The Demand for Stocks: An Analysis of IPO Auctions

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We analyze a unique dataset that includes the full demand schedules of 27 Israeli IPOs that were conducted as nondiscriminatory (uniform price) auctions. To the best of our knowledge, this is the first time the whole demand schedule for any asset is described. The demand schedules are relatively flat around the auction clearing price: The average elasticity is 37. The elasticity is low when the return distribution contains a large *unique* component. We also find a significant average abnormal return of 4.5% on the first trading day and a positive correlation between the abnormal return and the elasticity of demand.

This article uses a unique dataset of initial public offerings (IPOs) of securities conducted as nondiscriminatory (uniform price) auctions. Our data include the full demand schedules for 27 auctioned Israeli IPOs. To the best of our knowledge, this is the first time the whole demand schedule for any asset is described. Specifically, unlike prior studies that have estimated demand schedules from observed quantities demanded at different points in time (under an assumed stationarity of demand), we actually observe the whole demand schedule at a given point in time. We use these data to investigate three related issues: (i) the shape of the demand function for securities, and especially the elasticity of the demand for securities, (ii) the existence and magnitude of underpricing in auctions of initially offered securities, and (iii) the relation between the abnormal return on the first post-IPO trading

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day (i.e., the underpricing) and information released by underwriters about the shape of the demand function for the security in the auction.

In basic asset-pricing models in finance (e.g., CAPM, APT, Modigliani–Miller's propositions), the aggregate demand for financial assets is virtually perfectly elastic and an asset's value is almost independent of its supply. On the other hand, in models that allow for asymmetric information, the demand curves for financial assets are not perfectly elastic. Yet even if demand curves for stocks are not perfectly elastic, it is still an interesting empirical question to see how well an elastic demand function approximates actual demand schedules for stocks. Several studies examine whether actual demand for stocks is perfectly elastic. Scholes (1972), Mikkelson and Partch (1985), Holthausen, Leftwich, and Mayers (1990), and Keim and Madhavan (1994), among others, report significant price movements when large blocks of shares are traded. Harris and Gurel (1986), Shleifer (1986), Beneish and Whaley (1996), and Lynch and Mendenhall (1997) report a positive price reaction to the inclusion of a stock in the S&P 500 index, explained by the purchase of these shares by index funds. These empirical findings are consistent with inelastic demand for stocks. To the best of our knowledge, the only evidence to date for the magnitude of demand elasticity for stocks is provided by Bagwell (1992). She examines 31 Dutch auction repurchases in the United States and reports an average (median) demand elasticity of 0.68 (1.05). According to her findings, the assumption of infinite elasticity is not a valid approximation of actual demand schedules of securities, which appear to be quite inelastic in her sample.

We examine demand schedules for securities in Israeli IPOs. In the period December 1993–December 1996, IPOs in Israel were conducted as nondiscriminatory auctions with a minimum price but no maximum price. In these auctioned IPOs investors submit sealed bids that specify a schedule of demanded quantities at each price. From these orders the lead underwriter of each IPO calculates the aggregate demand function for the IPO. We have obtained the full aggregate demand schedules of 27 IPOs and use these data in our analysis. We find that the average (median) demand elasticity in our sample is 37.1 (21.0).[1] Our elasticity estimates indicate that security demand schedules are quite elastic.

The use of auctions in the IPOs we analyze allows us to explicitly examine another aspect of the demand for securities. Several empirical studies document underpricing in IPOs in various countries. [For reviews of these studies see Loughran, Ritter, and Rydqvist (1994) and Chowdhry and Sherman (1996).] This underpricing manifests itself by a positive average abnormal return to a strategy of buying stocks in the IPOs and selling them shortly

[1] While these estimates are well above Bagwell's estimates, the two estimates are not directly comparable. We discuss how the studies differ in Section 2.

after they start trading in the secondary market. The studies that examine this issue are different in many aspects (e.g., the country, the sample period, the period length from the IPO, the control for market movements), but they all report that the underpricing is economically and statistically significant.

Existing theoretical explanations for underpricing are based on the fact that in most IPOs (e.g., in U.S. IPOs) prices are fixed by the firm or by the underwriters before the securities are sold to the public. Ostensibly these theoretical explanations are not valid in IPOs where the stock price is not fixed prior to the IPO and where allocations are not determined by the issuers or the underwriters, such as in the auctioned IPOs we analyze. Surprisingly, a small but significant underpricing is documented even in countries where IPOs are conducted as auctions. Similarly we find in the Israeli IPO auctions we analyze that the average abnormal return on the first trading day is 4.5% (after controlling for simultaneous market movements). No significant abnormal return is found beyond the first trading day.

Lastly, we examine the relation between the information released by the underwriters after the auction but before the first trading day and the abnormal returns of the offered securities on their first trading day. Specifically, when announcing the auction clearing price, the underwriters also announce the oversubscription at the minimum price. This means that the announced auction results include two points on the aggregate demand function: the quantity demanded at the minimum price and the clearing price for the offered quantity. From these two points one can calculate an estimate of the elasticity of the demand schedule. We examine whether the information about the elasticity of the demand for the issued security that is revealed upon completion of the auction is related to the abnormal return of the security on its first trading day. We find a positive and significant correlation between the abnormal return on the first trading day and the publicly announced measure of demand elasticity.

We interpret the empirical relation between the price change following the IPO and the elasticity of the demand for the security as evidence that the elasticity information revealed in the auction includes price-relevant information that cannot be extracted from the clearing price alone. Under this interpretation, information that the demand for the security (in the IPO auction) is elastic is "good news." High demand elasticity may be considered "good news" since

- An elastic demand in the auction may reflect more accurate investor information about the payoff of the security. The accuracy of investor information affects the risk premium to be included in expected returns. Hence, learning that the IPO demand is more elastic than expected leads to a decrease in the demanded risk premium and a price increase on the first trading day (and vice versa).
- An elastic demand in the auction may indicate high future liquidity

("depth"), which means lower transaction costs in future trading. Since the expected trading costs affect the current value of the security [see, e.g., Amihud and Mendelson (1986)], learning that the demand for the stock is more elastic than expected leads to a price increase on the first trading day.

The article is organized as follows. Section 1 describes the data. In Section 2 we present and analyze the demand schedules. Section 3 documents the post-IPO performance. In Section 4 we discuss possible explanations for the underpricing and examine the relation between the extent of the underpricing and the slope of the demand schedules. Section 5 concludes the article.

1. Data

In the period December 1993–December 1996, IPOs in Israel were conducted as nondiscriminatory auctions. The IPO auctions were officially and practically open to all investors. In these auction IPOs, firms sell units that typically consist of shares and additional securities — warrants, convertible bonds, or straight bonds. The IPOs' prospectuses specify, among other information, the unit's composition, a minimum unit price, and the number of units offered. Any investor may participate in these auction IPOs by submitting, free of commission, one or several limit orders. Orders can be placed between 8:30 A.M. and 12:30 P.M. of the auction day. During these 4 hours investors submit, via any broker, limit orders specifying quantities and prices.[2] Orders may be at prices that exceed the minimum price by whole New Israeli Shekels (NIS) increments (roughly 1/3 U.S. dollar). This tick size represents a small fraction of the auction price, which averaged in our sample to NIS 180.2: one NIS increment equals in our sample anywhere from 0.17% to 2.86% of the auction price. The individual orders are aggregated by the lead underwriter and the auction's clearing price is the highest price at which demand at least equals supply. Orders at prices exceeding the auction clearing price are fully filled. Orders at the auction clearing price are prorated to fully sell the IPO. Orders below the auction clearing price are left unfilled. All filled orders are settled at the auction clearing price.

On the morning following the auction day the lead underwriter publishes the auction results, money is paid for the units bought, and the units are distributed to the winning bidders.[3] The issued securities begin to trade on the Tel Aviv Stock Exchange (TASE) 3 to 5 business days after the IPO. The issued securities trade on the TASE via a computerized call auction (i.e., without market makers and without bid-ask spreads).

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[2] Investors may submit multiple limit orders each specifying a desired quantity at a given price.

[3] Capital market transactions clear in Israel on the day following the transaction date.

Table 1
Summary statistics for IPOs

	Mean	SD	Median	Min	Max
Units sold in IPO (thousands)	207.14	189.46	137.50	50.00	847.18
Minimum unit price (NIS)	139.16	113.09	103.00	25.50	465.60
Auction clearing price (NIS)	180.19	140.18	125.50	35.00	590.00
Allocation at auction price (%)	53.48	29.06	57.75	4.78	95.56
Number of orders	4,077	3,151	2,486	1,388	13,518
Pre-IPO equity book value (NIS MM)	25.76	24.04	16.47	3.95	111.71
Post-IPO insider ownership (%)	74.41	7.03	75.00	53.86	89.69

Data are for 28 IPOs conducted on the Tel Aviv Stock Exchange between December 1993 and February 1994.

Our data include the 28 auctioned IPOs between December 1993 and February 1994.[4] We have collected all public information about these auctions and about trading in the issued securities following the IPOs from the prospectuses and from publications of the TASE. In addition, we have obtained from the lead underwriters of 27 of the 28 auctions the aggregate number of units ordered at each price.[5] Accordingly, in our analysis we use the full sample of 28 auctions when knowledge of the full demand function is not needed and only 27 observations when data about the demand function is used. In Appendix A we list the issuers, the composition of each issued unit, and the issue dates of our sample.

In Table 1 we provide summary statistics about our sample of auctioned IPOs. The table shows that on average a quarter of the issuing firms was auctioned in these IPOs. The number of orders, while overestimating the number of bidders (since some bidders might have submitted orders through more than one broker), is still quite large. This indicates widespread participation in these IPO auctions. Prior to the IPOs the issuing firms had an average equity book value of NIS 25 million, which is about $8 million. The average receipt from the IPOs was about NIS 12 million, or roughly $4 million, implying a post-IPO average market value of roughly $16 million.

2. Demand Functions

Our data allow us to examine the demand for stocks as revealed by investor demand schedules on IPO days. An important feature of the demand schedules we analyze is that they reflect bids submitted by thousands of investors. This means that investor incentives to bid strategically is very weak. Specif-

[4] At the end of February 1994 the Tel Aviv Stock Exchange crashed. Following the crash there was a dramatic decline in IPO activity and almost all the issues offered after the crash were sold at the minimum price set in the offers' prospectuses. Consequently, our data are limited both in time and in the number of observations, which reduces the power of our tests.

[5] The underwriter of one IPO has misplaced the records of the order quantities and prices of the auction.

ically, Ausubel and Cramton (1996) show that bidders in multiunit English auctions have an incentive to “shade” their bids since they may end up being the marginal bidders and affect the price they pay for the inframarginal units they win. The incentive to shade demand diminishes as the number of participating bidders increases ([see also Rustichini, Satterthwaite, and Williams (1994)]. Hence, in our sample, where thousands of investors bid for shares, the chance of any investor being pivotal is so small that we can safely assume that investors behave competitively — that in their bids investors ignore the small chance that they will have a small effect on the price they pay for the units they end up buying. However, this is not a pertinent assumption for our analysis: Even if investors bid strategically, it is of interest to examine the shape of the strategic demand schedules. Moreover, none of the analyses we carry in this article is predicated upon the demand schedules being nonstrategic. Note also that investors’ demand need not reflect their assessments of the value of the shares in the long run: Investors may bid according to their assessment of the price of the shares on the first trading day, the first day on which they can rebalance their holdings.

To illustrate the data we analyze, in Figure 1 we plot the demand schedule of the first IPO in our sample: the offering by Noga Inc. of units that include two shares and one warrant. It is a representative demand schedule in that the characteristics we point out below are present in virtually all the individual demand schedules. Noga offered 337.5 thousand units at a minimum price of 35 NIS each. At the minimum price there were 2.4 million units demanded, seven times more than the number of units offered. The auction’s clearing price was 45 NIS, 28.6% above the minimum price. Orders at prices above 45 NIS were fully filled. Orders at the auction clearing price were partially filled — 45% of the ordered number of units rounded to whole units. Thus no individual bid was actually pivotal in this auction (nor in any other auction in our sample: the highest allocation rate at the auction-clearing price in our sample was 96.6%).

The shape of Noga’s and all other demand schedules is similar: In all demand schedules we observe a relatively flat (i.e., elastic) section around the auction clearing price and a small number of units demanded at prices that far exceed the auction price. In the Noga IPO, which ended with a unit price of 45 NIS, 2,000 units were demanded at prices above 70 NIS (compared to 2.4 million units demanded at the minimum price of 35 NIS). We interpret these high-price bids as “virtual market” bids — bids by investors who want to buy a certain number of units (say, to mimic an index) at whatever price the market determines is appropriate for these units. It is interesting to note that in these “virtual market” bids, investors use mostly round prices (i.e., while there were units demanded at prices of 60 NIS and 70 NIS, there were no units demanded at prices of 69, 68, . . . , 61 NIS), while in bids close to

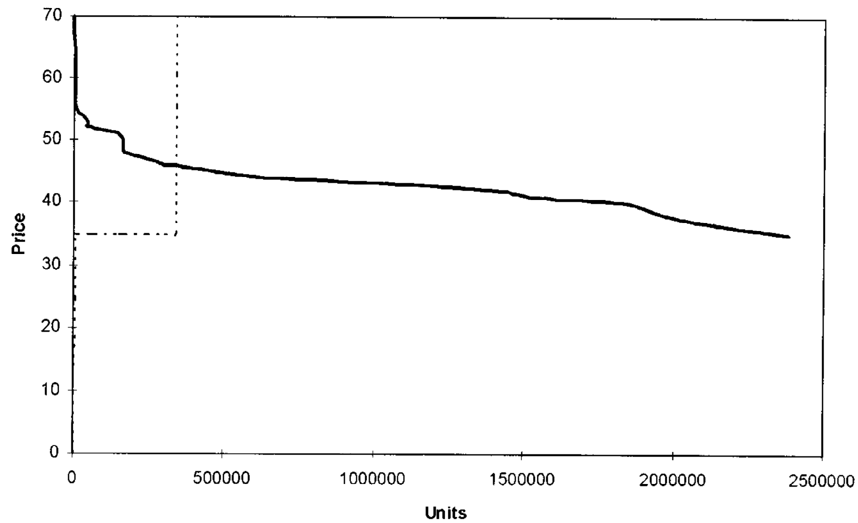


Figure 1
The demand for Noga securities in the IPO auction
The full demand schedule for the first IPO in our sample — the offering of Noga Inc. shares and warrants in units of two shares and one warrant each. There were 337,500 units offered at a minimum price of 35 NIS. The auction clearing price was 45 NIS. The figure depicts the demand schedule (the bold line) and the supply schedule — a flat line at 35 NIS up to 337,500 units and a vertical line thereafter.

the auction clearing price the whole spectrum of possible bid prices was utilized.[6]

In Figure 2 we plot the average demand schedule. To compute the average demand schedule we begin by normalizing each demand schedule to an auction price of 1.0 and to an offered quantity of 1.0. Then, for each price increment of 0.5% around the normalized auction price, we compute the demanded quantity in each auction by interpolating the two points in that auction's demand schedule that bracket this normalized price. These 27 demanded quantities are averaged and plotted in Figure 2. The average demand schedule also exhibits the high elasticity around the auction price and existence of some "virtual market" bids — bids at prices that far exceed the auction price.

In Table 2 we report statistics for four indicators of the slope of the IPO demand schedules: oversubscription at the minimum price, percentage allocation at the auction clearing price, and two measures of the elasticity of demand. The first elasticity measure is the elasticity of demand at the

[6] Kandel, Sarig, and Wohl (1997) analyze investor preference for round prices.

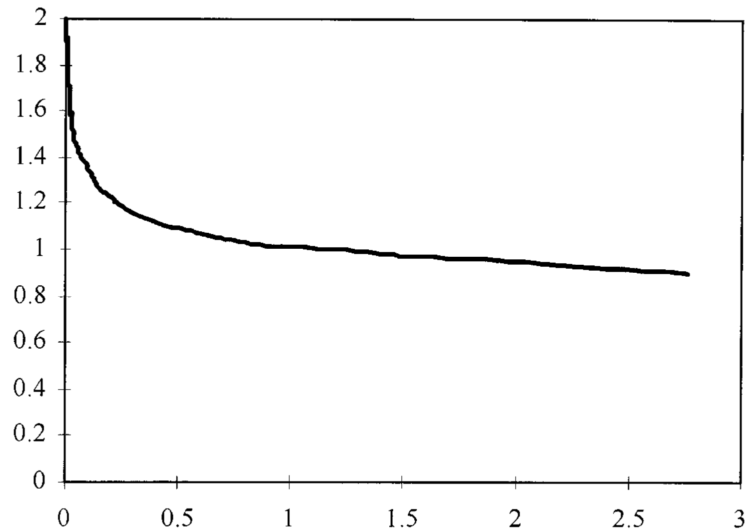


Figure 2
The average demand schedule in IPO auctions
The average demand schedule in 27 auctioned IPOs conducted on the Tel Aviv Stock Exchange between December 1993 and February 1994. All offered quantities and auction clearing prices are normalized to unity.

auction clearing price:

$$\text{elasticity} = \frac{(Q_{\text{auction}} - Q_{\text{auction}+1\ \text{NIS}})/Q_{\text{auction}}}{1/P_{\text{auction}}},$$

where Q_{auction} and $Q_{\text{auction}+1\ \text{NIS}}$ are the quantities demanded at the auction clearing price and at 1 NIS above it, respectively. We are able to compute this measure of demand elasticity from the detailed demand schedule data we have obtained from the underwriters. Since these data are not available to investors at large, we also calculate a second elasticity measure — *gross elasticity*, which is based on information that is announced to all investors upon completion of the auction. Specifically, since the lead underwriter announces the quantity demanded at the minimum price, investors can calculate a gross elasticity measure based on the quantities demanded at two points: the demand at the minimum price and at the auction clearing price.[7] That is,

$$\text{gross elasticity} = -\frac{(Q_{\text{minimum}} - Q_{\text{auction}})/Q_{\text{minimum}}}{(P_{\text{minimum}} - P_{\text{auction}})/P_{\text{minimum}}}$$

[7] The correlation coefficient between the elasticity and the gross elasticity measures is 0.099.

Table 2
The slope of the IPO demand schedules

	Mean	SD	Median	Min	Max
Elasticity	37.163	45.325	21.035	1.569	189.834
Gross elasticity	2.911	1.995	2.467	1.120	11.241
Oversubscription	5.104	3.019	3.970	1.580	12.960
Allocation (%)	53.484	29.059	57.745	4.780	96.630

Data are for 28 IPOs conducted on the Tel Aviv Stock Exchange between December 1993 and February 1994.
"Elasticity" denotes the elasticity of the demand schedules at the auction's price and the auction's offered quantity. Data on elasticity is available for only 27 firms of the IPO sample.
"Gross elasticity" denotes the elasticity of the demand schedule at the minimum auction price, calculated from publicly available information.
"Oversubscription" denotes the ratio of quantity demanded at the minimum auction price to the offered quantity.
"Allocation" denotes the proration ratio of the quantity demanded exactly at the auction clearing price.

We estimate an average (median) elasticity of 37.2 (21.0) and an average (median) gross elasticity of 3.0 (2.5). Both elasticity estimates are statistically and economically significantly larger than 1.0 (p-values of less than 0.1%). Similarly, since all measures of elasticity for all auctions are larger than 1.0, even a weaker nonparametric test of equal probability of the slope being larger or smaller than 1.0 is rejected at commonly used significance levels (p-value less than 0.1%). Our results indicate quite an elastic demand for stocks in IPOs.

To the best of our knowledge, the only other comparable computation of the elasticity of the demand for stocks is in Bagwell (1992): She analyzes investor bids in 31 cases where firms announced intention to repurchase their own shares at prespecified price ranges. Bagwell (1992) estimates an average (median) elasticity of the demand for stocks in the United States of 0.68 (1.05). There are several differences between our data and Bagwell's data:

- Bagwell's data concern bids for *traded* and *priced* shares, while our data concern the demand for securities in initial offerings.
- In Bagwell's data investor heterogeneity is partially tax motivated (due to differing cost bases) while in our case investors are not subject to capital gains tax so that investor heterogeneity is solely due to differences in estimated values.
- Investor bids in Bagwell's repurchases were bounded by the maximum price the firm announced it was willing to pay for the stock, while demand in the IPOs we analyze was not capped by a maximum price.

These differences may entail differences in the estimated elasticities. On the one hand, since information heterogeneity is probably larger in IPOs than in repurchases of already traded stocks, we may expect IPO elasticities to be *lower* than in the repurchase Dutch auctions. On the other hand, since investors in Bagwell's sample have heterogeneous cost bases off which capital gains tax will be assessed upon the sale of the securities, we may expect IPO elasticities to be *higher* than repurchase elasticities. Indeed, we find higher elasticities than Bagwell.[8]

Next we examine the relation between the elasticity of demand for initially offered securities and the decomposition of the offered securities' risk into systematic and specific components. We expect the elasticity of demand to be negatively correlated with the specific risk of the security and positively correlated with the systematic risk. Intuitively, this is because we expect most information asymmetry to be about the specific component of stock-return distributions while the systematic component (which is replicable by other traded securities) is relatively symmetrically known. As the models of Kyle (1985) and others imply, greater asymmetry of information entails a greater sensitivity of equilibrium prices to demanded quantities. This leads us to postulate that asset demand functions are less elastic when the specific risk component of the return distribution is high.[9]

To examine this postulate, we estimate the market model for the issued securities based on their weekly returns over the 6-month period following the sample period. We then separate the total variance of the securities' returns into systematic risk, which is estimated by β^2 times the market volatility in the period, and nonsystematic risk, which is estimated by the total variance less the systematic variability. We regress the demand elasticities on the ex post realized systematic and nonsystematic risks. The estimated regression relation is (heteroskedasticity-consistent standard errors in parentheses)

$$\underset{(18.113)}{\text{elasticity} = 36.372} + \underset{(2.940)}{3.866} * \text{systematic risk} - \underset{(1.501)}{2.642} * \text{nonsystematic risk}$$

$$R^2_{\text{adj.}} = 0.0275 \qquad F = 1.350$$

To interpret the estimated relation we assume that the *realized* systematic and nonsystematic risks of the stocks are unbiased proxies for investor expectations of these risk components at the time of the auction (in other words, we assume rational expectations of the risk components). Under the assumed rationality of expectations, the estimated regression coefficients

[8] A recent study by Nyborg, Rydqvist, and Sundaresan (1997) analyzes the demand for Swedish Treasury bills and bonds. The main differences between our data and theirs are (1) the Swedish auctions are discriminatory while the Israeli auctions are uniform-price auctions; (2) only 14 dealers can participate in the Swedish auctions while any investor can participate in the Israeli auctions; and (3) with few exceptions, the auctioned Swedish securities are concurrently traded in the secondary market while we analyze initially offered securities.

[9] See also Wohl and Kandel (1997) who analyze a model where investors can better learn from trading about the systematic components of the return distributions than they can learn about the specific components of the distributions. In the resulting equilibrium, asset demand functions are less elastic when the specific risk component of the return distribution is high than when it is low.

indicate, as postulated, that the elasticity of demand for the issued securities is relatively low for securities the return distribution of which contains a large element of nonsystematic risk.[10]

In sum, the demand schedules of the securities offered in the auction IPOs appear to be much more elastic than prior research has indicated. The demand elasticity is also found to be negatively correlated with the extent to which the stock's return distribution is nonsystematic.

3. Post-IPO Performance

The issued securities begin trading 3 to 5 business days after the auction takes place. Therefore, to study the post-IPO performance of the issued securities we need to adjust the first trading day return for the market movement in the period from the auction day to the first trading day. We adjust the returns of the issued securities for concurrent market movement in two ways:

- Using the market model of returns:

$$r_{i,t} = \alpha_i + \beta_i \cdot r_{m,t} + \epsilon_{i,t}$$

  with the firm-specific parameters estimated from returns in the 6-month period following the IPO, and
- Simply deducting the concurrent market returns, which is equivalent to using the market model with unit betas and zero intercepts for all securities.

The choice of an adjustment for concurrent market movements has little effect on our results. The raw first-day IPO returns of all offerings and the corresponding market returns in the periods from the auction days to the first trading days are given in Appendix B.

In Table 3 we report the characteristics of the market model adjusted abnormal returns for our sample of auctioned IPOs in their first 10 trading days. As is evident from the table, the auctioned IPOs were underpriced relative to the price investors deemed appropriate for the securities on the first trading day: The first day's average market model adjusted return is 4.5%, which is significantly higher than zero (heteroskedasticity consistent p-value of 0.3%). Similar results are obtained with market adjusted returns: a significant average abnormal first trading day return of 4.7% (heteroskedasticity-consistent p-value of 0.4%). On the other hand, the average abnormal returns on the second through tenth trading days of the issue are economically and statistically not significantly different from zero

[10] Estimating the regression with the *gross* elasticity (which is a more noisy measure of elasticity) rather than with the elasticity itself yields estimates of the same sign and size but of larger p-values. Similarly, estimating the regression with the R^2 (i.e., with the *percentage* of total variability explained by the market return) instead of estimating it with the separate risk components yields similar but weaker results.

Table 3
Abnormal returns on auctioned Israeli IPOs

Trading day	Mean (%)	SD (%)	Min (%)	Median (%)	Max (%)
1	4.536	7.872	−6.916	1.640	20.859
2	0.910	3.608	−5.837	0.599	8.232
3	1.168	4.746	−9.544	0.280	10.030
4	0.679	5.018	−9.153	0.475	9.187
5	−0.627	4.149	−9.459	−0.208	9.555
6	0.257	3.288	−6.546	0.312	6.563
7	0.092	2.965	−7.862	0.225	6.220
8	0.051	3.018	−7.067	−0.240	6.322
9	−0.024	4.644	−11.885	0.748	9.021
10	−0.252	4.479	−13.345	−0.495	8.915

"Trading day" refers to the trading day after the auctioning of the initially offered securities.
Data are for 28 IPOs conducted on the Tel Aviv Stock Exchange between December 1993 and February 1994. Abnormal returns are computed using the market model with parameters estimated over the 6-month period following the auctioning of the securities in the IPOs. The average estimated beta for the auctioned securities is 1.12 and the average daily market return in the sample period was −0.22%.

when returns are normalized by either the market model, or by subtracting the return on the market, or even when they are not normalized at all.

Our results are consistent with the recent findings of Hauser and Tanchuma (1997) who estimate abnormal returns in auctioned Israeli IPOs in the period December 1993–December 1996, a period that includes the post-market-crash IPOs. They report a positive average abnormal return in IPOs where the auction clearing price exceeds the minimum price. They find, however, a negative average abnormal return when the offered shares are sold at the minimum price. Note that when the auctioned shares are sold at the minimum auction price, the market clearing price may be below the IPO price (and the underwriters may be forced to purchase the undemanded shares).

Our finding of an underpricing in auctioned IPOs is puzzling. Theories to explain IPO underpricing examine the relations between the three parties to an IPO: the issuing firm (i.e., the selling current owners), the underwriters, and the buying investors. Some theories suggest benefits to the issuing firms or to the underwriters from fixing too low a price: signaling firm value, reducing the probability of subsequent class action, enhanced underwriter reputation among investors, implicit underwriter fee to be distributed among loyal clients, etc.[11] Clearly these explanations, which rely on the underpricing benefiting either the issuer or the underwriter, are not relevant in our case where the IPO price is determined by investors in an auction and not by either the issuers or the underwriters.

Other theories argue that if the IPO price is determined before bids are submitted, there must be a discount to ensure that the IPO is fully sold. For

[11] See, for example, Baron (1982), Allen and Faulhaber (1989), Tinic (1988), Grinblatt and Hwang (1989), Benveniste and Spindt (1989), Biais, Bossaerts, and Rochet (1996), and Chowdhry and Sherman (1996). Michaely and Shaw (1994) empirically examine these theories and conclude that information asymmetries better explain observed underpricing patterns than signaling motives.

example, in Rock (1986) informed investors do not participate in overpriced IPOs; they only buy shares in underpriced IPOs. Consequently, uninformed investors, who cannot distinguish underpriced IPOs from overpriced IPOs, receive a larger fraction of overpriced IPOs than of underpriced IPOs. To entice uninformed investors to participate in IPOs, the IPO price must be set so that on average uninformed investors receive a fair return. Rock's argument, however, is not applicable to the auctioned IPOs we analyze: If uninformed investors fear strategic purchases by informed investors, they could bid at very high prices and effectively let the informed investors determine the auction's clearing price. Moreover, since these are uniform-price auctions, positive average abnormal IPO returns entail strategies that yield abnormal profits: Any investor may bid a fixed quantity at prices that are clearly above the value of the securities (i.e., submit effectively market orders), receive all the quantity she demands, but pay only the auction clearing price. Rock's (1986) argument, therefore, cannot explain the underpricing we observe in the auctioned IPOs.[12]

It is possible that the positive abnormal return on the first trading day reflects underpricing by investors: Since each investor bids for multiple units, each investor has a chance of being the pivotal bidder — the marginal bidder who determines the auction clearing price, so that investors have an incentive to shade their bids [cf. Ausubel and Cramton (1996)]. However, as discussed in Section 1, since thousands of investors participate in the auctioned IPOs we analyze, the probability that any given investor will be the pivotal bidder is virtually zero. Hence the incentive to shade the demand is infinitesimal [cf. Rustichini, Satterthwaite, and Williams (1994) and Ausubel and Cramton (1996)]. Moreover, even if there is an incentive to shade demand in the IPO, a similar incentive exists in the first trading day. Hence, even if investors bid strategically, no abnormal return should be observed between the IPO day and the first trading day.

In sum, the underpricing in auctioned IPOs requires a different explanation than provided to date. We suggest a direction for finding such an explanation in the following section.

4. An Examination of the Post-IPO Performance

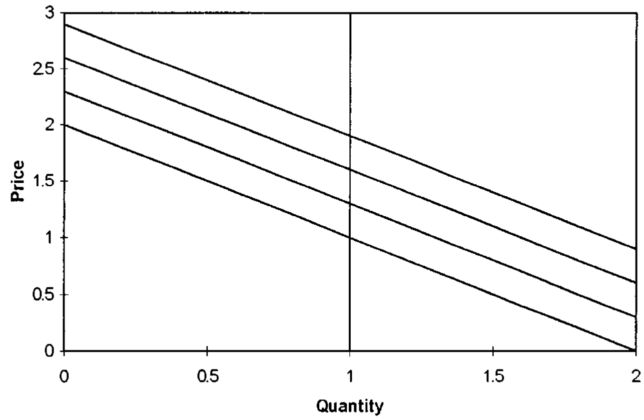
Assuming that investor expectations about the prospects of the IPOs are rational, we expect that the explanation for the positive abnormal return on the first trading day is related to new information revealed upon the completion of the auction and not to information known prior to the auction. Indeed, we test and find no correlation between the first day's abnormal returns and

[12] Welch (1992) suggests that IPO prices are discounted to avoid information cascades, which may cause IPOs to fail. The rationale provided in this paragraph for why Rock's argument does not apply to our sample of auctioned IPOs equally applies to Welch's argument.

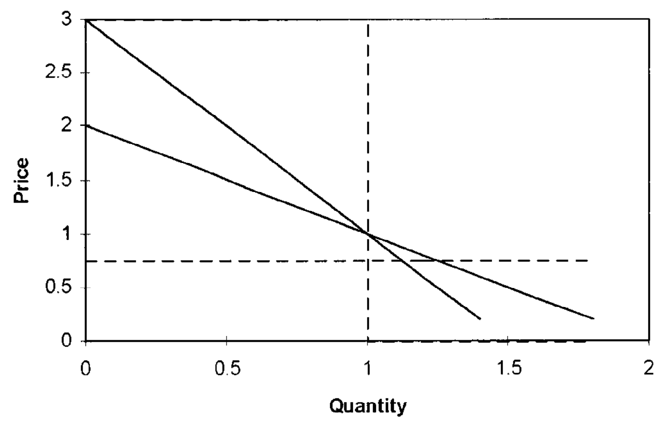
either the size of the firm (measured by the book value of its equity) or the percentage ownership of the firms' insiders following the IPOs, as both variables are known prior to the auction. Similarly we find that the abnormal returns are not correlated with the auction clearing prices (standardized by the book value of the equity of the issuer) since investors' demand schedules condition on these prices. On the other hand, new information released upon announcement of the auction results, information which cannot be conditioned upon ex ante, may explain the observed positive average abnormal returns.

One key feature of the auctioned Israeli IPOs we analyze is that, following the auction, investors gain information about the elasticity of the demand for the stock. Specifically, following the IPOs, underwriters announce the demand for the offered securities at two points: the demand at the minimum price and the demand at the auction clearing price. Given this information, investors can calculate the slope of the demand function between the minimum price and the auction price, that is the gross elasticity. Suppose that information about the elasticity of the demand for a security is important to determine the value of the security. Then, since prior to the auction investors are uncertain about the security's demand elasticity, and since this uncertainty is resolved in the auction, the first day price of the stock may differ from its auction clearing price.

The intuition for why information about the elasticity of the demand for a security is relevant for its pricing is as follows. Almost all rational expectations models of demand for securities assume demand schedules of the type depicted in Figure 3A: Demand schedules are parallel to each other because they result from a fixed number of investors with private information of a given accuracy. Since the number of investors and the accuracy of their information are assumed to be common knowledge, the slope of the demand schedule is also common knowledge in these models. Thus knowing the location of one point on the realized demand schedule reveals the whole demand schedule. Suppose, however, that the number of investors and the accuracy of their information is not common knowledge. In this case, there can be multiple demand schedules crossing the offered quantity at any given price. For example, demand could be high because many investors received moderately accurate signals about the assets or because few investors received very accurate information about the value of the asset. The two demand schedules entail the same clearing price, but the accurate information leads to a relatively elastic (i.e., flat) demand schedule while the relatively inaccurate information leads to relatively inelastic (i.e., steep) demand schedule. While both demand schedules lead to the same IPO price, they may entail differing subsequent valuations once the slope of the demand schedule becomes common knowledge: A relatively elastic demand schedule means that the stock is more valuable than the IPO clearing price alone indicates either because investors' information is of greater



A. Standard Rational Expectation demand schedules



B. Crossing multiple Rational Expectation demand schedules

Figure 3
Demand schedules for offered securities

accuracy than initially expected or because subsequent trading in the stock can be expected to be more liquid than initially expected. Although these uncertainties about the value of the security need not be priced, we expect the post-IPO price of the stock to be positively correlated with the elasticity of demand in the auction.

Note that usually uncertainty about the accuracy of information investors have about the firm and the degree of interest and commensurate liquidity of trading in the stock are revealed to investors only gradually. In the Israeli IPO auctions, however, the underwriters resolve the uncertainty about the elasticity of the demand for the security on the day of the auction. Thus the expected correlation between the elasticity of demand in the auction and the post-IPO price translates into a positive correlation between the first trading day's abnormal return and the elasticity of demand.

To examine the relations between the IPO demand elasticity and the first-day abnormal returns we use the previously defined measures of the slope of the demand schedule: the elasticity of the demand schedule at the auction clearing price and the gross elasticity of the demand schedule. Since only the later slope measure — the gross elasticity — is published to investors at large, we expect that the gross elasticity measure will show higher correlation with post-IPO returns.

In Table 4 we report the regression estimates of the relation between the first trading day returns and the two measures of the slope of the demand schedule. To account for the marketwide return in the period from the auction day to the first day of trading, the first trading day returns are normalized in two ways: relative to the market model return and relative to the market return. As hypothesized, the elasticity of the demand schedule measured at the auction clearing price, which is information investors are not privy to, is not (significantly) correlated with the abnormal returns on the first trading day. On the other hand, the gross measure of the slope of the demand schedule — the gross elasticity, which is information investors learn upon announcement of the auction results, is significantly (heteroskedasticity-consistent p-value 1.1%) positively correlated with the market adjusted returns on the first trading day. It appears that the information about the slope of the demand schedule released to investors upon completion of the IPO auction is important for investors to determine the post-IPO value of the security: Given the auction clearing price, a relatively flat demand schedule is "good news" and a relatively steep demand schedule is "bad news."

Our findings are related to recent research on the time-series properties of prices in noisy rational expectations equilibria. Several studies [e.g. Brown and Jennings (1989), Grundy and McNichols (1989), and Kraus and Smith (1989)] show that equilibrium prices may change over time even though no new information arrives and that the sequence of prices may reveal more information than a single price may.[13] Applied to our context, these analyses imply that prices on the first trading day (which is the second time investors get to trade the initially offered securities) may reveal more information about investors' assessments of the values of the offered securities than the auction prices alone reveal. If the uncertainty about the value of the initially offered securities cannot be diversified away, prices set when the securities are initially auctioned may include a risk premium that diminishes on the

[13] An example where a sequence of prices may reveal more information than a single price is in Kandel, Ofer, and Sarig (1993), where investors trade index bonds and sequentially learn inflation information.

Table 4
The relation between the slope of the IPO demand schedules and the abnormal return on the first trading day

Computation of AR	**Intercept**	**Elasticity**	**Gross elasticity**	R^2_{adj}
Market model adjustment	4.358 (1.957)	−0.0115 (0.029)		−0.035
	1.072 (1.850)		1.148 (0.562)	0.077
Market adjustment	4.426 (2.063)	−0.009 (0.031)		−0.037
	0.929 (2.096)		1.245 (0.591)	0.073

Data are for 28 IPOs conducted on the Tel Aviv Stock Exchange between December 1993 and February 1994.

The reported statistics are for the regression relation:

$$AR_i = \alpha_0 + \alpha_1 \cdot SLOPE_i + \epsilon_i$$

where

"AR_i" refers to the first trading day abnormal returns of firm i estimated with two adjustments: a market model adjustment and a market adjustment. The parameters of the market model adjustment for firm i (i.e., the firm-specific alpha and beta estimates) are estimated over the 6 months following the sample period. The market adjustment assumes a unit beta and a zero alpha for all IPOs.

"$SLOPE_i$" refers to the slope of the demand function for firm i where *SLOPE* is either "elasticity" or "gross elasticity."

"Elasticity" refers to the slope of the demand schedule estimated at the auction clearing price. Estimates of the elasticity are available for 27 of the 28 IPOs in our sample.

"Gross elasticity" refers to the slope of the demand schedule estimated from information released to investors following the IPO auction about the demand at the minimum price and the demand at the auction-clearing price.

Heteroskedasticity-consistent standard errors are in parentheses.

first trading day. This may explain the positive abnormal return observed in our sample of auctioned IPOs.

Note, however, that the standard deviation of the first trading day's return (given in Appendix B) is 11.3%. Comparing this value, for example, to the standard deviation of the return on the S&P 500 index (1926–1994) of 20.2%, and assuming that risk premia are proportional to the variance of return, we can translate the S&P's risk premium in this period of 8.4% to a "comparable" risk premium for the Israeli IPOs of 2.63%.[14] Thus, even if the IPO risk cannot be diversified away, the actual variance of the first days' returns does not seem to fully explain the abnormal return on the first trading day.

[14] The postderegulation Israeli stock market statistics (1986–1992) are a standard deviation of 29% and a market excess return of 17%, indicating a slightly lower "comparable" risk premium given the IPO's first day's risk of about 2.58%.

5. Concluding Remarks

We use a unique dataset of initial public offerings of securities, conducted as nondiscriminatory (uniform price) auctions. Our data include the full demand schedules for auctioned IPOs conducted in Israel. To the best of our knowledge, this is the first time the whole demand schedule for any asset is described and analyzed. Using these data, we examine demand schedules for securities in Israeli IPOs. We find that the average (median) demand elasticity at the auction clearing price in our sample is 37.1 (21.0). The elasticity of demand is lower for securities with return distributions which are largely unique than for securities with return distributions which are largely systematic.

We also find a small but significant average abnormal return on the first trading day of the IPOs (4.5% after controlling for simultaneous market movements). The underpricing in uniform-price auctioned IPOs with thousands of investors is puzzling. We present a direction for future research to explain this puzzle. As recent theories suggest, investors may possess more information than auction price alone can reveal. When investors' private nonprice information becomes public, investors reassess their positions and the prices of the securities are revised according to the revealed information. In the auctioned IPOs we examine, the lead underwriters reveal, inter alia, the elasticity of demand on the auction day. If this information leads investors to update their assessment of the value of the security, the uncertainty about the elasticity of demand may entail a risk premium. Consistent with this possibility, we find a positive and significant correlation between the abnormal return on the first trading day and the elasticity estimate. The variance of the first day return, however, does not seem high enough to fully explain the average return on the first trading day as a risk premium, which leaves these findings as a puzzle.

Appendix A: Issuers, Issue Compositions, and Issue Dates for IPO Sample

Issuer	Unit composition			Number of units (thousands)	Issue date
	Shares	Warrants	Convertible bonds		
Noga Electronics	2	1		337.5	26 Dec 93
Rats Rental	5		45	370.0	27 Dec 93
Sany Electronics	6	2		300.0	28 Dec 93
Tsamantcol	2	1		847.2	02 Jan 94
Hason	8	2		212.5	03 Jan 94
Feldman	10			55.5	04 Jan 94
Paltov	17	17		200.0	04 Jan 94
Al-bad	16	9		60.0	05 Jan 94
Lego	5	2		551.0	06 Jan 94
Pineros	20		90	120.0	06 Jan 94
Zion Textiles	10			140.0	11 Jan 94
Amnat	6	3		250.0	16 Jan 94

(continued)

Issuer	Unit composition			Number of units (thousands)	Issue date
	Shares	Warrants	Convertible bonds		
Hapach	14	7		100.0	17 Jan 94
Caduri	11	4		125.0	25 Jan 94
H Electronics	16	9		168.0	17 Jan 94
Nisan Industries	10			150.0	19 Jan 94
Tsinomtel	10	7		107.0	23 Jan 94
Yuval Engineering	10			200.0	24 Jan 94
MTY Computers	10			135.0	24 Jan 94
Tosaf Compounds	2	1		663.7	27 Jan 94
Tefen Engineering	10			62.5	30 Jan 94
Averbuch	18	15		100.0	30 Jan 94
Unitrol	35	16		50.0	02 Feb 94
Neviim Hotels	20	20		100.0	03 Feb 94
Galkom	20			115.0	08 Feb 94
Interkosma	19	11		54.6	09 Feb 94
Agish Transportation	10	3		160.0	09 Feb 94
Grofit Engineering	10	9		150.0	09 Feb 94

Appendix B: IPO Returns on the First Trading Day versus Market Returns in the Period from the Auction Day to the First Trading Day

Issuer	IPO return on first trading day (%)	Market return from auction day to first trading day (%)
Noga Electronics	16.73	−1.25
Rats Rental	10.63	−0.41
Sany Electronics	19.41	1.58
Tsamantcol	15.71	3.07
Hason	7.48	2.87
Feldman	0.00	2.87
Paltov	6.16	2.87
Al-bad	−0.21	0.67
Lego	2.45	1.50
Pineros	0.15	1.06
Zion Textiles	16.97	2.12
Amnat	−3.68	−3.88
Hapach	−9.28	−5.81
Caduri	−4.59	−5.81
H Electronics	−1.50	−3.00
Nisan Industries	26.60	6.16
Tsinomtel	26.07	5.05
Yuval Engineering	10.00	5.05
MTY Computers	17.50	4.31
Tosaf Compounds	6.55	−1.29
Tefen Engineering	0.75	−1.29
Averbuch	−1.86	−1.29
Unitrol	−0.03	−3.58
Neviim Hotels	−6.73	−8.00
Galkom	−16.28	−7.30
Interkosma	−2.29	−4.03
Agish Transportation	−8.79	−4.03
Grofit Engineering	−12.53	−4.03
Average	**4.121**	**−0.565**
Standard deviation	**11.291**	**3.947**

References

Allen, F., and G. R. Faulhaber, 1989, "Signaling by Underpricing in the IPO Market," *Journal of Financial Economics*, 23, 303–324.

Amihud, Y., and H. Mendelson, 1986, "Asset Pricing and the Bid-Asked Spread," *Journal of Financial Economics*, 17, 223–249.

Ausubel, L. M. and P. C. Cramton, 1996, "Demand Reduction and Inefficiency in Multi-Unit Auctions," working paper, University of Maryland.

Bagwell, L. S., 1992, "Dutch Auction Repurchases: An Analysis of Shareholder Heterogeneity," *Journal of Finance*, 47, 71–106.

Baron, D. P., 1982, "A Model of the Demand for Investment Banking Advising and Distribution Services for New Issues,"*Journal of Finance*, 37, 955–976.

Beneish, M. D. and R. E. Whaley, 1996, "An Anatomy of the S&P Game: The Effects of Changing the Rules," *Journal of Finance*, 51, 1909–1930.

Benveniste, L. M. and P. A. Spindt, 1989, "How Investment Bankers Determine the Offer Price and Allocation of New Issues," *Journal of Financial Economics*, 24, 343–362.

Biais, B., P. Bossaerts, and J.-C. Rochet, 1996, "An Optimal IPO Mechanism," working paper, Toulouse University.

Brown, D. P. and R. H. Jennings, 1989, "On Technical Analysis," *Review of Financial Studies*, 2, 527–552.

Chowdhry, B. and A. E. Sherman, 1996, "International Differences in Over-subscription and Underpricing of IPOs," *Journal of Corporate Finance*, 2, 359–381.

Grinblatt, M. and C. Y. Hwang, 1989, "Signaling and the Pricing of New Issues," *Journal of Finance*, 44, 393–420.

Grundy, B. D. and M. McNichols, 1989, "Trade and Revelation of Information Through Prices and Direct Disclosure," *Review of Financial Studies*, 2, 495–526.

Harris, L. and E. Gurel, 1986. "Price and Volume Effects Associated with Changes in the S&P 500: New Evidence for the Existence of Price Pressures," *Journal of Finance*, 41, 815–830.

Hauser S. and Y. Tanchuma, 1997, "A Study of the Effect of the Underwriting Methods in Israel on IPO Results," working paper, Israeli Securities Authority (in Hebrew).

Holthausen, R. W., R. W. Leftwich, and D. Mayers, 1990, "Large-Block Transactions, the Speed of Response, and Temporary and Permanent Stock-Price Effects," *Journal of Financial Economics*, 26, 71–96.

Kandel, S., A. Ofer, and O. Sarig, 1993, "Learning from Trading," *Review of Financial Studies*, 6, 507–526.

Kandel, S., O. Sarig, and A. Wohl, 1997, "Do Investors Prefer Round Stock Prices? Evidence from Israeli IPO Auctions," working paper, Tel Aviv University.

Keim, D. B. and A. Madhavan, 1994, "Anatomy of the Trading Process: Empirical Evidence on the Behavior of Institutional Traders," *Journal of Financial Economics*, 37, 371–398.

Kraus, A. and M. Smith, 1989, "Market Created Risk," *Journal of Finance*, 44, 557–569.

Kyle, A., 1985, "Continuos Auction and Insider Trading," *Econometrica*, 53, 1315–1336.

Loughran, T., J. R. Ritter, and K. Rydqvist, 1994, "Initial Public Offerings: International Insights," *Pacific-Basin Finance Journal*, 2, 165–199.

Lynch, A. W. and R. R. Mendenhall, 1997, "New Evidence on Stock Price Effects Associated with Changes in the S&P 500 Index," *Journal of Business*, 70, 351–384.

Michaely, R. and W. H. Shaw, 1994, "The Pricing of Initial Public Offerings: Tests of Adverse-Selection and Signaling Theories," *Review of Financial Studies*, 7, 279–319.

Mikkelson, W. H. and M. M. Partch, 1985, "Stock Price Effects and Costs of Secondary Distributions," *Journal of Financial Economics*, 14, 165–194.

Nyborg, K. G., K. Rydqvist, and S. Sundaresan, 1997, "Bidder Behavior in Multiple Unit Auctions: Evidence from Swedish Treasury Auctions," working paper, London Business School.

Rock, K., 1986, "Why New Issues Are Underpriced," *Journal of Financial Economics*, 15, 187–212.

Rustichini, A., M. A. Satterthwaite, and S. R. Williams, 1994, "Convergence to Efficiency in a Simple Market with Incomplete Information," *Econometrica*, 62,1041–1063.

Scholes, M. S., 1972, "The Market for Securities: Substitution Versus Price Pressure and the Effects of Information on Share Prices," *Journal of Business*, 45, 179–211.

Shleifer, A., 1986, "Do Demand Curves for Stocks Slope Down?," *Journal of Finance*, 41, 579–590.

Tinic, S. M., 1988, "Anatomy of Initial Public Offerings of Common Stock," *Journal of Finance*, 43, 789–822.

Welch, I., 1992, "Sequential Sales, Learning, and Cascades," *Journal of Finance*, 47, 695–732.

Wohl, A., and S. Kandel, 1997, "Implications of an Index-Contingent Trading Mechanism," *Journal of Business*, 70, 471–488.