The Formulation of the Four Factor Model when a Considerable Proportion of Firms is Dual-Listed

by

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Abstract

We examine the performance of the Fama-French-Carhart four factor asset pricing model in an economy, Israel, where a relatively large proportion of shares (14.4% in our sample) are dually listed, i.e. trade also on NYSE or NASDAQ. We find that a hybrid model (adding U.S. or global factors to the local 4 factors model) performs only slightly better than the local model, casting doubt on the practical necessity of hybrid models. Further tests suggest that the dually listed shares should not be excluded when constructing the local factors.

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Keywords: Local and hybrid four factor models; Dually-listed shares; Fama-French-Carhart model.

1. Introduction

The Fama-French-Carhart 4-factor asset pricing model (e.g. Fama and French, 1993, and Carhart, 1997) has been tested extensively in the U.S. and outside it. The common finding is that although the 4 factor model can be rejected in some cases, it performs reasonably well in other cases, and, in general, performs better that the previously-accredited Capital Asset Pricing Model (CAPM). Thus, in the recent decade, the 4 factor model became the standard empirical asset pricing model.

An important pending issue, debated in the literature, is whether the factors should be constructed locally (within the economy), regionally (within some economic region) or globally (using all world's stocks). Griffin (2002) studies U.S., Great Britain, Canada and Japan, and concludes that the local (own country based) Fama French model performs better than the global version (where factors are constructed using all shares in the four countries studied). In contrast, Hou, Karolyi and Kho (2011) study 27000 stocks from 49 countries over 1981-2003, and conclude that a hybrid model, comprising local and global factors has the lowest pricing errors. Last, Fama and French (2012) study 23 stock markets during 1989-2011 and conclude that adding global factors to local ones does not contribute to the explanatory power of the 4 factor model.

We contribute to the debate by studying pricing in an exchange (the Tel-Aviv Stock Exchange) where a relatively high proportion of shares is dual-listed. About one-seventh of our sample shares are listed also on the NYSE or NASDAQ. Given that dual-listed firm returns are bound to be influenced by foreign markets returns, is the hybrid model more successful and more pertinent in our sample?

We find that hybrid models (adding U.S. or global factors to the local model) have little contribution (if any) to the pricing performance of the local four-factor model. Thus, local versions of the Fama-French-Carhart model appear sufficient. In further unrelated tests we examine whether dually-listed shares should be excluded when constructing factors for pricing local non-dually listed shares. Interestingly, we find better pricing results when factors include dually-listed shares.

Section 2 provides some background on local and hybrid four-factor models. Section 3 describes the sample and data. Sections 4 and 5 report our results, and Section 6 concludes.

2. The global, local and hybrid formulations of the four factors model

The four factor model of Fama and French (1993) and Carhart (1997) postulates four risk factors that span the cross-sectional distribution of expected stock returns: market, size, value and momentum. In general, market risk is approximated by the excess return on a general stock market index; the size factor is the excess stock return of small firms relative to large firms; value is the excess return of high book to market firms relative to low book to market firms; and momentum is roughly the excess return of "winner" stocks (stock with the highest return in the past year) over past year "loser" stocks.

The four factor model was meticulously tested inside and outside the U.S. markets. Value and momentum premia are found all over the world – see, for example, Fama and French (1998), Chui, Titman and Wei (2010), and Asness, Moskowitz and Pedersen (2013). However, in empirical tests, the four factor model is only partially successful. For example, the four factor model fails to adequately explain returns of portfolios based on sorts of size and momentum (e.g. Fama and French, 2012, and Gregory et al., 2012).

Despite of its evidenced failures, researchers by and large commend the 4-factor model. This is because of the impression that the four factor model has some basis (value and momentum appear everywhere), and because the four factor model pricing performance is superior to that of its existing alternatives (the Capital Asset Pricing Model, for example). Thus, the 4 factor model became the standard in empirical asset pricing.

An interesting ongoing debate concerns the scope and exact formulation of the four factor model. Should the world be perceived as a single integrated market with global factors, or should the four-factor model be fitted separately for each individual economy (local factors)?

Empirical comparisons of the global and local versions of the 4-factor model favor the local version of the model. For example, Griffin (2002) demonstrates the superiority of the local version using U.S., U.K., Canada and Japan data. Fama and French (2012) find that regional versions of the model (where regions are, for example, North America or Europe) are sometimes "passable". Cakici, Fabozzi and Tan (2013) extend four-factor model tests to emerging markets. They study 18 emerging markets located in three regions: Asia, Latin America and Eastern Europe, and document that regional models perform much better than the global version of the four factor model.

The failure of the global version of the model may be due to segmented markets – see Karolyi and Stulz (2003) for a discussion of segmentation. Different country markets are not fully integrated because of barriers to international portfolio flows such as different regulation, information quality problems, political risks and more. Exchange rate risks should also be taken into account – see Solnik (1974), for example. Nevertheless, given the globalization process of world economies, and given the greater information availability and accessibility of foreign markets, global stock markets are probably increasingly inter-related.

If partial integration exists, a hybrid model (combining local and global risk factors) becomes plausible and has been suggested theoretically – see Errunza and Losq (1985). Hou, Karolyi and Kho (2011) use data on 27000 shares from 49 different countries to test a hybrid model comprising 8 factors: 4 local and 4 global. They conclude that the hybrid model is superior to local models (has the best explanatory power). In contrast, Fama and French (2012) mention that in their data a hybrid model is practically worthless.

We contribute to the debate about the usefulness of a hybrid model by fitting local and hybrid versions of the 4-factor model on stock returns from the Tel Aviv Stock Exchange (TASE). The relatively high proportion of dual-listed shares traded on TASE makes TASE particularly suitable for exploring potential benefits of hybrid models. About one-seventh of our sample stocks trade also on NYSE or NASDAQ. Can we document evidence supportive of hybrid models in TASE, i.e., in a stock market where the influence of global (and particularly U.S.) markets might be extensive?

3. Sample and variables

3.1 Sample and data

The raw sample comprises all companies traded on the Tel Aviv 100 (TA100) and Yeter Maagar (YM) lists of the Tel Aviv Stock Exchange (TASE). These lists include the largest and most liquid shares on the exchange. The sample period is July 2002 through June 2013.

As customary in the four-factor methodology, we use traded companies on June's end of year t to construct monthly factors for the period from July of year t to June of year t+1. Factor construction requires knowledge of the market value of equity on December of year t-1 and June of year t, and knowledge of book value on December of year t-1. Companies for which any of these data are missing, and companies with negative book equity, are omitted. Similarly, various partnerships (especially gas partnerships) are excluded. The exclusion criteria are identical to those reported in Fama and French (1993), and in general we follow closely the standard four-factor methodology.

Share returns of currently listed companies are collected from the web site of the Tel-Aviv Stock Exchange. For delisted firms we obtain return data from a private data analysis company (Alfa Beta). All stock returns are adjusted for dividends and various other distributions. Market value of equity data are also from the above sources, where market value of equity (ME) is defined as number of shares times share price.[1]

Table 1 describes the sample. The number of companies varies every year, predominantly because the number of companies on the YM list varies yearly. On average, we have 217 firms per year, ninety-some of which belong to the TA100 list (list of 100 largest firms on the exchange) and the rest come from the YM list.

The average market value of equity of our sample firms increases from 837 million New Israeli Shekels (NIS) in June 2002 to 2604 million NIS in June 2012. (The average exchange rate during the sample period is about 4.09 NIS per 1 US Dollar.) The mean book value over market value of equity (BE/ME) fluctuates between 0.49 (on June 2007, just before the large global economic crisis) and 2.50 (in June 2009, close to the crisis peak).

3.2. Factor construction

We compute the four factors, mimicking as closely as possible the classic four-factor construction methodology – see Fama and French (2012), for example. Our first factor is stock market excess return, Rm-Rf, where Rm as the return on the general market index (the value-weighted index of all stocks traded on TASE), and Rf is the one-month Israeli T-Bill rate. Rm data are taken from the TASE web site, and Rf data are collected from the Bank of Israel web site.

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[1] Our sample includes a few dual-class firms (10 at the beginning of the sample period, and 1 at the end). For them, ME is the total market value of both share classes. Further, in the case of dual-class firms, the return of the more heavily traded stock represents the company stock return.

Table 1: Sample descriptive statistics

Sub-period	Sample	Number of companies	Average market value (in millions of New Israeli Shekels) at the beginning of the sub-period	Book value of equity divided by market value, BE/ME
July 2002 - June 2003	Tel Aviv 100	89	1,911	0.69
	Yeter Maagar	133	127	1.05
	Total	222	842	0.91
July 2003 - June 2004	Tel Aviv 100	91	2,495	0.91
	Yeter Maagar	137	126	1.60
	Total	228	1,072	1.33
July 2004 - June 2005	Tel Aviv 100	90	3,434	0.55
	Yeter Maagar	130	207	1.01
	Total	220	1,527	0.82
July 2005 - June 2006	Tel Aviv 100	94	3,565	0.44
	Yeter Maagar	133	223	0.79
	Total	227	1,607	0.64
July 2006 - June 2007	Tel Aviv 100	95	4,481	0.45
	Yeter Maagar	137	310	0.69
	Total	232	2,018	0.60
July 2007 - June 2008	Tel Aviv 100	96	6,101	0.45
	Yeter Maagar	113	429	0.52
	Total	209	3,035	0.49
July 2008 - June 2009	Tel Aviv 100	97	5,820	0.79
	Yeter Maagar	116	282	0.93
	Total	213	2,804	0.87
July 2009 - June 2010	Tel Aviv 100	92	5,291	2.08
	Yeter Maagar	119	232	2.82
	Total	211	2,438	2.50
July 2010 - June 2011	Tel Aviv 100	94	6,016	1.02
	Yeter Maagar	114	253	1.11
	Total	208	2,857	1.07
July 2011 - June 2012	Tel Aviv 100	94	6,300	0.95
	Yeter Maagar	136	269	0.86
	Total	230	2,734	0.90
July 2012 - June 2013	Tel Aviv 100	90	5,309	1.32
	Yeter Maagar	102	218	1.43
	Total	192	2,604	1.37

The second factor is SMB, the excess return of small-firm over large-firm stocks. We define large (small) stocks as the stocks on the TA100 (Yeter) list, respectively. The TA100 list comprises the 100 largest firms traded on TASE, while the Yeter list includes the next 120-150 firms (in terms of market value). This division (between small and large firms) along the lines of trading lists appears natural for the Israeli stock market.

The third factor is HML, the return of high book value over market value stocks minus the return of low book value over market value stocks. The ratio of book to market value of each stock (BE/ME) is computed on December end of the previous year (year t-1). Then, every year we sort the sample stocks into 3 groups based on BE/ME, using the 30th and 70th percentile of TA100 (=large) firms as the cutoffs. Fama and French (2012) recommend cutoffs based on large firms, in order to assure that large firms are present in all BE/ME portfolios.

We intersect the above three BE/ME groups with our two size groups, to form six portfolios titled as: SG, SN, SV, BG, BN, and BV, where S symbolizes small firms, B big firms, G growth (low BE/ME) firms, N neutral (middle BE/ME) firms, and V value (high BE/ME) firms. Thus, for example, portfolio BV (the intersection of group B and V) comprises all big stocks (TA100 stocks in our case) that are also included in group V (top 30% of BE/ME). As customary in the four factor methodology, all six portfolios are generated on June's end of each year, and are updated yearly.

Next, we compute the return of each of the six portfolios as the value-weighted return of the stocks included in it, and calculate the SMB factor as the average return of the three small firm portfolios minus the average return of the three large firm portfolios:

(1) SMB = 1/3 (R_{SV} + R_{SN} + R_{SG}) - 1/3 (R_{BV} + R_{BN} + R_{BG}),

where R_p is the return of portfolio P. Similarly, the HML factor is defined as:

(2) HML = 1/2 (R_{SV} + R_{BV}) - 1/2 (R_{SG} + R_{BG}).

The fourth factor, the momentum factor, is based on the "momentum return" of each stock, defined as the stock return from month t-12 through month t-2.[2] Each month we sort the sample stocks into three groups according to their "momentum" return, using the 30th and 70th percentile of large (TA100) stocks as cutoffs. Then, we use the intersection of these three momentum groups with our two size groups to generate six portfolios: SW, SN, SL, BW, BN, and BL, where S (B) in the portfolio name symbolize small (big) firms, and W, N, and L denote high momentum (winners), neutral momentum, and low momentum (losers) stocks, respectively. Thus, for example, portfolio BW comprises all large (TA100) stocks whose "momentum" return is excellent (in the top 30%).

Next, we compute the return of each of the six portfolios as the value-weighted return of the stocks included in it, and calculate the WML factor as:

(3) WML = 1/2 (R_{SW} + R_{BW}) - 1/2 (R_{SL} + R_{BL}),

where, as before, R_p is the return of portfolio P.

[2] Month t-1 is omitted to prevent spurious correlation between the "momentum" and month t returns. Such a correlation might be due to infrequent trading and the bid-ask spread that might distort stock price at the end of month t-1.

4. The performance of the four factor pricing model in Israel

4.1. Examining the properties of the four factors

We compute the four factors based on our sample of 192-232 Tel Aviv Stock Exchange (TASE) stocks in the period July 2002 - June 2013 (132 months). Section 3.2 detailed the calculation procedure that is standard in the four factors' research. Table 2 describes the factors.

Table 2: Properties of the Fama-French-Carhart factors in Israel

The Fama-French-Carhart four factors are: the excess market return (Rm-Rf), the excess return of small over big stocks (SMB), the excess return of value over growth stocks (HML), and the excess return of positive over negative momentum stocks (WML). The factors are calculated for our sample that includes 192-232 Tel Aviv 100 and Yeter Maagar stocks in July 2002 through June 2013 (132 months in total) using a methodology that is similar to Fama and French (2012). More details are provided in section 3.2.

Factor ==>	Rm-Rf	HML	SMB	WML
Mean (monthly)	0.59%	0.13%	0.41%	0.57%
Standard deviation	4.95%	4.80%	4.63%	6.32%
t-statistic of the mean (p-value)	1.363 (0.18)	0.307 (0.76)	1.025 (0.31)	1.035 (0.30)
Median	1.23%	0.30%	0.04%	1.08%
Maximum	12.67%	15.76%	16.73%	20.26%
Minimum	-17.87%	-13.04%	-10.92%	-35.67%
% positive	58	54	51	61
p-value of the Wilcoxon Signed Rank test	0.05	0.68	0.41	0.02

The first factor, the excess market return (Rm-Rf), has a mean of 0.59% per month (7.28% per year) during the sample period. Fama and French (2012) report mean market risk premia during 1990-2011, ranging from 0.12% per month (in Japan) to 0.86% per month (in Asia-Pacific). Hence, the average level of the first factor in Israel is within the plausible range. The first factor standard deviation (4.95% per month) is also within the range of standard deviations reported in Table 1 of Fama and French (2012). Thus, the properties of the first factor in Israel are economically reasonable and definitely non-surprising given previous evidence in the literature.

Because of the high standard deviation of the first factor, we cannot reject the null hypothesis that the mean excess market return equals zero (t-statistic = 1.36, p-value=0.18). However, the non-parametric Wilcoxon Signed Rank test rejects the hypothesis that the excess market return distribution is centered on zero. The median excess market return is considerable (1.23% per month) and on 58% of the sample months the excess market return is positive.

The second factor, the excess return of small over big firm stocks (SMB), has a mean of 0.41% per month, yet its median is only 0.04% per month. Table 1 of Fama and French (2012) also reports a small insignificant positive global SMB.

The third factor, the excess return of value over growth firms (HML), has a mean of 0.13% per month, a median of 0.30% per month, and a standard deviation of 4.8% per month. The value factor in Israel is statistically insignificant and low relative to value premia around the world. Fama and French (2012) report a mean global HML of 0.45% per month. It is possible that the standard four-factor methodology we employ needs some adjustment or refinement when estimating the value factor in Israel. However, we are reluctant to abandon the standard methodology.

The fourth factor, the excess return of positive over negative momentum stocks (WML) has a mean of 0.57% per month (7.06% annually), comparable to the mean WML factor around the world (see Fama and French, 2012, Table 1). The high standard deviation of the fourth factor, 6.32% per month, prevents us from rejecting the null hypothesis that the mean fourth factor equals zero. However, the 1.08% per month median in our sample, and the fact that the momentum premium is positive on 61% of the sample months, helps reject the null that the fourth factor is centered on zero - see the Wilcoxon Signed Rank p-value in Table 2.

To sum, the findings in Table 2 leave the impression that Israel is a "normal" stock market. The means of the four factors in Israel have an identical sign as the global mean factors, and the levels of the factors in Israel are usually comparable to their counterparts in the world. According to our findings, the two most prominent factors in Israel are the market and the momentum.

4.2. The performance of the four factors model in Israel

In this subsection we will compare the relative performance of the one factor (= CAPM), three-factor and four-factor models. The comparison is based on two sets of test portfolios: 9 size-BE/ME portfolios, and 9 size-momentum portfolios. Fama and French (2012) prefer two sets of 25 test portfolios. However, our sample size is smaller, and we had to do with 9 portfolios.[3,4]

[3] An attempt to generate 16 portfolios yielded an empty portfolio in one of the sample months. Hence, it was abandoned.
[4] It is also noteworthy that our study is the first formal examination of the 4-factor model in Israel.

The 9 size-BE/ME test portfolios are constructed as follows. At the beginning of July of each year we sort our sample stocks into three groups based on the total market value of their shares on June's end. (We assign approximately one-third of the stocks to each group.) Independently and analogically, at the beginning of July we sort all sample stocks into three groups based on the stock BE/ME at the end of the previous calendar year. Then, we use the intersection of the three size groups with the three BE/ME groups to construct 9 value-weighted portfolios. These portfolios composition is updated once a year (at June's end of each calendar year). The number of stocks in each portfolio varies across portfolios and across time. On average, each of the 9 portfolios has 23 stocks, and the minimum number of stocks in a portfolio in a single month is 7 (i.e., on each month we have at least 7 stocks in each portfolio).

The 9 size-momentum test portfolios are constructed in a similar way, with one exception – portfolio composition is updated monthly. First, at the beginning of each month t we sort all sample stocks into three groups based on the total market value of their shares on the previous month end. Then, on the beginning of each month t we sort all sample stocks into three groups by their momentum return (return in months t-12 through t-2). The intersection of the three size groups with the three momentum return groups determines the composition of our 9 size-momentum test portfolios. As before, each test portfolio return is the value-weighted average of its individual stock returns.

According to asset pricing theories, time-series regressions of risky assets' excess returns on the factors should have zero intercepts. Thus, if an x-factor model (where x=1, 3, or 4) is an adequate pricing model, regressing the 9 test portfolio excess returns on the factors should yield 9 minute and insignificantly different from zero intercepts.

We run a time-series regression of each of our three factor models using two sets of 9 test portfolios (54 regressions in total). Table 3 compares the alternative factor models performance. The success criteria of a model, inspired by Fama and French (2012), are: 1) Average adjusted-R^2 across the 9 test portfolio regressions – the higher the adjusted-R^2 the better the model describes the portfolio return volatility; 2) Mean standard error of the intercept and mean absolute value of the intercept (across the 9 regressions) – a better model should yield closer to zero intercepts, i.e., both a lower mean standard error of the intercept and a lower mean absolute intercept; 3) Gibbons, Ross and Shanken (1989) test statistic (GRS test, in short) of the joint hypothesis that all 9 intercepts equal zero – the lower the GRS statistic, the higher its p-value, and the more accurate is the pricing model.

Panel A of Table 3 reports test results for our 9 size-BE/ME portfolios. Among the competing models, the average adjusted-R^2 of the CAPM model is the lowest (0.651), while the average adjusted-R^2 of the four-factor model is the highest (0.870). Clearly, the four factor model excels in "explaining" the portfolio return time-series volatility. The 3-factor model is close after the 4-factor model with an average adjusted-R^2 of 0.846.

Panel A also reports, for each pricing model, the mean standard error of the intercept and the mean absolute intercept. Both means are closest to zero when the four-factor model is employed. The relative ranking is as before, with the CAPM appearing the least successful, the four-factor model appearing the most successful and the three-factor model emerging somewhere in between.

Table 3: The performance of the four factor model in Israel

We examine the following time-series regressions, testing three pricing models:

CAPM: $R_{pt} - R_{ft} = a_p + b_p (R_{mt}-R_{ft}) + \tilde{n}1_{pt}$,

three-factor model: $R_{pt} - R_{ft} = a_p + b_p (R_{mt}-R_{ft}) + c_p\, SMB_t + d_p\, HML_t + \tilde{n}2_{pt}$,

four-factor model: $R_{pt} - R_{ft} = a_p + b_p (R_{mt}-R_{ft}) + c_p\, SMB_t + d_p\, HML_t + e_p\, WML_t + \tilde{n}3_{pt}$,

where $R_{pt} - R_{ft}$ is the portfolio excess return on month t, R_{mt}-R_{ft} is the excess market return on month t, SMB_t is the excess return of small over big stocks on month t, HML_t is the excess return of value over growth stocks on month t, and WML_t is the excess return of positive over negative momentum stocks on month t.

First, 9 portfolios are constructed based on some sorting methodology (for example, sorting all sample shares by size and BE/ME). Then, these 9 portfolio returns are fitted by each of the 3 above-presented pricing models, using standard OLS regressions. (For each pricing model we run 9 regressions.) The table reports, for each pricing model, the average adjusted R^2, the mean intercept standard deviation, and the mean absolute intercept of its 9 regressions. We also report the GRS test statistic (see Gibbons, Ross and Shanken, 1989), and the p-value, of the hypothesis that all 9 intercepts of the specific pricing model regressions equal zero. The sample comprises 192-232 Tel Aviv Stock Exchange shares in 7/2002 - 6/2013.

Panel A: Tests based on 9 portfolios sorted by size and BE/ME

Pricing model	Statistics based on 9 regressions for each pricing model				
	Average adjusted R^2	Mean intercept standard deviation s(a)	Mean absolute intercept |a|	GRS test for intercepts equal zero	p-value of the GRS test
CAPM	0.651	0.0041	0.0030	2.41	0.0151
3-factor model	0.846	0.0027	0.0030	2.38	0.0161
4-factor model	0.870	0.0026	0.0027	2.32	0.0193

Table 3 (continued)

Panel B: Tests based on 9 portfolios sorted by size and momentum

Pricing model	Statistics based on 9 regressions for each pricing model				
	Average adjusted R^2	Mean intercept standard deviation s(a)	Mean absolute intercept |a|	GRS test for intercepts equal zero	p-value of the GRS test
CAPM	0.625	0.0044	0.0043	6.30	0.0000
3-factor model	0.783	0.0033	0.0046	6.11	0.0000
4-factor model	0.857	0.0027	0.0052	5.73	0.0000

The GRS tests also yield results that are consistent with our previous findings. The GRS test statistic in Panel A declines as we add factors to the model, suggesting that the four factor model is superior to its alternatives. However, all models can be rejected at the 5% significance level, but not at the 1% significance level. Thus, it is difficult to conclude whether any factor model is a satisfactory asset pricing model.

Panel B of Table 3 documents tests with our 9 size-momentum portfolios. As in previous research (Fama and French, 2012, for example) momentum based portfolios seriously challenge the four-factor models. In Panel B, the 4-factor model tends to score better than the CAPM and the 3-factor models, yet all models fail miserably the GRS test. Possibly, the only encouraging finding in Panel B is that the four-factor model preserves its high return explanatory power, with an adjusted-R^2 of 0.857.

In sum, our tests of the four factor model in Israel, yield results and conclusions that are typical of four-factor tests across the world. Based on our findings, it can be argued that the four factor model is superior to the one- and three-factor models, and it appears that it (the 4-factor model) is "passable" in some tests. However, we also document some failures of the 4-factor model, suggesting that the quest for an adequate pricing model must continue.

5. Dual-listed stocks, local and hybrid four factor models

5.1. Local vs. hybrid four factor models

The interesting fact about our sample and the main reason for our study of the Tel Aviv Stock Exchange is the presence of a relatively large proportion of dually-listed firms on TASE. About one-seventh of our sample stocks trade also on NYSE or Nasdaq. This relatively high proportion of foreign-listed firms may help us determine the potential need for and benefit of hybrid models (models that include both local and global factors) in pricing securities. Hou et al. (2011) advocate the use of hybrid models while Fama and French (2012) do not find them useful. Can hybrid models prove themselves vital in a local market with many dually-listed stocks that are naturally affected by foreign markets' returns?

We focus on the four-factor model, and test a local and two hybrid versions of it. One hybrid model adds the global four factors while the other adds the U.S. four factors. We examine also the U.S. hybrid model because the dually-listed stocks in our sample trade on U.S. markets. The U.S. and global factors data are taken from Ken French's web site. However, before using these factors in the regressions we convert their U.S. Dollar returns into local currency returns (returns as perceived by an Israeli investor). The conversion formula for global factors is:

(4) $R_{t,GLOBAL} = (1+ R^{\$}_{t,GLOBAL}) (NIS/\$_t / NIS/\$_{t-1}) - 1,$

where $R_{t,GLOBAL}$ is the local return of the global factor (the return used in our regressions), $R^{\$}_{t,GLOBAL}$ is the \$ return of the factor (as it appears on French's web site), and $NIS/\$_x$ is the New Israeli Shekels per one U.S. Dollar exchange rate at the end of month x. An analogous conversion formula applies to U.S. factors.

Table 4 documents the local and hybrid models comparison results. In Panel A (size-BE/ME portfolios) the improvement offered by the global hybrid model appears extremely slight. The adjusted-R^2 increases from 0.870 (local model) to 0.874 (global hybrid model), and correspondingly GRS declines from 2.32 to 2.31. The improvement offered by the U.S. hybrid model is somewhat higher yet still very slight. The adjusted-R^2 increases from 0.870 (local model) to 0.875 (U.S. hybrid model), and correspondingly GRS declines from 2.32 to 2.27. The finding that hybrid models with U.S. factors outperform hybrid models with global factors is natural for our sample, given that all our dual-listed firms trade on U.S. markets.

Panel B of Table 4 reinforces the impression that hybrid four-factor models are not contributing much. In Panel B (size-momentum portfolios), global and U.S. hybrid models have slightly higher adjusted-R^2s than the local model, yet their GRS statistics are slightly worse (i.e., higher) than that of the local four factor model.

In sum, the results in Table 4 are disappointing from the perspective of hybrid models. In a market with relatively many foreign-listed stocks, hybrid models at best slightly improve the performance of the local model. In our sample hybrid models appear neutral – they do not hurt and do not contribute to pricing performance. Thus, given the traditional goal of model parsimony, for practical purposes, hybrid models appear redundant.

Table 4: Local vs. hybrid versions of the four factor model in Israel

We examine the following time-series regressions, testing possible formulations of the four-factor models:

Local model: $R_{pt} - R_{ft} = a_p + b_p (R_{mt}-R_{ft})_{IL} + c_p SMB_{t,IL} + d_p HML_{t,IL} + e_p WML_{t,IL} + ñ1_{pt}$,

Hybrid model (global): $R_{pt} - R_{ft} = a_p + b_p (R_{mt}-R_{ft})_{IL} + c_p SMB_{t,IL} + d_p HML_{t,IL} + e_p WML_{t,IL} + f_p (R_{mt}-R_{ft})_{GLOBAL} + g_p SMB_{t,GLOBAL} + h_p HML_{t,GLOBAL} + i_p WML_{t,GLOBAL} + ñ2_{pt}$,

Hybrid model (US): $R_{pt} - R_{ft} = a_p + b_p (R_{mt}-R_{ft})_{IL} + c_p SMB_{t,IL} + d_p HML_{t,IL} + e_p WML_{t,IL} + f_p (R_{mt}-R_{ft})_{US} + g_p SMB_{t,US} + h_p HML_{t,US} + i_p WML_{t,US} + ñ3_{pt}$,

where $R_{pt} - R_{ft}$ is the portfolio excess return on month t, $(R_{mt}-R_{ft})_x$ is the excess return of market x on month t, $SMB_{t,x}$ is the excess return of small over big stocks in market x on month t, $HML_{t,x}$ is the excess return of value over growth stocks in market x on month t, and $WML_{t,x}$ is the excess return of positive over negative momentum stocks in market x on month t. All returns are in local currency, that is U.S. and global returns are translated into local (Israeli currency) returns via: $R_{t,GLOBAL} = (1+ R^{\$}_{t,GLOBAL}) (NIS/\$_t / NIS/\$_{t-1}) - 1$, where $R_{t,GLOBAL}$ is the local return of the global factor (the return used in our regressions), $R^{\$}_{t,GLOBAL}$ is the \$ return of the factor (as it appears on French's web site), and $NIS/\$_x$ is the New Israeli Shekels per one U.S. Dollar exchange rate at the end of month x.

First, 9 portfolios are constructed based on some sorting methodology (for example, sorting all sample shares by size and BE/ME). Then, these 9 portfolio returns are fitted by each of the 3 above-presented models, using standard OLS regressions. (For each model we run 9 regressions.) The table reports, for each model, the average adjusted R^2, the mean intercept standard deviation, and the mean absolute intercept of its 9 regressions. We also report the GRS test statistic (see Gibbons, Ross and Shanken, 1989), and the p-value, of the hypothesis that all 9 intercepts of the specific model regressions equal zero. The sample comprises 192-232 Tel Aviv Stock Exchange shares in 7/2002 - 6/2013.

Panel A: Tests based on 9 portfolios sorted by size and BE/ME

Version of the four factors pricing model	Statistics based on 9 regressions for each version				
	Average adjusted R^2	Mean intercept standard deviation s(a)	Mean absolute intercept |a|	GRS test for intercepts equal zero	p-value of the GRS test
Local	0.870	0.0026	0.0027	2.32	0.0193
Hybrid (global)	0.874	0.0025	0.0027	2.31	0.0199
Hybrid (U.S.)	0.875	0.0025	0.0026	2.27	0.0221

Table 4 (continued)

Panel B: Tests based on 9 portfolios sorted by size and momentum

Version of the four factors pricing model	Statistics based on 9 regressions for each version				
	Average adjusted R^2	Mean intercept standard deviation s(a)	Mean absolute intercept |a|	GRS test for intercepts equal zero	p-value of the GRS test
Local	0.857	0.0027	0.0052	5.73	0.0000
Hybrid (global)	0.864	0.0026	0.0052	5.83	0.0000
Hybrid (U.S.)	0.866	0.0026	0.0054	5.75	0.0000

5.2. Should dual-listed stocks be excluded from the analysis?

Dual-listed firms are typically firms whose main business is abroad and whose stock return is also affected by a foreign market (U.S. market in our case) returns. As such, dual-listed stocks may be perceived as contaminating local factors when they are included in local factors. Further, including them in test portfolios may introduce noise into these portfolio returns. Thus, an interesting research question is: Do dual-listed stocks reduce the performance of local four factor models? Given the evidence that local four-factor models perform best, the question of the exact definition, scope and limits, of "local" becomes important. Our sample is particularly adapted to examining this issue because of the relatively high proportion of dually-listed stocks in it that might accentuate any effect.

To examine the dual listed stock effect we do some preparatory work and construct factors and test portfolios based on the subsample of non-dual-listed firms only. The factor returns and the test portfolio returns are computed using the same procedures and formula as before. For example, to generate the 9 size-BE/ME test portfolios we first sort all non-dual-listed stocks into three groups according to their market value. Then, we sort all non-dual-listed stocks into three groups by their BE/ME. Last, we intersect the three size groups with the three BE/ME groups to form 9 test portfolios.

Table 5 examines 3 versions of the local four-factor model. The first version employs all stocks to build test portfolios and factors. It is essentially the local version of the 4-factor model reported in both Table 3 and 4. The second version we examine constructs test portfolios with non-dual-listed stocks only and employs the all stocks' factors. The third version constructs both test portfolios and factors with non-dual-listed stocks only.

Panel A of Table 5 summarizes results for size-BE/ME portfolios. First, the effect of the test portfolio composition can be analyzed, by comparing the first version with the two other versions. When the test portfolios consist of all stocks, model fit appears better (higher adjusted R^2 and lower standard error of the residuals) than when test portfolios comprise non-dual-listed stocks only. This appears to indicate that it is better to use all stocks, i.e., that dual-listed stocks should not be excluded. However, the GRS statistic is much lower when the test portfolios comprise of non-dual-listed stocks only, suggesting the opposite, i.e., that dual-listed stocks should be excluded. Hence, the evidence on test portfolios optimal composition is mixed and definitely not clear-cut. In fact, the most intriguing evidence in Panel A is the finding that when test portfolios are built with non-dual-listed stocks only, the four factors model cannot be rejected even at the 10% level (its p-value exceeds 0.10).

Table 5: Local four factor tests with and without dual-listed firms

We examine time-series regressions of the following four-factor local model:

$$R_{pt} - R_{ft} = a_p + b_p (R_{mt}-R_{ft}) + c_p SMB_t + d_p HML_t + e_p WML_t + ñ_{pt},$$

where $R_{pt} - R_{ft}$ is the portfolio excess return on month t, $(R_{mt}-R_{ft})$ is the excess market return on month t, SMB_t is the excess return of small over big stocks on month t, HML_t is the excess return of value over growth stocks on month t, and WML_t is the excess return of positive over negative momentum stocks on month t. Three versions of the model are reported: 1) test portfolios and factors include all stocks, 2) test portfolios include non-dual listed stocks only and factors are built with all stocks, and 3) test portfolios and factors are built with non-dual stocks only.
First, 9 portfolios are constructed based on some sorting methodology (for example, sorting all sample shares by size and BE/ME). Then, these 9 portfolio returns are fitted by the above-presented four factor model, using standard OLS regressions. (For each version of the four factor model we run 9 regressions.) The table reports, for each version, the average adjusted R^2, the mean intercept standard deviation, and the mean absolute intercept of its 9 regressions. We also report the GRS test statistic (see Gibbons, Ross and Shanken, 1989), and the p-value, of the hypothesis that all 9 intercepts of the specific pricing model regressions equal zero. The sample comprises 192-232 Tel Aviv Stock Exchange shares in 7/2002 - 6/2013.

Panel A: Tests based on 9 portfolios sorted by size and BE/ME

Version		Statistics based on 9 regressions for each version				
Test portfolios source	Factors source	Average adjusted R^2	Mean intercept standard deviation s(a)	Mean absolute intercept |a|	GRS test for intercepts equal zero	p-value of the GRS test
All stocks	All stocks	0.870	0.0026	0.0027	2.32	0.0193
Non-dual stocks	All stocks	0.848	0.0028	0.0024	1.46	0.1718
Non-dual stocks	Non-dual stocks	0.822	0.0031	0.0029	1.54	0.1422

Table 5 (continued)

Panel B: Tests based on 9 portfolios sorted by size and momentum

Version		Statistics based on 9 regressions for each version				
Test portfolios source	Factors source	Average adjusted R^2	Mean intercept standard deviation s(a)	Mean absolute intercept |a|	GRS test for intercepts equal zero	p-value of the GRS test
All stocks	All stocks	0.857	0.0027	0.0052	5.73	0.0000
Non-dual stocks	All stocks	0.849	0.0028	0.0055	3.47	0.0008
Non-dual stocks	Non-dual stocks	0.816	0.0031	0.0067	3.84	0.0003

The effect of the factor composition (with or without dual-listed stocks) can be inferred by comparing the second and third versions of the four factor model in Panel A. When the factors are built based on all stocks, the four factor model appears to perform better. Note that the compared versions 2 and 3 in Panel A utilize test portfolios built with non-dual-listed stocks only, and that even in such an environment all test statistics are better when factors are constructed with all stocks.

The superiority of factors based on all stocks may indicate that dual-listed stocks in our sample are mainly influenced by the local market. Thus, they are heavily affected by local factors, and one can benefit from including them in local factors' construction.

Panel B of Table 5 analyzes size-momentum portfolios and invokes analogous results and identical conclusions as Panel A. In Panel B, test portfolios based on all stocks have a better fit yet a worse GRS than test portfolios based on non-dual-listed stocks only. And, factors based on all stocks appear superior (provide better fit and GRS statistics).

The evidence in Table 5 makes it difficult to conclude on the issue of whether or not dual-listed firms should be excluded before local versions of the four-factor model are employed. On one hand, we find that factors based on all stocks perform better. On the other hand, the GRS statistics are better when dual-listed stocks are excluded from the test portfolios. Perhaps a cautious conclusion is that in practical applications both versions of the local four-factor model (with and without dual-listed stocks) should be attempted. However, our opinion is that the evidence in Table 5 does not prove that dual-listed firms should be excluded. Thus, dual-listed-stocks should be preserved in the sample, at least for Israeli market studies and applications.

Replications of our study in other economies might yield different evidence and different local conclusions. It is possible that for other markets it would be beneficial to exclude dual-listed firms from the analysis. In such a case of market-dependent results, our main contribution is in demonstrating a methodology for deciding on the worthiness of excluding dual-listed firms from the sample prior to the 4-factor model estimation and tests. In fact, our methodology may be perceived more generally, as it can be used for deciding whether or not to exclude any particular "dubious" group of stocks from the sample. For example, some studies exclude financial firms from the 4-factor model analysis. Is such exclusion prudent? Can it be empirically justified?

6. Summary and conclusions

We study the performance of the four-factor Fama-French-Carhart asset pricing model in Israel, where many of the stocks are dually listed, i.e., trade both on the Tel-Aviv-Stock Exchange and on NYSE or Nasdaq. Our sample comprises 192-232 stocks in the July 2002 – June 2013 period.

The concentration of dual-listed stocks on the exchange affords us to examine two research issues. First, we investigate the efficacy of hybrid models (models that combine local and foreign factors). Theory predicts that in the current state of the world, partial segmentation of markets, hybrid models might be beneficial. However, empirical tests of hybrid models yield inconclusive results. Hou et al. (2011) advocate and demonstrate the use of hybrid models, while Fama and French (2012) claim they are not useful. We seek to shed some light on this ongoing debate by examining if in an environment such as ours, with many dual-listed firms that are naturally affected by foreign markets returns, hybrid models outperform the simple local four-factor model.

Our evidence appears to side with the proponents of the simple local four-factor model. In our sample, hybrid models improve the local four-factor model performance only very slightly. Thus, practically, hybrid four-factor models appear redundant.

Our second research issue is more technical and involves the question of whether or not dual-listed-firms should be excluded from the sample prior to fitting a local four-factor model. Given the worldwide evidence that local four-factor models perform the best, it becomes relatively important to define the borders of "local".

Dual-listed-stocks may be perceived as contaminated (subject to foreign influence), thus it can be argued that they should be separated out. Our tests of this issue are indecisive; however, in our opinion, they do not support the exclusion of dual-listed stocks. Notably, the tests we conduct while attempting to determine the usefulness of excluding dually-listed stocks might be applicable for investigating or justifying exclusion criteria in other empirical studies of local four factor models as well. Thus, this study also offers a novel potentially useful methodology.

As usual, we have not exhausted the topics. Particularly, future studies should further examine the value and practical contribution of hybrid models in order to unveil circumstances and settings under which hybrid models are essential.

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