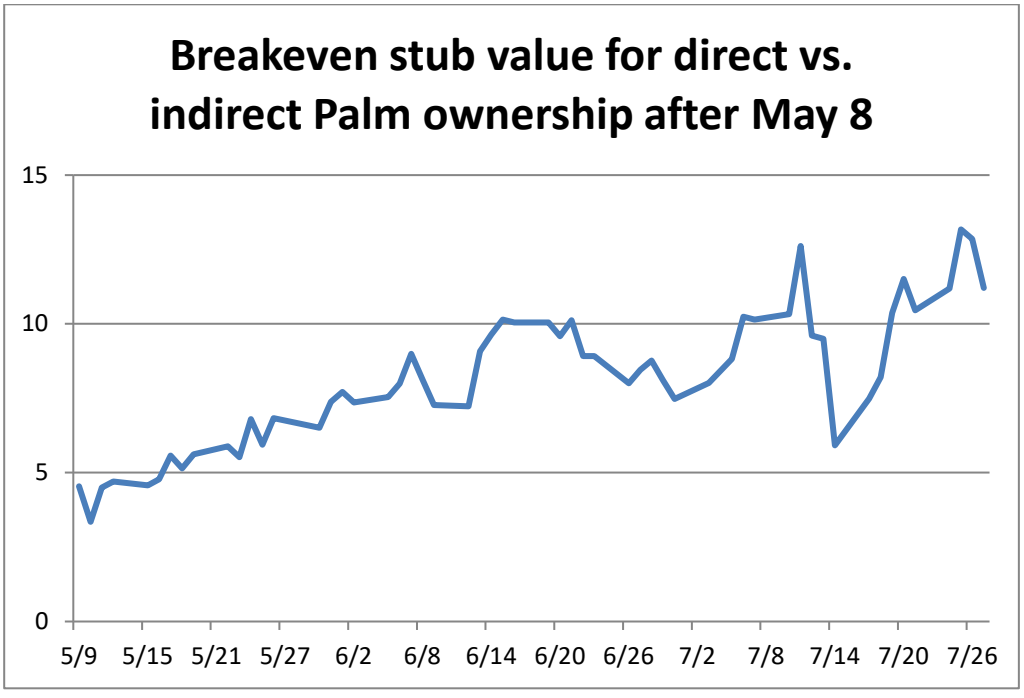


Figure 6. The breakeven stub value is calculated as 1.5 * the Palm share price less the 3Com share price. The valuations for direct and indirect Palm ownership are quite different.

Before the spinoff uncertainty was removed on May 8, the decision of a non-lending rational investor interested in Palm was more complex, as it would depend on the investor's valuation of Palm and the 3Com stub, an assessment of the likelihood of the spinoff, and the potential divergence between indirect vs. direct ownership of Palm if the spinoff did not occur.

If the spinoff were cancelled, direct ownership of Palm shares might be preferable. For example, 3Com might decide to repurchase the outstanding Palm shares at a premium. Palm shares might also be taken out at a premium if 3Com were taken over. Even if the existing Palm shares continued to trade alongside a public 3Com, direct and indirect ownership of the subsidiary might not be equivalent. For example, indirect ownership of Palm would involve increased managerial expenses at the 3Com level. Managers also choose whether and how to invest the profits from a successful subsidiary, and there are many examples where management has made ex ante poor investment decisions due to various agency problems.[17] Closed-end funds are another example: they often trade at significant discounts to their net asset value, in part because of the additional fees levied by the closed-end fund.

Thus, direct ownership in a subsidiary may be preferable because the parent firm is not a mechanical box where cash flows from subsidiaries go out to investors unaltered, but rather the parent firm has considerable leeway to decide how to use the cash flowing from a profitable

[17]The historical example of Pan Am may be instructive here. For some time, Pan Am owned a large stake in InterContinental hotels, but it was also possible to invest directly in InterContinental. Ultimately, Pan Am reinvested most of its profits from InterContinental into its "core" airline business, with well-known poor results.

subsidiary. For investors that did not trust 3Com's management of Palm-generated cash flows and worried about completion of the spinoff, direct ownership of Palm could easily be the preferred route.

9.1 A model with differences of opinion about completion of the spinoff

To make this intuition precise about the difference between direct and indirect ownership of Palm's cash flows, we next derive a set of conditions needed to support an equilibrium in the presence of fully rational investors. Continuing our earlier notation, let S_t be the share price of Palm, and let $S_{3COM,t}$ be the share price of 3Com. Consider only the subset of investors who cannot lend or do not receive any direct benefit from lending their Palm shares. Define $\overline{S_t}(x_i)$ as the "indirect price" for one such investor *i* of owning Palm via 3Com when that investor believes that the 3Com stub value is x_{it} :

$$\overline{S_t}(x_{it}) = (S_{3COM,t} - x_{it})/\ 1.5 \tag{17}$$

Furthermore, let p_{it} = investor *i*'s subjective probability assessment at time *t* that the spinoff completes, and let that investor's time *t* valuation of Palm's cash flows be V_{it}.

We assume without loss of generality that if an investor owns a Palm share outright, the spinoff outcome does not influence her cash flows. Thus, an investor would be willing to hold (and not lend) a Palm share outright if $V_{it} \geq S_t$. Now consider the same investor's valuation of indirect ownership of Palm. This investor's subjective valuation of indirect ownership of Palm via 3Com is denoted with a superscript *I*

$$V_{it}^{I} = p_{it}V_{it} + (1 - p_{it})V_{it}(1 - d_{it}) \tag{18}$$

where d_{it} represents investor *i*'s time *t* belief about the value destruction associated with indirect ownership of the subsidiary if the spinoff is not completed. Thus, this rational investor is willing to buy Palm indirectly if and only if $\overline{S_t}(x_{it}) < V_{it}^I$, and a non-lending rational investor is willing to hold Palm directly if and only if $V_{it} - S_t \geq 0$, and this investor prefers a direct investment in Palm to an indirect investment via 3Com if and only if

$$V_{it} - S_t \geq V_{it}^I - \overline{S_t}(x_{it}). \tag{19}$$

The left-hand side is the surplus from holding Palm directly. This surplus must be non-negative and at least as big as the surplus from holding Palm indirectly (the right-hand side of the inequality). In particular, for a rational equilibrium to hold, there must be a sufficient mass of non-lending investors willing to directly hold the outstanding Palm float of 23 million shares. For simplicity, suppose that these investors have homogeneous expectations. Then they are the marginal investors in Palm. The Palm share price must reflect their opinion about Palm's valuation ($S_t = V_{it}$), and if there is to be an equilibrium, these investors must be unwilling to hold Palm indirectly, or equivalently

$$\overline{S_t}(x_{it}) \geq p_{it}S_t + (1 - p_{it})S_t(1 - d_{it}) \tag{20}$$

Put another way, in order to prefer a direct investment in Palm, these investors must see some probability that the spinoff does not complete, and there must be enough value destruction implicit in the indirect ownership. Thus, for markets to clear at every moment in time, it must always be the case that for these investors

$$d_{it} \geq \frac{S_t - \overline{S_t(x_{it})}}{S_t(1-p_{it})}. \tag{21}$$

For example, on March 21, 2000, Palm's share price was $48.375, and 3Com closed at $64.11 per share. On this date, if there is a set of investors who believe that the 3Com stub is worth $4, that there is a 70% chance that the spinoff will be completed ($p_{it} = 0.7$), and that 57% of 3Com's value (including its Palm holdings) is destroyed if the spinoff is not completed ($d_{it} = 0.57$), there is a fully rational equilibrium where these non-lending investors choose to hold Palm directly rather than indirectly via 3Com. The 70% probability of spinoff completion is chosen to match the evidence in Mitchell, Pulvino, and Stafford (2002), and the stub value of $4 is chosen to match the post-May 8 breakeven stub value. These beliefs do imply a non-trivial amount of value destruction, but these beliefs seem far from irrational given the experience of other investors in other equity carve-outs.

10. Conclusions

The Palm—3Com episode is a memorable one. It appears to provide a singular challenge to the notion of rational market pricing, and the episode has had a strong impact on the finance profession's view of market efficiency. For example, in a widely used introductory finance textbook, Welch (2017) writes:

> Occasionally, there is evidence that refutes even the truest of believers [in market efficiency] —but this is rare. The most dramatic example occurred in 2000, when the network company 3Com spun off the PDA company Palm. Widely reported in the press at the time, 3Com retained 95% of Palm's stock—and announced that each shareholder of 3Com would soon receive 1.525 shares of Palm. After the IPO, Palm closed at $95.06 per share. Therefore, 3Com should have been worth at least 1.525 ·$95.06 = $145. Instead, 3Com shares closed at $81.81. (p. 285)

This paper offers an alternative interpretation of this particular example. We provide novel and systematic evidence that, throughout this episode, the shares of Palm held by 3Com are

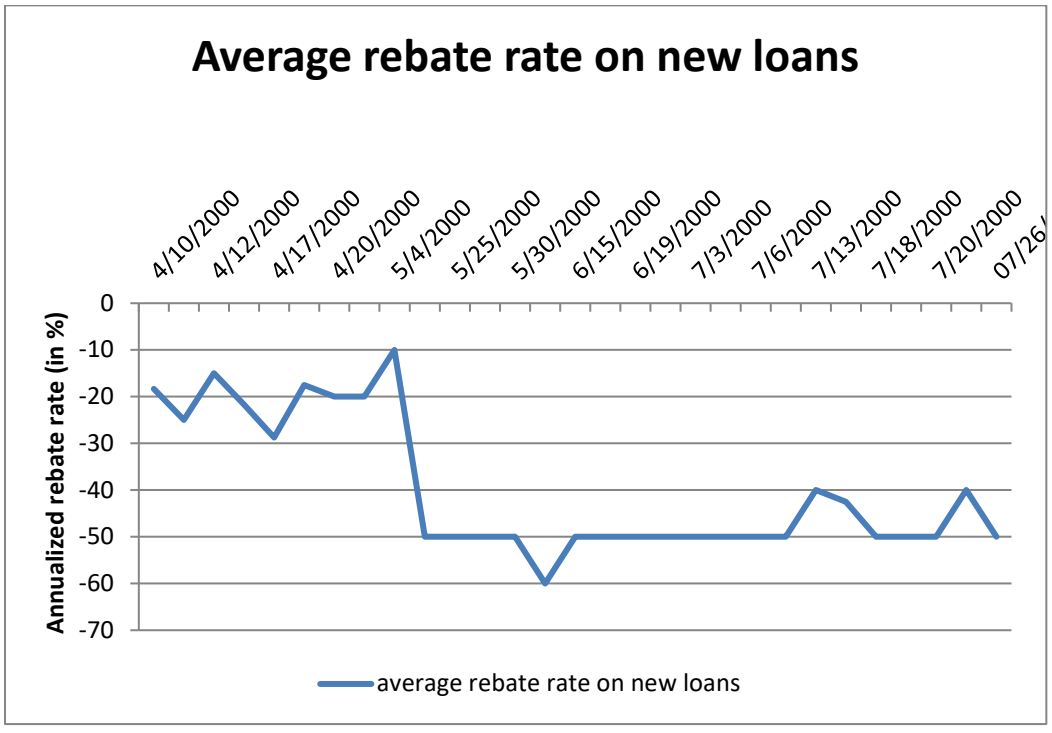
fundamentally different from the small number of freely trading Palm shares because the former cannot be lent to short sellers. There is also substantial uncertainty about the completion and timing of the spinoff. Together these give rise to severe shorting constraints, in contrast to the pricing null posed by Lamont and Thaler (2003b) and Welch (as quoted above). We show that markets are jointly pricing both Palm and 3Com in a sensible way, and no-arbitrage pricing is preserved. Furthermore, we show that potentially reasonable differences of opinion would give rise to a fully rational equilibrium with the Palm and 3Com price patterns that we observe.

We should be clear that we do not believe that markets are always efficient. For example, the beliefs that we propose in our fully rational equilibrium may or may not be reasonable to an outside observer. In addition, one of us has identified a bond-pricing example that seems difficult to reconcile with the law of one price (Dammon, Dunn, and Spatt, 1993). Our purpose here is simply to provoke a reconsideration of the dramatic Palm/3Com example that has mistakenly been taken as obvious evidence of extreme irrationality on the part of investors as well as evidence of poorly functioning capital markets.

Appendix: Lending Palm for Money

We have a share lending dataset from a large agency broker covering 56 separate loans of Palm shares during 2000 for a total of about 5.4 million shares, which is about 23% of the available float of 23 million shares. All loans originated sometime between April 10 and July 26 and all were closed (i.e., repaid) by August 1 once the spinoff was completed. At the time, the convention in the lending marketplace was that the loans were daily loans that would end if the lender recalled the shares, or the borrower returned them. Furthermore, the convention was that the rates would stay unchanged on previously issued loans and that re-pricing loans by either side would be a violation of the norms of the marketplace. The graph below shows the rebate rates for loans originated on different dates.

Figure A1. Average rebate rates on new overnight loans of Palm shares at various origination dates. The data are from a large agency lender. These actual lending rates, like implied lending rates, are substantial.



References

Cochrane, John H., 2003, "Stock as Money: Convenience Yield and the Tech Stock Bubble" in William C. Hunter, George G. Kaufman and Michael Pomerleano, Eds., *Asset Price Bubbles* Cambridge: MIT Press (previously NBER working paper 8987).

Cornell, Bradford, and Qiao Liu, 2001, "The Parent Company Puzzle: When is the Whole Worth Less than One of the Parts?" *Journal of Corporate Finance* 7, 341-366.

Cremers, Martijn, and David Weinbaum, 2010, "Deviations from Put-Call Parity and Stock Return Predictability," *Journal of Financial and Quantitative Analysis* 45, 335-367.

Dammon, Robert, Kenneth Dunn, and Chester Spatt, 1993, "The Relative Pricing of High-Yield Debt: The Case of RJR Nabisco Holdings Capital Corporation," *American Economic Review* 83, 1090-1111.

D'Avolio, Gene, 2002, "The Market for Borrowing Stock," *Journal of Financial Economics* 66, 271-306.

Dimson, Elroy, 1979, "Risk Measurement When Shares are Subject to Infrequent Trading," *Journal of Financial Economics* 7, 197-226.

Duffie, Darrell, Nicolae Gârleanu, and Lasse Heje Pedersen, 2002, "Securities Lending, Shorting, and Pricing," *Journal of Financial Economics* 66, 307-339.

Harrison, J. Michael, and David M. Kreps, 1978, "Speculative Investor Behavior in a Stock Market with Heterogeneous Expectations," *Quarterly Journal of Economics* 92(2), 323-336.

Hong, Harrison, Jose Scheinkman, and Wei Xiong, 2006, "Asset Float and Speculative Bubbles," *Journal of Finance* 61(3), 1073–1117.

Jones, Charles M., and Owen A. Lamont, 2002, "Short Sale Constraints and Stock Returns," *Journal of Financial Economics* 66, 207-239.

Kolasinski, Adam C., Adam V. Reed, and Matthew C. Ringgenberg, 2013, "A Multiple Lender Approach to Understanding Supply and Demand in the Equity Lending Market," *Journal of Finance* 68(2), 559-595.

Kondor, Peter, 2009, "Risk in Dynamic Arbitrage: The Price Effects of Convergence Trading," *Journal of Finance* 64, 631-655.

Lamont, Owen A., and Richard H. Thaler, 2003a, "Anomalies: The Law of One Price in Financial Markets," *Journal of Economic Perspectives* 17, 191-202.

Lamont, Owen A., and Richard H. Thaler, 2003b, "Can the Market Add and Subtract? Mispricing in Tech Stock Carve-outs," *Journal of Political Economy* 111, 227-268.

Miller, Edward M., 1977, "Risk, Uncertainty, and Divergence of Opinion," *Journal of Finance* 32, 1151-1168.

Mitchell, Mark, Todd Pulvino, and Erik Stafford, 2002, "Limited Arbitrage in Equity Markets," *Journal of Finance* 57, 551-584.

Morris, Stephen, 1995, "The Common Prior Assumption in Economic Theory," *Economics and Philosophy* 11, 227-253.

Ofek, Eli, and Matthew Richardson, 2003, "DotCom Mania: The Rise and Fall of Internet Stock Prices," *Journal of Finance* 58(3).

Ofek, Eli, Matthew Richardson, and Robert F. Whitelaw, 2004, "Limited Arbitrage and Short Sales Restrictions: Evidence from the Options Markets," *Journal of Financial Economics* 74, 305-342.

Ross, Stephen, 2004, *Neoclassical Finance*, Princeton, NJ: Princeton University Press.

Ross, Stephen, 1976, "Return, Risk and Arbitrage." In *Risk and Return in Finance*, ed. I. Friend and J. Bicksler, Cambridge, MA: Ballinger.

Ross, Stephen, 1978, "A Simple Approach to the Valuation of Risky Streams," *Journal of Business* 51, 453–75.

Routledge, Bryan, Duane Seppi, and Chester Spatt, 2000, "Equilibrium Forward Curves for Commodities," *Journal of Finance* 55, 1297-1338.

Saffi, Pedro A. C., and Sigurdsson, Kari, 2011, "Price Efficiency and Short Selling," *Review of Finance Studies* 24, 821-852.

Scheinkman, Jose A., and Wei Xiong, 2003, "Overconfidence and Speculative Bubbles," *Journal of Political Economy*, 1183-1219.

Schill, Michael J., and Chunsheng Zhou, 2001, "Pricing an Emerging Industry: Evidence from Internet Subsidiary Carve-outs," *Financial Management* 30, 5-33.

Schill, Michael H., Ioan Voicu, and Jonathan Miller, 2007, "The Condominium v. Cooperative Puzzle: An Empirical Analysis of Housing in New York City," *Journal of Legal Studies* 36(2), 275-324.

Stock, James H., and Mark W. Watson, 1993, "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," *Econometrica* 61(4), 783-820.

Welch, Ivo, 2017, *Corporate Finance,* 4th edition, available at https://book.ivo-welch.info/read/.