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CAN VENTURE CAPITAL FUNDS PICK WINNERS? EVIDENCE FROM PRE-IPO SURVIVAL RATES AND POST-IPO PERFORMANCE

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This paper documents pre- and post-IPO (initial public offering) differences in the performance of venture capital financed Israeli companies in comparison with other high-tech firms during the period 1991 to 2000. Using a newly constructed database we find that: (1) the probability of survival until the IPO stage is higher for venture-backed companies, and (2) according to several different measures, conditional on making an IPO, the post-listing performance of venture-backed companies is not statistically different from that of companies financed by non-venture financiers throughout the 1990s. One interpretation of these findings is that venture capital funds increase the survival rates of young technology-intensive firms; another is that there are fundamental – though not always observable – differences between venture-backed companies and other high technology firms and venture capital funds select companies which are inherently more likely to go public. Both interpretations indicate that venture-backed companies are associated with low "infant mortality," but not with stellar post-IPO performance.

1. INTRODUCTION

The role of venture capital (VC) funds in financing innovative activities is well documented in the literature (for an overview, see Gompers and Lerner, 1999 and 2001). In the presence of severe informational problems regarding the quality of innovative young firms, VC funds are viewed as a mechanism to identify and select promising startups, and to add to their value by monitoring their progress and advising their management. By contrast, other financial intermediaries are typically reluctant to finance risky early stage activities of innovative firms: bank loans are not suitable because of the lack of tangible assets and because of the difficulty in evaluating the value and progress of startup firms. Similarly,

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severe information problems make it virtually impossible for young innovative companies to raise funds on stock markets. VC funds are organized in a way that enables them to meet these informational challenges (Gompers and Lerner, 2001), and their activity is therefore of particular economic importance.

Israel is regarded as a success story of high technology startups and venture capital activity. According to many accounts, VC activity in Israel in the 1990s was one of the most intensive in world, exceeded only by California and Massachusetts (e.g. Mayer, Schoors, and Yafeh, 2005). The dramatic evolution of the venture capital industry in Israel from a small, government-sponsored sector in the early 1990s, into a booming private industry with over 100 active funds investing billions of dollars per annum in the late 1990s, has made government policy in support of the infant VC industry in Israel a possible model for many other countries (e.g. Avnimelech and Teubal, 2004a). Israeli VC funds are interesting not only because of the industry's phenomenal success, but also because of the striking organizational resemblance between VC funds operating in Israel and their American counterparts: Israeli VC funds, like their American counterparts, are organized as limited partnerships and use American-style financial contracts with the entrepreneurial firms they invest in (Kaplan and Stromberg 2003 describe these contracts in considerable detail). Furthermore, the fact that virtually all Israeli VC-backed IPOs take place on NASDAQ and not on the Tel Aviv Stock Exchange makes the lessons drawn from studies of this industry potentially relevant elsewhere.

The present study attempts to contribute to the VC literature by empirically examining two main questions:

(1) Is VC finance associated with a higher probability of survival of young innovative firms prior to their "exit?"

(2) Conditional on survival until the exit stage, do VC-backed companies outperform their peers (according to several different criteria) after the IPO?

The two hypotheses, which measure the ability of VC funds to select "winners" and to add to their value, are examined using a newly constructed database containing detailed information on *all* Israeli VC funds and their portfolios of client companies and yield two sets of results. First, we provide evidence in support of the first conjecture: in comparison with other high-tech firms financed by non-VC sources, the probability of survival until the exit stage is significantly higher among VC-backed companies. Second, conditional on making an IPO, we find little evidence to suggest superior post-IPO performance of VC-backed companies in comparison with non-VC-backed high-tech firms. This conclusion holds when examining initial valuation (at the time of the IPO), 36-month stock performance, accounting profitability and asset growth rates in the three years following the IPO.

One possible interpretation of these findings is causal: the reason for the high survival rate of VC-backed companies prior to the IPO and for the absence of a significant difference in their post-IPO performance relative to their peers is that VC finance adds value by reducing mortality rates among high-tech firms (perhaps through monitoring, guidance and financial assistance); but, among the population of survivors, VC funds are unable to identify "winners." An alternative interpretation of the results is selection-based: VC funds pick "survivors," that is, invest in companies that are inherently more likely to go

public. The question of "value-added" (or "nurture") vs. "selection" (or "nature") is prevalent throughout the VC literature and the present paper, like many other studies, cannot resolve it.[1]

The present study is related to the large literature on VC funds around the world and their contribution to the success of their portfolio companies. Well–known studies of the VC industry in the US tend to portray a positive contribution of venture capital finance to the likelihood of making an IPO (Shane and Stuart, 2002), to innovative activity or to the introduction of efficient management (e.g. Gompers and Lerner, 1999 and 2001; Hellman, 1998 and Hellman and Puri, 2000; Lerner and Kortum, 2000).[2] Less well known studies using European data tend to be more nuanced. For example, Manigart and Van Hyfte (1999) find that Belgian VC-backed start-ups do not have higher survival rates, but at least some of them do grow faster prior to the exit stage, albeit with higher volatility (see also Manigart et al., 2002). Engel and Keilbach (2002) find faster growth for German-backed VC companies, also prior to the exit stage, but not higher patenting rates (see also Tykvova and Walz, 2005, on VC-backed IPOs in Germany). Examining companies listed on Europe's "new markets," Botazzi and Da Rin (2002) do not find any evidence to suggest that VC-backed companies fare better than other high-tech companies in terms of growth rates or stock prices. Our view of the VC industry in Israel, especially with respect to pre-IPO differences in survival rates, is more in line with the positive US-based views, perhaps because of the similarity in organizational form and in the extent of development of the VC sector in the two countries.[3]

The rest of the paper is organized as follows. The next section describes the database used for this study, and provides some background information on VC activity in Israel since the early 1990s. In Section 3 we compare the pre-IPO attributes of VC client firms with those of other high-technology companies, and discuss their survival rates. Section 4 contains the empirical analysis of post-IPO performance. Further discussion of the results and some conclusions are offered in Section 5.

2. THE DATA

The data set used in this study is constructed by combining and updating two data sets. The first is the data set used in Ber (2003), extended and updated through 2002, containing information on all the start-ups that were included in the portfolios of all VC funds at any

[1] A recent study by Sorensen (2007) offers a highly technical and difficult two-sided matching model to address this issue, and finds that both effects are important.

[2] There are also a number of studies on the post-IPO stock performance of VC-backed high-technology companies (e.g. Megginson and Weiss, 1991, or Brav and Gompers, 1997), which typically report superior performance of VC-financed companies in comparison to various control groups. Jain and Kini (1995) report superior post-IPO accounting performance of VC-backed firms in the US, as well as higher initial valuations relative to a matched sample of companies not financed by VC funds.

[3] On international comparisons of the organizational form of VC funds, see Kaplan, Martel and Stromberg (2007), Lerner and Schoar (2005), and Mayer, Schoors, and Yafeh (2005).

point between 1997–2000 (661 companies; similar data for earlier years are unavailable).[4] The database provides detailed information on each company supported by a VC during the period, including its line of business, firm characteristics, and status through 2002 (on-going with VC support, closed/deleted from the VC's portfolio, or performed an "exit:" IPO, private sale, or merger). Because most of those companies are private, this information is not available to the general public, and was gathered primarily from reports of the Israel Venture Association (IVA), to which all VC funds report. Alongside these data, similar information was collected for a control group of high-tech companies that were not supported by a VC fund and raised capital from non-VC sources, primarily from 32 investment companies (data are also from the Israel Venture Association). These investment companies are private equity funds (although the term is not commonly used) which are focused on financing high technology, but are not organized as VCs: for example, they are not necessarily organized as limited partnerships with limited and general partners; unlike VC funds, investment companies are not set up for an (*ex ante*) limited period; and investment companies are characterized by flexibility in their investments, unlike VC funds, which often specify clear investment policies and rules in their charters. (In addition, investment companies are typically much smaller than VC funds in terms of capital managed). Many studies have argued that the organizational characteristics of VC funds and the contracts they use are particularly suitable for resolving information and incentive problems associated with investment in high technology (Kaplan and Stromberg, 2003, for example). If the organizational form of VC funds is indeed crucial for VCs to be able to successfully select and advise client firms, then high-tech firms financed by private equity companies not organized as VC funds constitute an interesting comparison group. This comparison, however, raises two questions: first, why would some firms choose to seek finance from non-VC entities, and second, if non-VC private equity investment companies suffer from organizational shortcomings in comparison with VC funds, how do they survive? One possible answer is that VC funds and non-VC investment companies offer different products (for example, in the extent of advice and involvement provided by the financier), which may also be priced differently, and different firms have different preferences over these two modes of finance. In addition, budget constraints may prevent both VC funds and non-VC investment companies from offering financing to all firms. To some extent, we attempt to address these sample selection issues econometrically in the analysis which follows; and to some extent, despite the fact that the selection problems cannot be fully addressed given the available data, it is still of interest to document differences in pre-IPO survival rates between VC-backed high-tech companies and their non-VC financed peers; the selection issues should be taken into consideration in the interpretation of the empirical results.

The second database we use, constructed by the Bank of Israel, contains information on the accounting and stock-based performance measures for all Israeli high-tech companies listed on NASDAQ. This information is used to compare the post-IPO performance of 51

[4] Israeli VC funds are those listed in the Israel Venture Association, regardless of their sources of funds or ownership. The data set does not include information about foreign VC funds operating in Israel.

VC-backed IPOs in comparison with 38 other high-tech firms that went public between 1991 and 2000.[5]

In the analysis that follows, we draw conclusions on the pre-IPO survival rates and post-IPO performance of VC-backed firms in comparison with other high-tech companies as if the two data sets contained information on the same firms in different stages of their life, before and after the IPO. In practice, however, the pre-IPO characteristics and survival rates of VC-backed and other companies refer to the period 1997-2002, whereas the comparisons of post-IPO performance are based on information on companies that went public between 1991 and 2000. The discussion and conclusions that we draw are therefore based on the strong (but, in our view, plausible) assumption that both the pre- and post-IPO differences between VC-backed and other high-tech companies are a general phenomenon, which applies to periods beyond the sample years.[6]

a. The VC Industry in Israel

Prior to the 1990s there existed no VC industry in Israel; the industry was created as a result of the initiative and direct involvement of the government in 1991. Initially the government provided some guarantees for the purchase of shares in three VC funds founded in 1991–93, and in 1992 the "Yozma" government VC fund was set up in order to establish VC funds in cooperation with private foreign investors. Until its dissolution, the fund, which was set up for a limited period of seven years with $100 million of equity, supported the establishment of ten private VC funds, which together raised a total of $ 2.7 billion by 2000. At present, the government is no longer involved in the VC industry in any way, and the sector is comprised entirely of private entities. By mid-2000 Israel's VC funds—which are registered with the Registrar of Companies—managed $5 billion of capital via 62 management companies, controlling 97 funds. Finance raised by the funds in 2000 amounted to 2.7 percent of GDP—a particularly high rate compared to other countries (in the US, for example, it was 0.7 percent of GDP at that time). This ratio declined in 2001 and 2002 due to the sharp fall in financial markets, but remained relatively high even during these years: 1.8 and 1 percent, respectively. Basic statistics on the VC industry appear in Table 1; for further information on its evolution, on sectors and stages of companies receiving VC finance, and on the organization of VC activity (sources of

[5] The overwhelming majority of IPOs by Israeli high-tech companies takes place on NASDAQ, not on the Tel Aviv Stock Exchange (there were only three cases of a VC-backed IPO on the Tel Aviv Stock Exchange during our sample period), and by the late 1990s, the number of Israeli companies listed on NASDAQ exceeded the number of all other foreign firms combined (excluding Canadian companies). With very few exceptions, these companies belong to high-tech industries; see Blass and Yafeh, 2001, for a detailed discussion of this unusual phenomenon. Because, during the 1990s, NASDAQ high-tech IPOs tended to perform better than the IPOs on the domestic market (Blass and Yafeh, 2001), our data may be viewed as a comparison of VC-backed issues with the best non-venture-backed technology IPOs.

[6] During the overlapping period of 1997-2000, the database we use for the analysis of the pre-IPO survival rate covers 26 of the 38 firms that went public during these four years. The remaining 12 companies must have been financed by non-VC entities which are not included in our control sample.

finance, contracts between VC funds and recipient companies, etc.), see Avnimelech and Teubal (2004b), Ber (2003), and Mayer, Schoors, and Yafeh (2005).

3. RECIPIENTS OF VC FINANCE AND THEIR PRE-IPO SURVIVAL RATES

Panel A of Table 2 presents some descriptive statistics on high-tech companies in the portfolios of VC funds and non-VC private equity investment companies between 1997 and 2000. The two samples appear to be quite similar in their (admittedly limited number of) observable characteristics such as age, number of employees, and, with some exceptions, type of activity. Panel B presents probit regressions attempting to characterize the recipients of VC finance. The predictive power of these regressions is poor, and the number of correct predictions is very close to the number that could be predicted by simply using the proportion of VC-backed firms in the sample. We conclude that it is hard to predict (given the available data) who will receive VC finance based on observable firm characteristics.[7]

Table 3 describes changes in the portfolios of VC funds and other investment companies. A striking feature of Panel A is that the fraction of companies deleted from the portfolio of VC funds between 1997 and 2002 (due to business failure or bankruptcy) - about a quarter - is less than half the corresponding figure for non-VC private equity investment companies. Over half of the portfolio of the non-VC investment companies failed, mostly between the years 2000 and 2002. Panel B shows several (simple and ordered) probit specifications indicating that, controlling for firm characteristics, the probability of being deleted from the portfolio of a non-VC investment company during the period 1997-2002 was significantly higher than the probability of being deleted from the portfolio of a VC fund. In addition, the regressions show that the probability of reaching the exit stage was also higher for VC-backed firms (during the 1997-2002 period about 28 percent of the firms in the portfolio of VC funds "exited," versus slightly more than 10 percent of the non-VC backed companies in the sample).[8] The main conclusion from Table

[7] One additional variable that would have been interesting to include is firm size. This variable (number of employees) is not available for the time in which the firm was initially financed, and is therefore not an exogenous determinant of VC funding. In addition, data are missing for many firms. It might also be of interest to compare the technological "stage" of companies financed by VC funds and other financiers; these data are not readily available, but since there is empirical evidence that Israeli VC funds tend to finance companies in early stages (Mayer, Schoors, and Yafeh, 2005), it is implausible that the differences in pre-IPO survival rates between VC-backed and other companies are due to the fact that VC funds finance more mature companies than the ones financed by investment companies.

[8] It is also possible to control for the number of employees, a measure of firm size (which is positively correlated with firm age). This variable is not included in the regressions in Table 3 because information on size is not available for about a quarter of the sample firms. Nevertheless, regressions with the number of employees (not shown) suggest that, as can be expected, larger firms are more likely to exit and less likely to fail (the VC effect is unchanged). In one probit specification we control for the "average reputation" of VC funds that finance each company. Reputation is measured as the percent of firms in the VC's portfolio that exited during the fund's life (the mean value of this variable is about 13 percent). This statistic is averaged across all funds that finance each company because the individual contributions of each fund are unknown. We find no evidence that VC fund reputation is associated with higher survival or exit rates. The results are similar (i.e. fund reputation has no effect) if reputation is measured by the size of the fund's

3 is therefore that there is substantial evidence of higher survival rates among VC-backed firms. We discuss possible interpretations of this finding after examining differences in post-IPO performance.

4. THE POST-IPO PERFORMANCE OF VC-BACKED AND OTHER IPOS

In this section we investigate several measures of post-IPO performance of VC-backed firms in comparison with non-VC backed high technology firms.

a. Comparison of Valuation at the Time of the IPO

We begin by investigating whether there are differences between VC-backed and other companies in their stock valuation when their shares are offered to the public. First, we examine the extent of underpricing, a common phenomenon associated with IPOs: shares are offered at a discount relative to their true market value, and as a result, prices tend to rise on the first day of trading. There are a variety of explanations for this phenomenon (surveyed in Ritter and Welch, 2002), but many of them are associated with information problems – investors demand a discount because of fears that the shares they are buying may not be as good as they appear to be. These problems are especially acute in the context of young innovating firms, whose quality and growth prospects are hard to measure. Is VC-finance regarded as a quality certification, so that investors demand a smaller discount on these shares (i.e. less underpricing, or a smaller price increase on the first day of trading)? The literature on VC funds in the US has suggested that this is sometimes the case: Megginson and Weiss (1991), for example, find that VC-backed IPOs are less under-priced than other issues. In our sample, stock prices increase on average by about 9 percent on the first day of trading, although this masks considerable variation between the boom years of the late 1990's (when the extent of underpricing was much higher) and the earlier years. For the purpose of this study, however, the most important comparison is between VC-backed and other issues – in contrast with Megginson and Weiss' (1991) early study, we find that VC-backed IPOs are underpriced more than other issues (11.7 percent vs. about 6 percent), although the difference is far from being statistically significant. To control for the possibility that VC-backed issues differ in size, industry, or timing, we also run multivariate regressions controlling for these factors, where the dependent variable is the extent of underpricing (price increase on the first day of trading, see Table 4, columns 1 and 2) and again, find no difference between VC-backed and other stock issues.

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portfolio or by its age, in both ordinary probit and ordered probit specifications. Similarly, when we introduce variables measuring the reputation of non-VC investment companies, we do not find any significant effect (not shown). A number of recent studies have emphasized the importance of the VC fund network and contacts for the success of portfolio companies (Stuart, Hoang and Hybels, 1999; Hochebrg, Ljungqvist, and Lu, 2007); we do not have the data to examine these issues here. Finally, we examine also specifications allowing for a different VC effect across industrial sectors by interacting the VC dummy with the industry dummies, but do not find any significant differences in the VC effect across sectors.

Next, we examine the valuation of VC-backed IPOs at the end of the first day of trading (when stock prices are assumed to reflect fundamental values) and find that, on average, VC-backed IPOs are somewhat more highly valued (both in absolute terms – $58m vs. $43m - and in terms of market-to-book ratios), but in this case too, the differences are far from being statistically significant. Again, we run multivariate regressions where the dependent variable is initial valuation (at the end of the first day of trading) and the explanatory variables include IPO cohort (1996-2000 boom years vs. the early years), firm size and industry, but after controlling for these factors there still is no evidence that VC-backed IPOs are priced differently than other issues (Table 4). The results are similar when market-to-book ratios are used instead of valuation.

b. Comparisons of Stock Returns for VC-backed and other IPOs

Next, we turn to a decade-long comparison of stock returns for the first three years following the NASDAQ IPO of VC-backed and other high-tech companies. Is it the case that initial valuations did not fully anticipate the subsequent performance and VC-backed companies "surprised" (or disappointed) investors?

To address this issue, we calculate post-IPO stock returns using two different methods described in Ritter (1991). In both methods, the excess (or abnormal) return for firm *i* in month *t* after the IPO is defined as the difference between the return on the firm's equity and the market (NASDAQ) return. More sophisticated excess return calculations relative to a (matched) "reference portfolio" (e.g. Brav and Gompers, 1997) are not feasible in our case because of the sample size and because of the absence of comparable (Israeli) firms to which Israeli IPOs in the US should be compared. This is not a severe handicap, however, given that our objective is not to measure long-run excess returns in the most precise possible manner, but rather to compare the returns of venture-backed IPOs relative to non-venture backed issues. The calculations that follow ignore the return on the first day of trading, which are typically highly positive due to the well-documented phenomenon of "underpricing."

In the first approach, we calculate "buy and hold" cumulative abnormal returns for 36 months following the IPO under the assumption that the shares bought at the IPO are held for the entire period. For each company we calculate cumulative returns in excess of the NASDAQ index for a three-year period, and then calculate the (simple) mean and median returns for the sub-samples of VC and non-VC-backed IPOs.

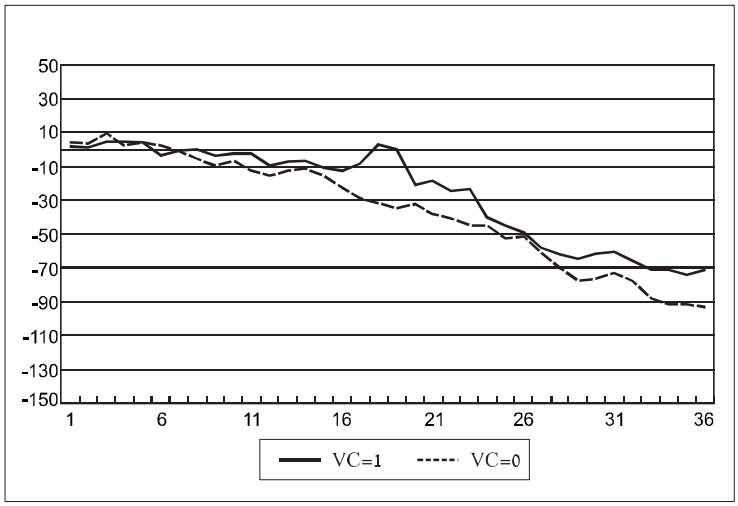
The second calculation method proceeds as follows. Again, we begin by calculating the abnormal return for each company in every month *t*, where *t* equals 1 to 36: $ar_{it} = r_{it}-r_{mt}$, where r_{it} is the return on company *i*'s stock in month *t* and r_{mt} is the NASDAQ index return in the same month. We then calculate the (simple) mean (or median) abnormal return for every month *t*, AR_t, for the sub-sample of VC-backed companies and for the sub-sample of non-VC-backed companies separately. For each of the two sub-samples we define the cumulative abnormal return, CAR_t as the sum of the mean abnormal returns, AR_t from month 1 to month *t*. This calculation method assumes "re-balancing" of the portfolio every

month, so that gains or losses in previous months are ignored and each month begins with an equal investment in all IPO cohorts.[9]

In order to test hypotheses about the CAR of VC-backed IPOs in comparison with other firms one needs to derive standard errors for the mean or median sample CAR. Although Ritter (1991) offers a method to derive the standard errors for his proposed CAR statistics, recent studies often use statistics derived through bootstrapping techniques (e.g. Hertzel et al., 2002). The use of standard errors based on bootstrapping is a way to get around the fact that the distribution of excess returns is rarely normal and typically unknown.

Table 5 and Figure 1 present the estimated cumulative excess returns (CAR) for VC-backed and other companies for 36 months according to the "buy and hold" method; the results for the second calculation method are qualitatively similar and appear in the Appendix. In line with the well-documented phenomenon of long-run under-performance of IPO shares (Ritter, 1991) the returns on both groups of issues fell far below the NASDAQ index.[10] More interestingly, there is little to suggest that VC-backed IPOs exhibit higher returns than other issues. According to the calculation presented in Table 5, VC-

Figure 1
Mean Post-IPO Stock Returns for VC-backed and Other IPOs
"Buy and Hold" Excess Returns over the NASDAQ Index



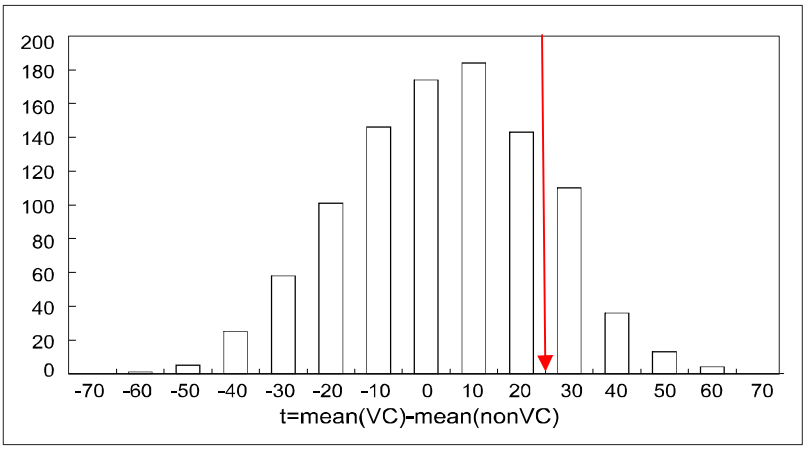
[9] Our calculations are based on simple means rather than on size-weighted averages. This is because of the sample size and because of the difficulty in assigning size-based weights to IPOs in different time periods.

[10] Ritter (1991) documents lower negative abnormal returns of about –30 percent over a three-year period for his sample of American IPOs. His interpretation of this phenomenon is of a "hot market" effect, whereby firms schedule their IPOs in a period when demand is particularly high, and investors are perhaps "over-optimistic." Some more recent studies suggest that severe measurement problems lead to what appears like long-run under-performance of IPO shares, see Ritter and Welch (2002).

backed IPOs fared better than their non-VC-backed peers, but the variance within each sample is so high that, using Ritter's (1991) standard errors, it is impossible to reject the null hypothesis that the mean and median CAR are in fact equal. The absence of significant differences in post-IPO stock returns between VC-backed and other IPOs is corroborated also by the second CAR calculation (see Appendix).

To verify the robustness of this finding we repeat the analysis using bootstrapped standard errors to gauge the significance of the difference in mean stock returns between VC-backed and non-VC-backed issues. The calculation of standard errors using bootstrapping is based on drawing 1000 samples of VC-backed and non-VC-backed IPOs (with replacement) and calculating the likelihood that the observed difference in the mean 36-month CAR between the two sub-samples is "unusually high" (see Efron and Tibshirani, 1993, for technical details). The results are displayed graphically in Figure 2. It is impossible to reject the hypothesis that the mean CAR is in fact equal for VC-backed and other IPOs (the *p*-value is 0.15); the actual difference in mean CAR between the two samples is close to the center of the distribution of the differences in the 1000 draws.[11]

Figure 2
Bootstrapping the Distribution of the Difference in Mean CAR between VC-backed and Other IPOs (1000 Draws with Replacement)
Distribution of difference of means (VC – non-VC), observed value = 22.3

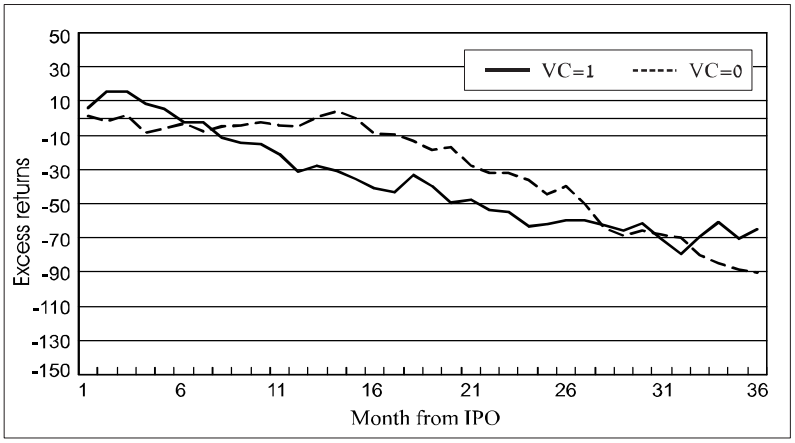


We now turn to the issue of clustering of IPOs in certain time periods. First, we divide our IPO sample into two cohorts, the first half of the 1990s and the "boom years" (1996-2000). This is because the incentives and ability of VC funds to pick successful companies

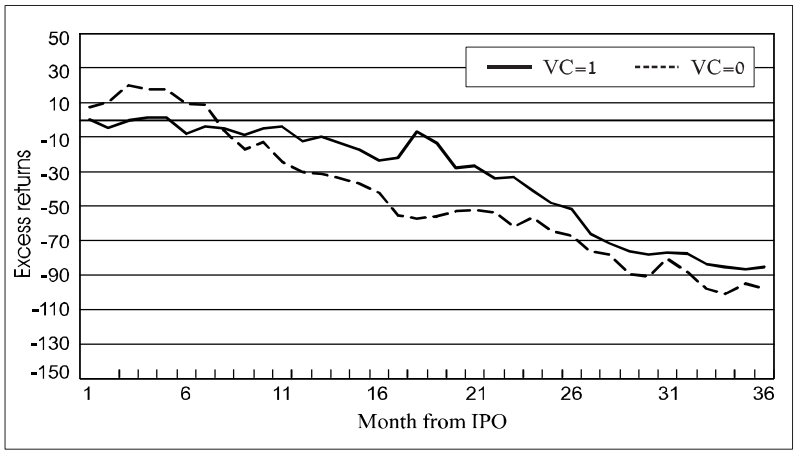
[11] Mitchell and Stafford (2000) argue that conventional measures of statistical significance are often overstated because of "clustering" – the fact that observations which belong to the same cohort or industry share some common features and are therefore not truly independent. They propose a solution – comparisons of calendar-time portfolios of firms – that is not feasible for our small sample. However, if, as they argue, the bootstrapped standard errors we calculate may be too small, the correct *p*-value for the difference between VC-backed and other IPOs is even smaller than the figure reported above.

may have been different in the early 1990s and in the hot market of the second half of the decade. Although IPOs on NASDAQ fared worse relative to the index in the boom years, we find that the performance of VC-backed IPOs during both periods was very similar to that of non-VC-backed IPOs (Figure 3). The differences are not statistically significant at conventional levels and neither are the differences in medians.

Figure 3
Mean Post-IPO Stock Returns for VC-backed and Other IPOs by Cohorts 1991-1995



1996-2000



Next, Table 6 presents regression results where the dependent variable is each firm's cumulative abnormal return during the 36-month period following its IPO. Explanatory variables include controls for industry, cohort and, in some specifications, age and firm size

(assets) at the time of the IPO.[12] Even after controlling for these observable characteristics, there is still no difference between the returns of VC-backed and other IPOs.

Finally, the last column of Table 6 displays a regression specification that takes into account the fact that Tables 5 and 6 are based on "survivors" only, i.e. on firms that "made it" to the IPO stage. This specification is designed to address the possibility that reconstructing the original distributions of VC-backed and other companies might change our impressions on the relative performance of the two types of firms and on the impact of VC's on post-issue performance. Using the (simple) probit regression in Table 3B, which explains the likelihood of survival until the exit stage, we generate for each firm a propensity score (ranging between zero and one) and an inverse Mills ratio. These should be treated with caution; only 26 of the 89 IPOs in our sample (with IPO dates between 1997 and 2000) are included in the probit regression (see footnote 6). For the other firms, propensity scores and Mills ratios are "fitted values" derived from the coefficients in Table 3B. The regression results with the propensity score (shown) and the inverse Mills ratio (not shown) corrections for sample selection remain unchanged. We conclude that, even after correcting for the possibility that the sample of firms that reached the IPO stage is non-random, there is still no evidence that VC financed companies are associated with superior stock returns after they go public.[13]

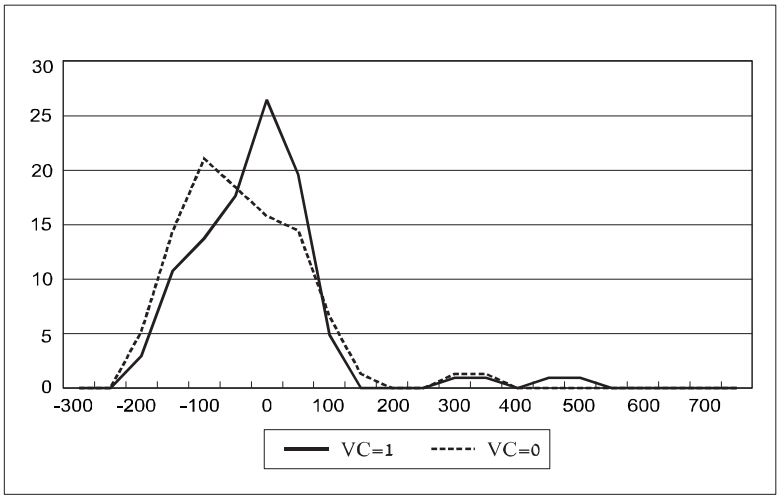
c. Comparisons of Risk and Return Distributions

Our estimates so far have detected no systematic differences in long-run mean and median stock returns between VC-backed and other IPOs. We now examine whether the entire distribution of post-IPO stock returns is different for the two sub-samples. Figure 4, which portrays the distribution of returns for the two sub-samples, suggests that the distributions are very similar. More formally, we conduct a test for the equality of the variances of the two sub-samples and cannot reject the hypothesis that the two are equal. Furthermore, stochastic dominance tests (Kolmogorov-Smirnov test of equality of distributions, and Wilcoxon (sum-of-ranks) test) strongly suggest equality of the two distributions: the *p*-values associated with the tests are 0.44 and 0.26, respectively. Finally, we also use bootstrapped standard errors to compare the two distributions, and again, find no statistically significant difference between them – the *p*-value associated with this test is about 0.5 (see Efron and Tibshirani, 1993, Chapter 16). We conclude that stock returns on VC-backed IPOs and other high-technology issues are drawn from a similar distribution. This is despite the finding that the rate of survival (the probability of reaching the IPO stage) is higher among VC-backed firms, an issue to which we will return below.

[12] We control for age because VC-backed IPOs tend to be relatively young when they go public (with a mean age of about 8 years) in comparison with non-VC backed companies (where the average age at the time of listing is 11.6 years) – a statistically significant difference.

[13] Another regression specification that we examine includes interaction terms between the IPO cohort and all the explanatory variables. The results (not shown) do not suggest any significant changes between the early 1990s and the later years (the only exception is the coefficient on the health and life science industry that becomes negative in the later years).

Figure 4
The Distribution of 36 Month "Buy and Hold"
CAR's among VC-backed and Other IPOs



It is impossible to assess the relative return on VC-backed IPOs without investigating risk as well. First, we examine the standard deviation of the monthly abnormal returns for each firm, and find no difference in this measure of volatility between VC-backed and other IPOs. *Betas* for VC-backed companies are slightly higher than for other IPOs (about 1.1. relative to 0.9, and this difference is statistically significant), so that there is no reason to suspect that VC-backed issues are superior in that they offer lower risk than other technology IPOs.

d. Accounting Measures of Post-Issue Performance

Turning to accounting measures of post-issue performance, Table 7 suggests that there are virtually no statistically significant (unconditional) differences between VC-backed IPOs and other firms in commonly used measures of profitability (ROA, net profits to assets, and pre-tax profits to assets). Mean asset growth rates are much higher on average for VC-backed IPOs, but as in the case of initial valuations, the variance within each sub-sample is high. (The difference in growth rate is significant only at the 8 percent level).[14] There are also no significant differences between VC-backed IPOs and other firms in multivariate

[14] (a) Data limitations reduce the sample size in some of the rows of Table 7. The results on post-IPO stock returns (the absence of a significant difference between VC-backed and other issues) hold for each of the sub-samples used in this table. (b) Table 7 displays means; the absence of significant differences remains unchanged when medians are used instead. (c) The statistical significance of the asset growth test refers to a one-sided test of the hypothesis that VC-backed firms outperform their peers. (d) One measure of post-IPO performance that we do not address here is the failure or bankruptcy rate, because none of the companies within our sample went bankrupt during the three years following its IPO.

regressions where the dependent variable is either one of the measures of profitability used in Table 7, or asset growth rates, and explanatory variables include firm size, industry, IPO cohort and the propensity score used above (not shown).

5. DISCUSSION AND CONCLUDING REMARKS

The contribution of VC finance to the development of high-tech industries has been the subject of a large and growing literature. One interpretation of the results in the present study would be that much of the contribution of venture capitalists is in reducing pre-IPO mortality rates, rather than in selecting companies with stellar post-IPO performance. For example, if "childhood diseases" affect young high-tech firms between their inception and the time of their IPO, then VC support can lower the mortality rate associated with these diseases. This need not necessarily lead to superior post-exit performance of the surviving firms because VC funds may reduce mortality rates among client firms of *all* types, not just among the very best (or worst) companies (for example, because ranking new companies in innovative fields may be extremely difficult). Stated differently, "students" of the VC "school" do not achieve the highest exam scores (post-IPO performance); their "grades" appear to be similar to those of other "students" (firms). However, the probability of reaching the "high school graduation stage" (IPO) is much higher for VC clients. Of course, other interpretations of the results in this paper are also possible: In comparison with non-VC investment companies, VC funds may be reluctant to terminate poorly performing investments (Kandel, Leschinskii, and Yuklea, 2005); alternatively, VC funds may select firms with high survival or exit rates, which do not offer particularly high stock returns or accounting profitability if they reach the IPO stage.[15] All of these interpretations suggest that, *if* VC funds do contribute to economic growth and social welfare, they are more likely to do so by reducing mortality rates of high technology firms in their early stages or, by reducing spending on firms that are unlikely to reach the IPO stage, than by selecting firms which exhibit outstanding performance after they go public.

[15] VC funds may also extract rents from client firms, so that their performance does not appear to be superior to that of their peers.

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Table 1
Industrial Organization of the Israeli VC Industry over Time: Basic Statistics

	1997	2000	2002
Number of VC funds	58	101	135
Total amount of capital managed by VC funds ($ million)	1,674.7	5,084	10,575
The share of capital managed by the 5 largest funds (%)	36.2	24.8	27.1
The share of capital managed by the 10 largest funds (%)	51.0	36.3	37.7
Herfindahl Index	0.039	0.027	0.025
Number of new funds	-	63	48
Number of closed funds	-	20	14

Table 2

The sample in both panels consists of the entire population of companies included in the portfolios of VC funds and other private equity investment companies at any time between 1997 and 2000. Age and the number of employees refer to the year 2000. * denotes a difference which is statistically significant at the 5 percent level between VC-funds and non-VC investment companies.

Panel A: High-tech Firms in the Portfolios of VC Funds and Non-VC Private Equity Investment Companies

	VC funds	Non-VC Investment Companies
Firms in Portfolio	492	169
Average Age	7.9	7.1
Number of employees (average)[a]	83.1	87.7
Distribution by Industry (%)		
Software and Computers	38	49
Communication	22	18
Other Technology	15	16
Healthcare and Life Science	21	12*
Other Non-Technology	3	5

a – Data are available for 502 firms only.

Panel B: Probit Regressions: Who is Included in the Portfolio of VC Funds?

The dependent variable takes the value one if a firm received VC finance and zero if a firm was financed otherwise. The omitted industry is "non-technological industries." Standard errors appear in parentheses. ** and * denote statistical significance at the 5 and 10 percent levels, respectively.

	VC
Constant	Yes
Age	0.02**
	(0.01)
Software and Computers	0.24
	(0.27)
Communication	0.50*
	(0.28)
Other Technology	0.27
	(0.28)
Healthcare and Life Science	0.70**
	(0.29)
McFadden's R-squared	0.02
N	661

Table 3
Changes in the Portfolios of VC Funds and Other Private Equity Investment Companies 1997-2002

Panel A: Firms Deleted from the Portfolio

	VC funds	Non-VC Investment Companies
Deleted from the portfolio	26.0	49
(% relative to the total number of firms included in the portfolio at any time between 1997 and 2000)	(127 Obs.)	(83 Obs.)
Average age (years)	7.6	7.3
Distribution of deleted firms by industry (%)		
Software and Computers	49	49
Communication	21	18
Other Technology	9	13
Healthcare and Life Science	18	10
Other Non-Technology	4	10

Panel B: Probit Regressions Estimating the Survival Rates VC-backed and Other High-tech Firms

The sample in this panel consists of the entire population of innovative companies included in the portfolios of VC funds and non-VC private equity investment companies at any time between 1997 and 2000. The first three columns display probit regressions: The dependent variable "FAIL" takes the value one if a firm failed (was deleted from the portfolio) by 2002, and zero otherwise. The dependent variable EXIT takes the value one if a firm has made an exit during the same 1997-2002 period (IPO, sale, or merger), and zero otherwise. VC reputation is measured as the percent of companies in the VC's portfolio that have made an exit, and this variable is averaged across all VC funds that financed the company and equals zero for non-VC backed firms. The last column displays an ordered probit regression, where the dependent variable equals zero if the company failed, one if it is still in the VC's portfolio (and no form of exit has taken place), and two if the firm has made an exit. In all regressions, VC equals one for VC-backed companies, AGE is years from foundation, and the omitted sector is "non-technological industries." Standard errors appear in parentheses. ** and * denote statistical significance at the 5 and 10 percent levels, respectively.

	FAIL	EXIT	EXIT	Ordered Probit
	(1)	(2)	(3)	(4)
Constant	Yes	Yes	Yes	N/A
VC	-0.62**	1.48**	1.50**	0.64**
	(0.11)	(0.31)	(0.32)	(0.10)
VC Reputation			-0.10	
			(0.67)	
Age	-0.003	0.14**	0.14**	0.04**
	(0.009)	(0.02)	(0.02)	(0.01)
Software and Computers	-0.45*	0.65	0.65	0.46
	(0.27)	(0.54)	(0.54)	(0.24)
Communication	-0.64**	1.00*	1.00*	0.67**
	(0.28)	(0.56)	(0.56)	(0.25)
Other Technology	-0.83**	0.32	0.32	0.57**
	(0.29)	(0.57)	(0.59)	(0.26)
Healthcare and Life Sciences	-0.70**	-0.43	-0.43	0.36
	(0.29)	(0.59)	(0.59)	(0.26)
McFadden's R-squared for columns 1-3; LR index (Pseudo R-squared) for column 4	0.053	0.14	0.14	0.054
N	661	661	661	661

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Table 4
Initial Valuation Regressions

OLS regressions, where the dependent variable is under-pricing (percent increase in stock prices on the first day of trading) or initial valuation (market value at the end of the first day of trading). Data on pre-IPO assets is available for 75 of the 89 IPOs in our sample. VC equals one for VC-backed companies. The omitted sector is "non-technological industries." Robust standard errors appear in parentheses. ** and * denote statistical significance at the 5 and 10 percent levels, respectively.

	Under-pricing (1)	Under-pricing (2)	Initial Valuation (3)	Initial Valuation (4)
Constant	Yes	Yes	Yes	Yes
VC	0.07	-2.37	0.85	-2.50
	(6.96)	(6.18)	(10.75)	(10.58)
Age at the time of IPO	-0.24	0.14	-2.17	-1.94
	(0.29)	(0.32)	(1.73)	(1.74)
Pre-IPO Assets	-0.02	-0.03	0.55**	0.53**
	(0.02)	(0.03)	(0.26)	(0.26)
Dummy for 1996-00 IPOs	15.01**	11.48**	36.98**	33.97**
	(5.91)	(4.95)	(13.58)	(12.79)
Software and Computers		3.83		-1.39
		(5.34)		(17.32)
Communication		27.87*		21.73
		(14.81)		(20.37)
Other Technology		-6.18		-4.62
		(4.58)		(22.20)
Healthcare and Life Sciences		2.28		-8.56
		(4.54)		(22.32)
R-squared	0.05	0.16	0.47	0.48
N	73	73	75	75

Table 5
Long-run Post-IPO Stock Returns for VC-backed and Other IPOs
"Buy and Hold" Cumulative Excess Returns over the NASDAQ Index
Means and Medians for the Whole Sample

Number of observations for each month: VC-backed = 51, Non-VC-backed = 38. None of the differences in medians or means is statistically significant at levels of 5 percent or less.

	Median			Mean		
Month from IPO	VC=1	VC=0	Significant difference?	VC=1	VC=0	Significant difference?
1	-5.8	-0.8	No	1.7	3.9	No
2	-2.0	-0.9	No	1.1	3.2	No
3	-5.3	-0.7	No	4.5	9.3	No
4	-3.3	-8.8	No	4.8	2.5	No
5	-4.4	-9.5	No	4.1	3.8	No
6	-18.6	-12.3	No	-3.6	2.1	No
7	-22.9	-12.6	No	-0.6	-1.0	No
8	-22.8	-12.6	No	-0.4	-5.5	No
9	-24.6	-16.8	No	-3.8	-9.6	No
10	-29.7	-10.0	No	-2.4	-6.8	No
11	-26.4	-20.7	No	-2.4	-12.5	No
12	-25.6	-25.0	No	-9.5	-15.4	No
13	-30.7	-28.5	No	-7.3	-12.7	No
14	-31.4	-34.5	No	-7.0	-11.8	No
15	-34.4	-42.7	No	-10.8	-15.6	No
16	-35.7	-38.2	No	-12.5	-23.1	No
17	-29.0	-52.5	No	-8.4	-29.0	No
18	-32.2	-65.3	No	2.6	-31.8	No
19	-29.7	-63.0	No	-0.2	-34.5	No
20	-34.7	-62.8	No	-21.2	-32.3	No
21	-44.8	-66.2	No	-18.9	-38.2	No
22	-39.1	-64.5	No	-24.5	-41.0	No
23	-47.9	-63.2	No	-23.6	-44.6	No
24	-53.7	-79.1	No	-40.2	-44.7	No
25	-59.8	-72.2	No	-45.0	-52.9	No
26	-56.6	-82.4	No	-49.2	-51.4	No
27	-60.3	-91.2	No	-58.0	-61.1	No
28	-65.3	-92.4	No	-62.4	-70.1	No
29	-71.2	-99.1	No	-64.6	-77.5	No
30	-74.4	-89.1	No	-61.4	-76.3	No
31	-75.6	-91.8	No	-60.6	-73.1	No
32	-67.3	-106.3	No	-66.1	-77.5	No
33	-77.6	-97.4	No	-71.2	-87.7	No
34	-68.2	-104.0	No	-71.1	-91.7	No
35	-82.0	-104.2	No	-74.3	-91.2	No
36	-69.3	-102.2	No	-71.3	-93.6	No

Table 6
Cross-sectional Excess Returns Regressions

OLS regressions, where the dependent variable is cumulative "buy and hold" abnormal returns for 36 months. VC equals one for VC-backed companies. The propensity score is based on the Exit probit in Table 3B. The omitted sector is "non-technological industries." Robust standard errors appear in parentheses. The sample size varies because of one missing observation on age and several missing observations on pre-IPO assets. Robust standard errors appear in parentheses. ** and * denote statistical significance at the 5 and 10 percent levels, respectively.

	Cumulative Buy and Hold Abnormal Returns	Cumulative Buy and Hold Abnormal Returns	Cumulative Buy and Hold Abnormal Returns	Cumulative Buy and Hold Abnormal Returns
Constant	Yes	Yes	Yes	Yes
VC	13.64	13.67	13.38	8.94
	(25.72)	(25.44)	(24.29)	(29.21)
Age at the time of IPO		-0.35	-0.42	
		(1.11)	(1.17)	
Pre-IPO Assets			0.08	
			(0.15)	
Propensity Score				224.83
				(290.79)
Dummy for 1996-00 IPOs	-36.47	-35.15	-24.03	-33.95
	(28.21)	(28.11)	(23.03)	(28.86)
Software and Computers	68.67**	66.60**	72.60**	64.98**
	(24.06)	(26.11)	(28.73)	(23.54)
Communication	104.93**	106.47**	79.64**	106.30**
	(27.45)	(29.84)	(22.72)	(28.42)
Other Technology	22.54	23.03	12.92	23.56
	(27.59)	(27.17)	(29.04)	(26.73)
Healthcare and Life Science	-35.51	-36.90	-18.16	-27.80
	(32.90)	(31.73)	(35.17)	(40.85)
R-squared	0.18	0.18	0.17	0.19
N	89	88	75	88

Table 7
Accounting Measures of Post-issue Performance

Mean values of post-IPO accounting profitability and asset growth rates for VC-backed and other companies. The sample size varies because of missing accounting data. For firms that merged or changed their name data are not available for all three years and averages are based on the available data.

	VC=1	VC=0	Is the difference between VC and non-VC significant at the 5% level?
Operating profits to assets (average for 3 years after the IPO, N=67)	-5.7%	1.6%	No
Net profits to assets (average for 3 years after the IPO, N=70)	-16.3%	-5.5%	No
Pre-tax profits to assets (average for 3 years after the IPO, N=70)	-5.2%	-28.1%	No
Average asset growth three years after the IPO (N=70)	63%	27%	No, P=0.08 (one-sided test)

Appendix: Alternative Calculation of Long-run Post-IPO Stock Returns with Monthly Re-balancing (see text)

Number of observations for each month: VC-backed = 51, Non-VC-backed = 38. None of the differences in medians or means is statistically significant at levels of 5 percent or less.

	Median			Mean		
Month from IPO	VC=1	VC=0	Significant difference?	VC=1	VC=0	Significant difference?
1	-5.8	-0.8	No	1.7	3.9	No
2	-6.7	-3.7	No	3.3	3.8	No
3	-7.0	-2.1	No	7.0	8.5	No
4	-10.4	-9.6	No	8.0	1.3	No
5	-13.0	-13.9	No	6.5	2.4	No
6	-22.5	-17.5	No	1.1	0.0	No
7	-22.9	-17.1	No	3.8	0.2	No
8	-27.2	-19.9	No	5.3	-3.4	No
9	-29.4	-24.0	No	4.7	-6.1	No
10	-31.8	-23.0	No	6.7	-3.4	No
11	-33.7	-28.7	No	7.1	-10.0	No
12	-40.6	-34.1	No	2.2	-15.4	No
13	-41.2	-36.8	No	1.3	-16.3	No
14	-44.9	-40.1	No	1.5	-16.8	No
15	-47.8	-41.8	No	-1.5	-21.2	No
16	-52.4	-49.7	No	-5.4	-30.1	No
17	-52.7	-59.9	No	-2.7	-41.5	No
18	-57.2	-59.6	No	-1.5	-30.7	No
19	-63.3	-61.7	No	-3.4	-32.2	No
20	-63.6	-64.3	No	-6.4	-28.0	No
21	-65.1	-71.6	No	-7.3	-35.9	No
22	-66.0	-75.6	No	-5.9	-37.4	No
23	-65.9	-76.4	No	-8.9	-30.4	No
24	-69.3	-79.6	No	-9.4	-32.9	No
25	-70.0	-86.5	No	-10.6	-35.8	No
26	-68.0	-89.8	No	-5.8	-34.5	No
27	-72.1	-97.2	No	-10.7	-39.0	No
28	-71.8	-97.9	No	-8.4	-27.8	No
29	-71.3	-104.6	No	-7.4	-29.1	No
30	-71.2	-103.8	No	-4.6	-15.3	No
31	-75.6	-112.7	No	-4.8	-5.2	No
32	-79.0	-111.9	No	-7.6	-0.9	No
33	-83.6	-114.4	No	-8.1	0.9	No
34	-85.2	-121.8	No	-1.3	-6.4	No
35	-87.0	-124.0	No	-2.2	4.8	No
36	-87.5	-125.0	No	-3.6	6.0	No