# "A solution to the Palm–3Com spinoff puzzles"*

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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 crucially important 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 on May 8, 2000.

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## A Solution to the Palm-3Com Spinoff Puzzles

### Preface

A fundamental paradigm and bedrock principle in modern financial economics is the efficiency of market pricing and the absence of arbitrage.[1] An important challenge to this paradigm comes from the hypothesis that asset prices are instead sometimes driven by behavioral biases. A celebrated example is the spinoff of Palm from 3Com in 2000. After the carve-out of Palm and IPO of 5% of its shares, 3Com still owned the remaining 95% of Palm. Extrapolating the market valuation of the traded Palm shares to the remaining 95% of Palm, the total stock market value of 3Com was much lower than 3Com's holdings of Palm. 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. For example, Lamont and Thaler (2003b) entitle their well-known paper, "Can the Market Add and Subtract? Mispricing in Tech Stock Carve-outs."[2] In light of the striking nature of the Palm-3Com example and the wide attention paid to it,[3] a fully rational reconciliation of the evidence seems like a very difficult challenge. However, this paper shows that a model with uncertainty associated with the spinoff, combined with shorting constraints, can indeed explain the relative levels and comovements between Palm and 3Com share prices.

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[1]See, for example, Ross (1976, 1978, and 2004).
[2]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)).
[3]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 a decade later, there are frequent references to the episode in the popular and academic press.

## 1. An introduction to the Palm-3Com episode

Here are the main facts of the Palm-3Com saga. At the end of 1999, 3Com 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) were offered to the public in an initial public offering (IPO). 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.

But 3Com still owned 532 million Palm shares valued at $50 billion, implying that the value of 3Com's non-Palm assets ( its "stub" value) was a staggering -$22 billion!!! The record shows that 3Com had no debt, more than $1 billion in cash, and a positive market value before acquiring Palm. Furthermore, 3Com had a $5 billion capitalization the day after Palm's spinoff was completed later that year. Obviously, the financial market recognized the considerable residual value in 3Com. How then can 3Com's stub value be negative on March 2? We claim that there is no paradox, once one recognizes that Palm shares held outside of 3Com are quite different from Palm shares inside of 3Com. In that case, the market value of the floating Palm shares should not be mechanically applied to the remaining 95% of Palm shares still owned by 3Com.

The most obvious difference between the two types of Palm shares is their ability to be lent. Owners of floating Palm shares are free to lend their shares, while 3Com cannot lend out its

Palm shares.[4] The presence of a non-zero lending fee establishes the following no-arbitrage relationship between the spot price of a Palm share vs. its forward price:

Spot price of Palm = PV[Palm lending fees] + 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, 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 532 million shares (owned by 3Com) does not reflect those lending fees at all.[5] This introduces a potentially large wedge between the valuation of 3Com's owned Palm shares and Palm's floating shares.[6]

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, Garleanu 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

[4] The Palm shares held by 3Com are not registered and thus are not fungible with the 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.
[5] See, for example, Duffie, Gârleanu and Pedersen (2002).
[6] The lending fees are substantial: our data show that annualized Palm lending fees were as high as 60%. D'Avolio (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 and Palm Inc. are examples of such stocks, exhibiting [annualized] loan fees as high as 50% and 35%, respectively." Additional data on contemporaneous lending fees can be found in Ofek and Richardson (2003); historical lending fee data are analyzed by Jones and Lamont (2002) .

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. When shorting costs are explicit, the size of the divergence is generally given by the capitalized present value of these expected costs.

To correctly value 3Com, 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 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 with no other changes. The capitalized wedge is much smaller: 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 far away, 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 investigate the market's expectations about the date of the spinoff and the lending fees expected at various intervals in the future.[7] In this case, 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 do this, the various paradoxes disappear. The correctly-calculated stub value is always positive (Section 4), and Palm's synthetic forward price behavior is consistent with significant uncertainty about the spinoff that is later resolved (Section 6). Lastly, the perceived violations of put-call parity and of the law of one price are absent (Section 7). More importantly, we derive a novel theoretical relationship for the comovement of the share price of Palm and 3Com (Section 2) and then test it against data: Section 3 tests the Palm/3Com relationship and Section 5

[7] 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 (2002).

compares the model-implied lending fees vs. actual lending fees. The empirical tests strongly support our theory.

We conclude that markets correctly priced in the uncertainty associated with Palm's spinoff and the size of Palm's 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 before the conclusion (Section 8), we discuss the single remaining puzzle: there must be investors who choose 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 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 above 25% between April 10 and May 9 and above 50% after May 9. Separately, Mitchell, Pulvino and Stafford (2002) locate 84 cases 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 was costly and risky — and it was not an arbitrage trade at all!

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

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".[8] Among

[8] 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

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 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 is 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."[9]

The case of a known spinoff date

Let $F_{T,t}$ denote the time $t$ 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

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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 that:

"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."

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

up front for the 3Com stub plus the forward claim on 1.5 Palm shares. Thus, the value of 3Com is the value of the stub plus a prepaid date $T^*$ forward on 1.5 Palm shares:[10]

$$S_{3COM,t} = STUB_t + 1.5\ \mathrm{PV}\left[\mathrm{F}_{\mathrm{T}^*,\mathrm{t}}\right] \quad (1)$$

Assume a constant continuous risk-free rate R and continuous constant "lending fees" $\delta$ for all $t < T^*$.[11] Then:

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

And

$$\mathrm{PV}\left[\mathrm{F}_{\mathrm{T}^*,\mathrm{t}}\right] = S_{\mathrm{t}} e^{-\delta(\mathrm{T}^*-t)} \quad (3)$$

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

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

From (3) we get

$$\mathrm{PV(lending\ fees)} = S_t(1 - e^{-\delta(T-t)}) \quad (5)$$

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

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

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

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

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 $G(T^*, t, \delta) = 1.5\ e^{-\delta(T^*-t)}$.

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:

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

in this case with $\widetilde{T^*}$ uniformly distributed[12] over $[a, a + z]$. Integrating over possible stopping times, it can easily be shown that equation (7) continues to hold with:

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

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

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 reasonable 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 $S_{3COM}$ .

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.

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*.[13] From put-call parity, the forward price is given by:

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

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

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

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:

[13] 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.

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

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

$$F_T^{MID} = \frac{F_T^B + F_T^A}{2} \quad (14)$$

## 3. Empirical verification of the predicted comovement between Palm and 3Com

Taking first differences of equation (7) to obtain stationary variables, we see that the same comovement expression should hold in price changes:

$$\Delta S_{3COM,t} = \Delta STUB_t + G(T^*, t, \delta) * \Delta S_t \, . \quad (15)$$

As before, $G(T^*, t, \delta) < 1.5$ measures the contribution of 1.5 3Com-held Palm shares to the valuation of 3Com. This relationship can be estimated by OLS 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 ($\rho$ = 0.026, $t$ = 0.206). These OLS regressions are always performed on just one 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 each passing day). 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 comovement between Palm and 3Com at different points in time. This yields an estimator of $G(T^*, t, \delta)$ in equation (7), and equation (9) allows us to determine whether the estimates are consistent with plausible values of the parameters *a*, $\delta$, and *z*. Over each interval we study, we find a good fit between our theory and the empirical observations.

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

After the IPO was priced overnight, Palm shares started trading at 11:30am on March 2; we examine the minute-by-minute Palm and 3Com share prices between 11:30am and 4:00pm that first trading day. To be precise, we regress one-minute 3Com share price changes on the Palm share price and three (one-minute) leads and lags of the differenced Palm share price. Summing the seven slope coefficients, we obtain the following comovement 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 consistent with the parameter triplet $\delta = 0.35, a = 0.4$ years, and *z* = 7.95 years in equation (9), implying considerable uncertainty about the spinoff time. This is 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 11:30am and 4:30pm 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.

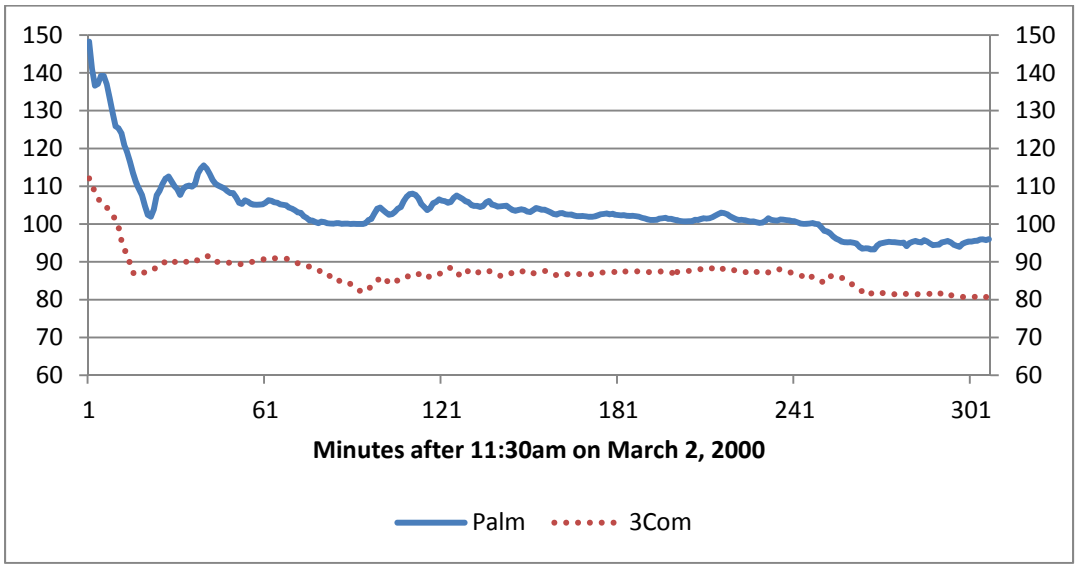



Figure 1: Minute-by-minute share prices of Palm and 3Com after trading opens at 11:30am on March 2, 2000.

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

In the after-hours of May 8, 3Com announced that it would spin off its shares of Palm on July 27, 2000, well before its original estimated spinoff date of December 2000.[14] 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 owns 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 disappeared. The market learned that a Palm share would earn lending fees only

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

over a much shorter time interval, and thus the capitalized value of these expected lending fees dropped sharply. This means that, all else equal, the value of a traded Palm share should have 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 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. Equivalently, 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 comovement 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 comovements between Palm and 3Com reflect this change in the expected spinoff time, we split our sample at May 8, 2000 and investigate the joint daily evolution of Palm and 3Com's share price before and after the spinoff announcement. During the March 2 to May 8 period, there is substantial uncertainty about the spinoff date, and 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 5-minute 3Com transaction price changes on contemporaneous Palm price changes and three leads and lags of Palm price changes. Figure 2 below reports the average estimated comovement 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. Prior to May 9, we calculate the single spinoff date that provides the best mean-squared error fit between the associated theoretical comovement 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 8 period.

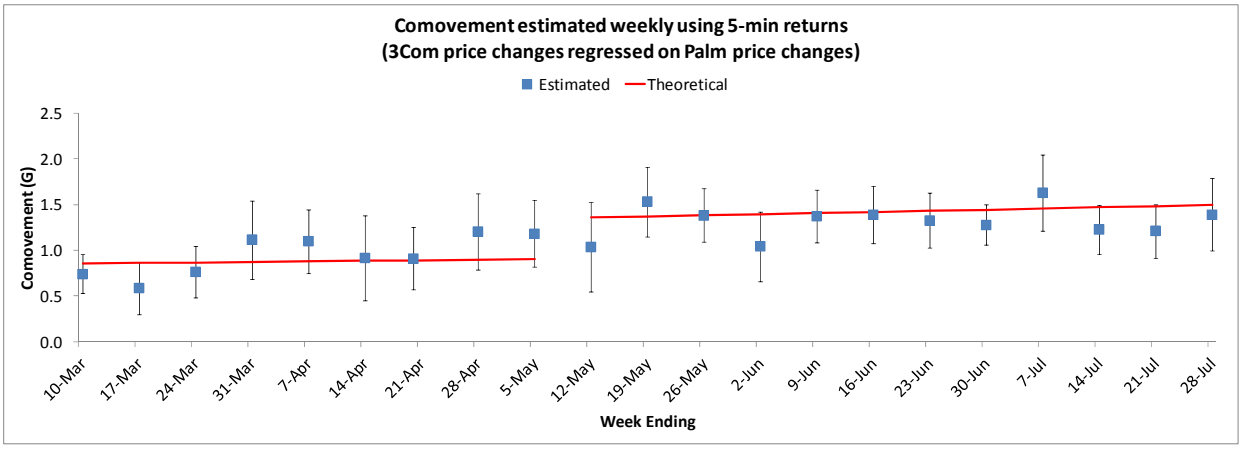



**Figure 2.** Daily regressions of $\Delta S_{3COM,t} = c + \beta_{-3}\Delta S_{PALM,t-3} + \beta_{-2}\Delta S_{PALM,t-2} + \ldots + \beta_3\Delta S_{PALM,t+3}$ using 5-minute transaction price changes. Reported coefficients are weekly averages of daily summed slopes $\beta_{-3} + \beta_{-2} + \beta_{-1} + \beta_0 + \beta_1 + \beta_2 + \beta_3$. Error bars represent 95% confidence intervals based on Newey-West standard errors.

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 comovement 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 comovement regime-switch. We also test whether the weekly estimated slope coefficients differ from their theoretical counterparts, and we find that we cannot reject the joint null that they are all equal,

with a chi-squared statistic of 29.71 ($p$ = 0.098). We conclude that the Palm/3Com price relationship theory derived above explains their joint share price behavior well.

## 4. Empirical verification that 3Com's stub value was never negative

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

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%.

**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** |

First, we observe from the last column that longer-dated forward prices are lower (see discussion in footnote 7 regarding downward sloping forward curves), as one would expect from $F_{\mathrm{T}^*,t} = S_{\mathrm{t}} * e^{(\mathrm{R}-\delta)*(\mathrm{T}^*-t)}$.

November 2000 is the longest option expiration available, so that is also the latest date for which one can 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 Nov 2000, as was 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 stub only appears if the stub is calculated using Palm's spot price rather than using the appropriate post-spinoff forward price.

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 few exceptions (all of them before April 13, 2000) the value of the stub is positive and above $3.75. Figure 3 shows that throughout this period, the part is never consistently larger than the whole.

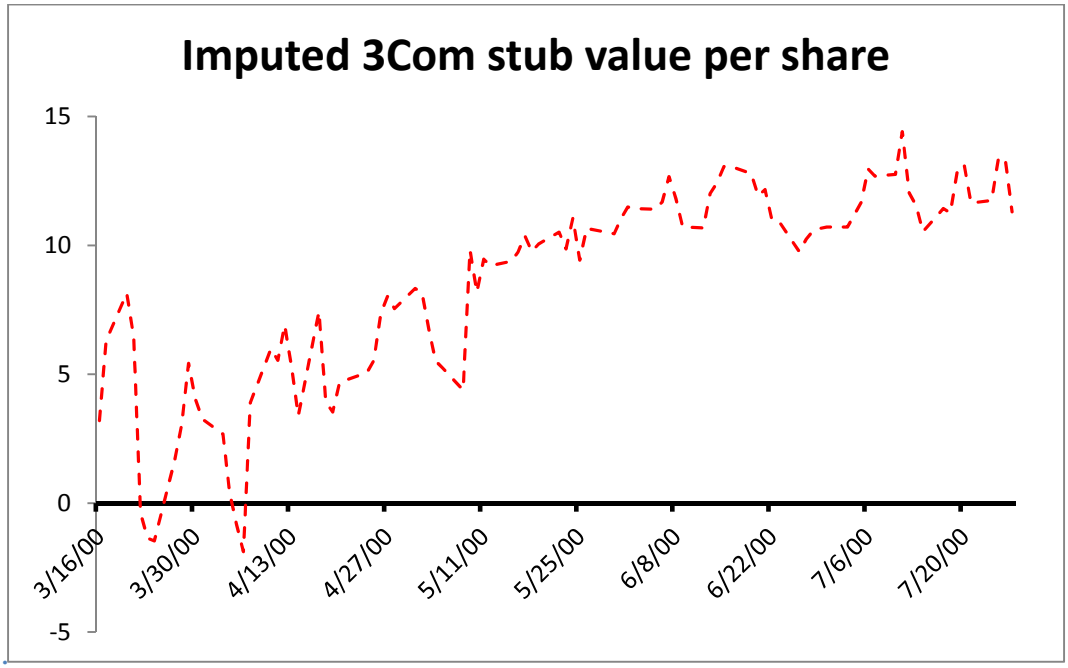


**Figure 3.** Estimates of 3Com stub value, calculated as the share price of 3Com less 1.5 times the PV of the synthetic forward price of Palm.

## 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 $\delta$ 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.

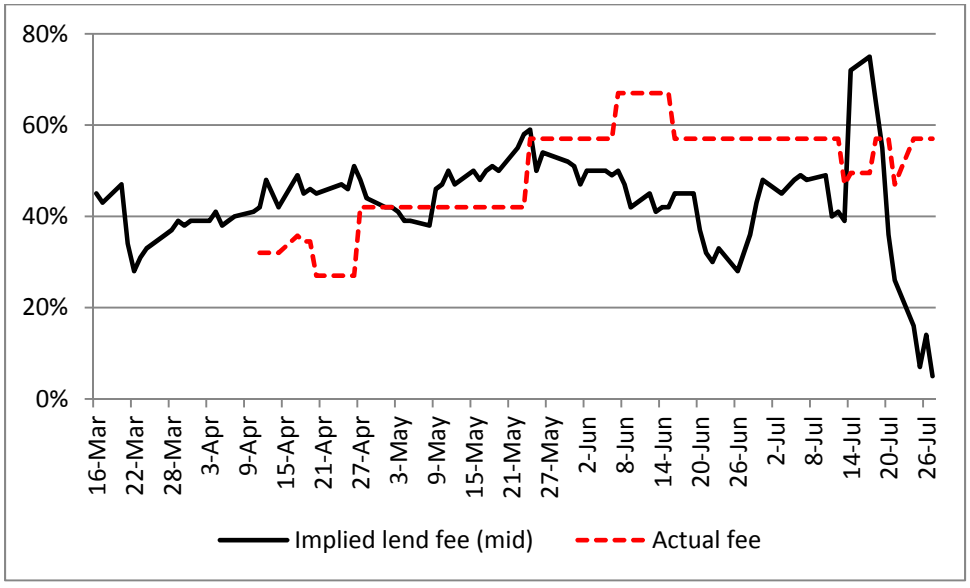



**Figure 4.** Annualized Palm lending fees implied by forward prices calculated on various dates.

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 given 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 process (mean difference = -0.0584, Newey-West t-stat with 5 lags = 1.44).

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

From the no-arbitrage relationship $F_{Aug,t} * (e^{(0.063-\widehat{\delta})*(\text{Nov}-Aug)} = F_{\text{Nov},t}$, 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 becoming essentially zero ($t$ = 1.03) once the July 27 spinoff date is announced, exactly as the theory would predict!

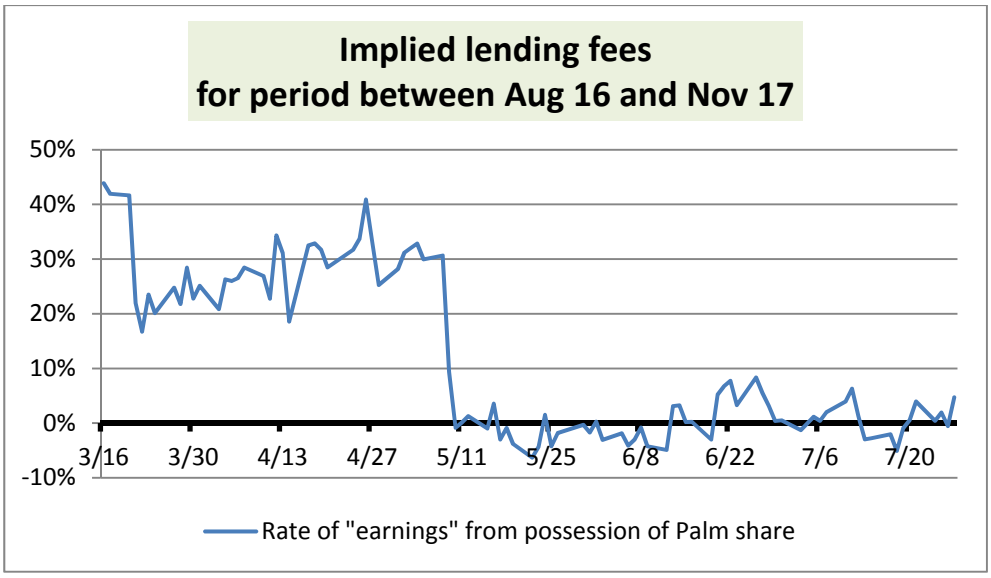



**Figure 5.** Palm lending fees implied from Aug 2000 and Nov 2000 forward prices.

## 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 since 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 $\delta$.

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 $\delta$ 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, LOOP requires that assets be deliverable in lieu of the other for the law to be observed within the limits of transaction costs. As 3Com could not be delivered in lieu of a shorted Palm share until the spinoff had occurred, LOOP is not violated. As the time of spinoff was uncertain, the Palm-3Com case offers at most a "risk arbitrage" 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[15] 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.[16] Here the part is more valuable than the whole. But it does not mean that these two markets break the LOOP: 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.

[15] 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 US coins, but it is currently illegal to melt pennies or nickels.

[16] In addition, a bag of these coins contains copper that was worth about $80 on that date.

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 LOOP. 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 more precise implications than the broader perspective that there is huge latitude within limits of arbitrage.

**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.

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: otherwise identical apartments may trade at a 30% price difference if one is in a co-op and the other is a condo![17] Matching of cash-flows is not enough, as we learn from "on-the-run" vs. "off-the-run" Treasury bond markets or closed-end funds trading at a discount.

[17] 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 condo apartments.

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 if all parameters are carefully matched. This was not the case in the Palm-3Com story: outright ownership of Palm shares vs indirect ownership of Palm shares via ownership of 3Com is the crucial difference that drives these 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 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.

## 8. A fully rational equilibrium

In any equilibrium, there must be a set of investors that holds Palm shares and does not lend them out. Duffie, Garleanu, 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. 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.

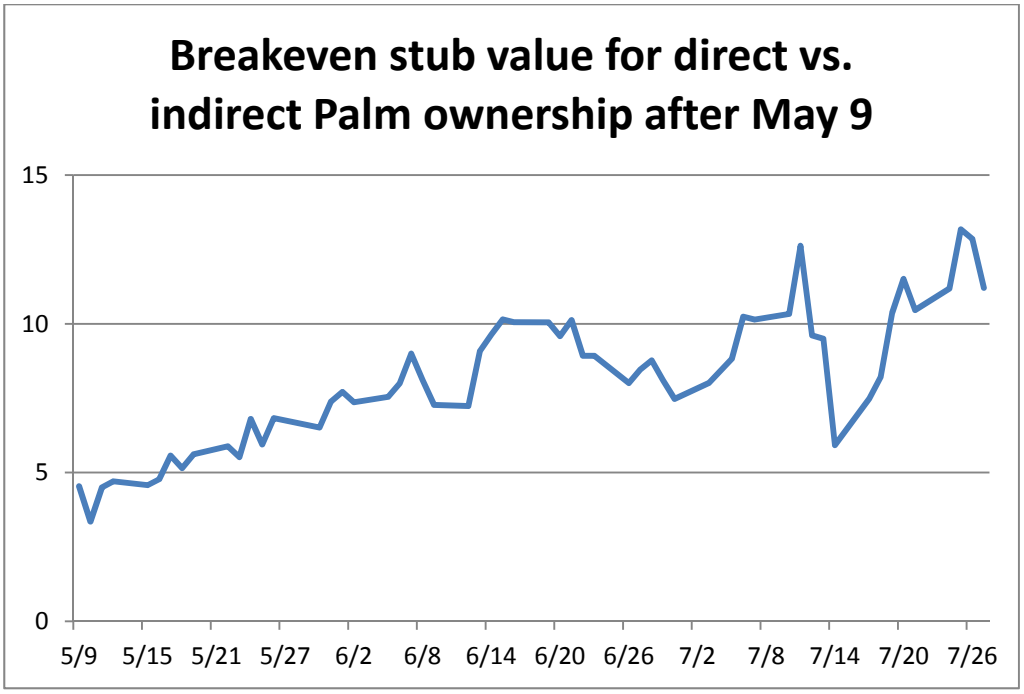



**Figure 6.** The breakeven stub value is calculated as 1.5 * the Palm share price less the 3Com share price.

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 expense 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.[18] 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 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.

*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 shares. Define $\overline{S_t}(x_i)$ as the

[18] 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.

"indirect price" for one such investor *i* of owning Palm via 3Com when that investor believes that the 3Com stub value is $x_{it}$:

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

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* and is given by:

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

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:

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

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 hold directly 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:

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

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 9 breakeven stub value. These beliefs do imply a non-trivial amount of

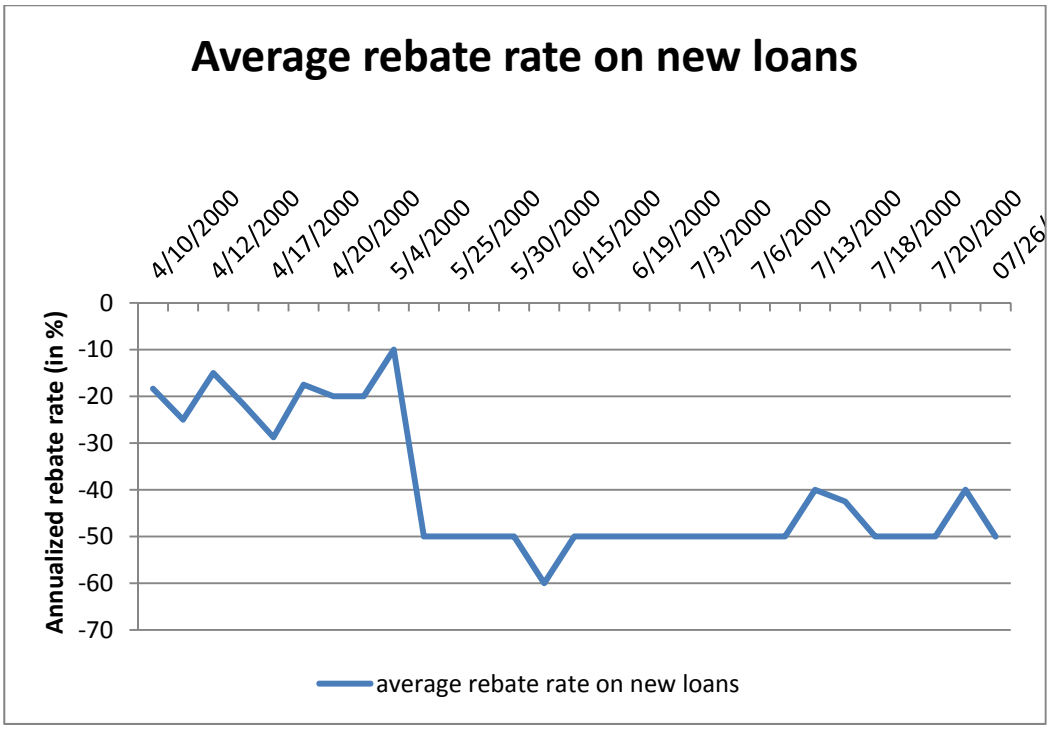
value destruction, but these beliefs seem far from irrational given the experience of other investors in these equity carve-outs.

## 9. Conclusions

The Palm—3Com episode is a memorable one. It appears to provide a singular challenge to the notion of rational market pricing. This paper offers an alternative interpretation. We provide novel and systematic evidence that, throughout this episode, 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 the observed price patterns in both Palm and 3Com.

**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 were originated sometime between April 10 and July 26 and all were closed (i.e., repaid) by August 1 once the spinoff was completed. The graph below shows the rebate rates for loans originated at different dates.



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