Size-portfolio Idiosyncratic Volatility with Aggregate Return, Cross-Sectional Return, and GDP Growth: U.S. and International Evidence

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Firm size is an essential factor in examining the relation between returns and idiosyncratic volatilities. This paper documents that, when the idiosyncratic volatility is specified by firm size, the size-portfolio idiosyncratic volatility is statistically significant in explaining the future *aggregate* return. This property prevails for the equally- or value-weighted scheme, the different time periods in the U.S. market, or the international markets. This paper also examines the relation between size-portfolio idiosyncratic volatilities and future *cross-sectional* returns. The size-portfolio idiosyncratic volatilities are also significantly related to future cross-sectional returns for both the U.S. and international markets. Finally, this paper examines the predictive ability of the size-portfolio idiosyncratic volatility for GDP growth. It concludes that size-portfolio idiosyncratic volatility contain significant information for forecasting future GDP growth for both the U.S. and the international markets.

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Keywords: Idiosyncratic Volatility, Cross-Sectional Excess Return, Aggregate Market Excess Return, GDP Growth

1. Introduction

The classical intertemporal capital asset pricing model (ICAPM) model of Merton (1980) generally predicts that return should be positively related to idiosyncratic risk. However, the empirical results have been quite inconclusive. Some studies (French et al. (1987), Campbell and Hentschel (1992), Ghysels et al.(2002) , Goyal and Santa-Clara (2003)) have reported consistently positive and significant estimates of the risk premium, while others (Campbell (1987), Turner et al. (1989), Breen et al. (1989), Glosten et al. (1993), Bali, Cakici, Yan, and Zhang (2005)) report negative values or otherwise insignificant estimates. For example, Goyal and Santa-Clara (2003) (henceforth GS) find a significant positive relation between idiosyncratic volatility and future aggregate market return in the United States. However, in a challenge to GS, Bali, Cakici, Yan, and Zhang (2005) (henceforth BCYZ) show that the weighting scheme and sample period make a difference. BCYZ argue that the conclusion of GS, established in equally-weighted measure, does not apply in value-weighted measure, nor does it apply to an extended time period ending in 2001.

This paper states that firm size should be an important factor when examining the relation between return and idiosyncratic volatility. The motivation for firm size in this study comes from the literature including Gertler & Gilchrist (1994), Peres-Quiros and Timmermann (2000), Cooley and Quadrini (2006). For example, Peres-Quiros and Timmermann (2000) suggest that, since the firm-specific volatility cannot be diversified away, profit volatility should translate into a disproportionately higher risk premium on small firms. Many cross-sectional papers, including Banz (1981), Reinganum (1981), Fama and French (1993, 1998), Amihud (2002), Baker and Wurgler (2006) have demonstrated that small firms tend to possess more volatile stock returns than large firms. In addition to the above studies, there are also practical reasons for studying the idiosyncratic volatility by firm size. It is quite often that institutional investment managers, in an effort to maximize returns, deliberately structure their portfolios (such as small cap stocks) to take considerable idiosyncratic risk. Although a portfolio mix of 20 or 30 stocks should be well diversified, eliminating idiosyncratic risk. Many portfolios, in reality, are under-diversified. For example, Goetzmann and Kumar (2004) use 62,000 U.S. household investors in 1991-1996 and show that more than 25 percent of the investor portfolios contain only one stock.

Different from previous studies (e.g. Fama and French (1993, 1998)) that typically treat firm size as one explanatory variable, this paper specified the returns and idiosyncratic volatility measures by firm size. Several interesting findings are documented in this paper. First, the debate between GS and BCYZ is partly due to the fact that the firm size is not explicitly specified. When firm size is specified in GS or BCYZ, the result between idiosyncratic volatility and the future *aggregate* return is evidentially noticeable. This finding prevails for either equally- or value-weighted schemes, for the sample periods covered by GS (year=1963-1999) and BCYZ (year=1962–2001), and the extended sample 1963-2009. The volatilities of small firm portfolios tend to show a strong and positive relation with the one-month-ahead aggregate market return in the U.S. This significance relationship is confirmed in international markets as well. Concerning our finding may be the result of a particular sample, or data-snooping (Lo and MacKinlay (1990)), this paper examines the international markets that have been selected frequently in other studies. It shows that size-portfolio volatility is statistically significant in explaining the future aggregate return for 9 out of 14 international markets. There are some consistent findings in these 9 markets. The volatilities of small firm portfolios, similar to the U.S. result, are generally positively related to future aggregate returns. On the other hand, the volatilities of large firm portfolios tend to show a negative relation with future aggregate market returns.

Second, this paper examines the relation between size-portfolio volatilities and future *cross-sectional* return, and finds the firm-size factor significant. The results show a positive relationship existing in small firm portfolios between idiosyncratic volatility and future cross-sectional return in the U.S. market. In the international markets, 9 out of 14 markets show that volatility is statistically associated with future cross-sectional returns. Some markets show a negative relation, and this seems at odds with the positive prediction by ICAPM. Previous studies have suggested short-horizon monthly return reversals are the cause. Jegadeesh and Titman (1995) explain that stocks with high idiosyncratic risk have greater firm-specific information, so possibly experience larger short-horizon return reversals. Huang, Liu, Rhee, and Zhang (2007) (henceforth HLRZ) find that the negative relationship in AHXZ (2006) is the result of short-horizon return reversals. This study does not rule out this possibility, yet it has to leave the causes of the positive or negative relations for future research.

The third empirical finding is the strong predictive ability of the size-portfolio idiosyncratic volatility for future GDP growth. This predictive ability is evident in the U.S and most of the international markets.

The paper proceeds as follows: Section 2 reviews the related literature. Section 3 presents the methodology. Section 4 discusses data sources. Section 5 presents the empirical findings. Section 6 concludes.

2. Literature Review

The empirical literature concerning the relations between return and idiosyncratic risk can be broadly summarized into two types: that which focuses on *aggregate* market return and that which focuses on *cross-sectional* return. As to *aggregate* market return, GS present a significant positive relation between idiosyncratic volatility and future aggregate market return in the United States. This result is challenged by BCYZ. BCYZ argue that the result of GS is a special case, and therefore does not support the ICAPM or similar models.

As to the relationship between idiosyncratic volatility and *cross-sectional* return, a positive relationship between the two in the U.S. market is reported by Tinic and West (1986), Merton (1987), Malkiel and Xu (1997), Malkiel and Xu (2002), Spiegel and Wang (2005), and Fu (2009). On the contrary, a negative relation is suggested by Ang, Hodrick, Xing, and Zhang (2006) (henceforth AHXZ). Bali and Cakici (2008) point out that data frequency used to estimate idiosyncratic volatility, weighting schemes used to compute average portfolio returns, and breakpoints utilized to sort stocks into quintile portfolios play a crucial role in determining the significance of a cross-sectional relation between idiosyncratic risk and future returns. Different combinations of these three suggested factors can lead to varying results. Jegadeesh and Titman (1995) explain that stocks with high idiosyncratic risk have greater firm-specific information, so possibly experience larger short-horizon return reversals. Huang, Liu, Rhee, and Zhang (2007) (henceforth HLRZ) find that the negative relationship documented in AHXZ (2006) is the result of short-horizon return reversals. The analysis in this paper focuses on the relation between one-month-ahead return and lagged idiosyncratic volatility. It does not measure the relation between return and expected volatility. Fu (2009) points out that expected volatility is unobservable and should be estimated. Fu (2009) uses Exponential Generalized AutoRegressive Conditional Heteroskedasticity (EGARCH) to estimate expected idiosyncratic volatility. Nevertheless, AHXZ (2009) argue that lagged idiosyncratic volatility is highly correlated with future idiosyncratic volatility. Similar to AHXZ (2009), this paper examines the contemporaneous relation between expected future idiosyncratic volatility and realized return. This study shows that the relation between return and lagged realized volatility still applies for contemporaneous return and idiosyncratic volatility. This conclusion holds for the studies on aggregate return and the cross-sectional return, and for the U.S. and international markets.

In addition to the relation between returns and volatilities, the predictive ability of idiosyncratic volatility for macroeconomic variables is an attractive topic in literature. Campbell, Lettau, Malkiel, and Xu (2001) (henceforth CLMX) show that the idiosyncratic volatilities of market, industry and firm levels have predicting power for the GDP growth in the U.S. Aghiona *et al*. (2010) show that because tighter firm-level credit affects the cyclical composition of investment, higher volatility and lower economic growth may result. Brockmana *et al*. (2010) present international evidence that information production drives the co-movement patterns observed in stock returns and that they are countercyclical.

3. Methodology

3.1. Size-Portfolio Volatility Measures

The volatility measures of GS and BCYZ is modified to incorporate the size factor. The monthly variance of stock i in size group j becomes:

$$V_{ijt} = \sum_{d=1}^{D_t} r_{ijd}^2 + 2\sum_{d=2}^{D_t} r_{ijd} r_{ij,d-1}. \tag{1}$$

Eq. (1) uses within-month daily return data. D_t is the number of trading days in month t, and $r_{ij,d}$ is the return of stock i in size group j on day d. The second term on the right-hand side adjusts for the autocorrelation in daily returns (French, Schwert, and Stambaugh (1987)).

Eq. (2) defines the equally-weighted idiosyncratic volatility for size group j as the arithmetic average of the monthly variance, where N_t is the number of stocks in month t. Value-weighted idiosyncratic volatility size group j is given in Eq. (3). The weight, $\omega_{j,t}$, of firm i in size group j is calculated by the market capitalization in period $t-1$. Assume that the weights are constant within period t. As discussed in GS, the variances in Eq. (2) or Eq. (3) are not, strictly speaking, the variance measures because they do not demean the returns. However, for daily frequency, the impact of subtracting the means is trivial.

$$VAR_{ew,jt} = \frac{1}{N_t} \sum_{j=1}^{N_t} V_{ijt}. \tag{2}$$

$$VAR_{vw,jt} = \sum_{i=1}^{N_t} \omega_{ij,t} V_{ijt}. \tag{3}$$

The measure VAR approximates the variance of a stock by its squared return. This is a measure of total risk that includes both systematic and idiosyncratic components. GS demonstrate that the effect of idiosyncratic risk is diversified away in the equally-weighted measure, but it makes up almost 85%

of the stock variance. Therefore, the volatility measures in Eqs. (2) and (3) are fundamentally the measures of idiosyncratic risk. An alternative measure for the idiosyncratic risk is the standard deviation of the residuals of the single-factor CAPM model or the Fama-French three factor model. BCYZ also construct the idiosyncratic volatility from the single-factor CAPM model, and check whether it explains the time-series variation in excess return. Their study shows that the two different ways of constructing the volatility measure do not result in different conclusion about the relation between volatility and return.

3.2. Relations between Lagged Volatilities and Future Returns

3.2.1. Between Lagged Size-Portfolio Volatility and One-Month-Ahead Aggregate Market Excess Returns

The simple (not log) aggregate market excess return in GS and BCYZ is modified to regress on the lagged size-portfolio volatility measures:

$$r^e_{w,t} = \alpha_1 + \beta_1 \cdot VAR_{w,j,t-1} + \varepsilon_{jt} \tag{4a}$$

Where $r^e_{w,t}$ is the aggregate market excess return of month *t*, $w \in (ew, vw)$ representing equally-weighted and value-weighted, $VAR_{w,j,t-1}$ denotes the daily volatility in Eqs. (2) and (3). Since it is often documented that empirical results might be sensitive to different weighting schemes (for example, Bali and Cakici (2008)), this study performs the regressions with the two weighting methods.

It would be informative to include a dummy variable RECS to Eq. (4a), because the market volatility might be related to business cycles (Hamilton and Lin (1996)). Let RECS equal 1 in recessions and 0 otherwise. Eq. 4(b) becomes:

$$r^e_{w,t} = \alpha_2 + \beta_2 \cdot VAR_{w,j,t-1} + RECS_t + \varepsilon_{jt} \tag{4b}$$

In equation (4a) and (4b), α_k and β_k are the intercept and the slope coefficient for $i \in (1,2)$.

3.2.2. Between Lagged Size-Portfolio Volatility and One-Month-Ahead Cross-Sectional Excess Return

In contrast to the *aggregate* market excess return in Eq. 4(a), the dependent variable in Eq. (5) is the *cross-sectional* excess return of size-portfolio *j*. The independent variable is the lagged volatility measure of size-portfolio *j*:

$$r^e_{w,jt} = \alpha_1 + \beta_1 \cdot VAR_{w,j,t-1} + \varepsilon_{jt} \tag{5}$$

where $r^e_{w,jt}$ is the simple excess return of month *t*; $w \in (ew, vw)$ representing equally-weighted and value-weighted, $VAR_{w,jt}$ denotes the daily volatility.

3.2.3. Between Lagged Size-portfolio Volatility and Future GDP Growth

CLMX use ordinal least squares (OLS) to regress GDP growth on lagged GDP growth, lagged market return, and lagged volatilities at market-, industry- and firm-levels. They document that when the volatility variables are not present, the lagged GDP growth and the lagged market return are individually significant. When adding the volatility variables, the lagged return is driven out; whereas, lagged GDP growth remains significant. This section maintains the basic formulation of the CLMX model but replaces the market-, industry-, and firm-level volatilities by size-portfolio volatilities. This allows us to compare the significance of the size-portfolio volatilities to the volatilities in CLMX. The equation is present as below:

$$GDP_t = c + b_g GDP_{t-1} + b_r R_{qtr,t-1} + \sum_{j=1}^{5} b_j VAR_{j,t-1} + \varepsilon_t \tag{6}$$

where $VAR_{j,t-1}$ is the lagged volatility measure of size 1 through 5, GDP_{t-1} is the lagged GDP time series, $R_{qtr,t-1}$ is the lagged quarterly market return, not the excess return (see CLMX). The intercept is

c; the coefficients are b_g, b_r, and b_j. Because GDP is measured on a quarterly frequency, the volatility series are re-constructed on a quarterly frequency. The volatility series uses daily returns as before. Since the various size volatilities are positively correlated, stepwise regression will be employed to select the one size-portfolio volatility that best explains the GDP growth.

4. Data

4.1. U.S. Data

Firm-level daily and monthly return data in the CRSP dataset from July 1962 to December 2009 are used. This is an extended sample of GS (1962:7 – 1999:12), CLMX (1962:7 – 1999:12), and BCYZ (1962:7 – 2001:12). Following GS, in each month the study uses all the stocks of NYSE/AMEX/Nasdaq that have a valid return and a valid market capitalization at the end of the previous month. Stocks with fewer than five trading days in a month are excluded from calculations for that month.[1] The market capitalization is defined as price times shares outstanding (Fama & French (1998)).

All stocks of NYSE/AMEX/NASDAQ in each month are ranked by size (market capitalization) into five groups (1=the smallest and 5=the largest). There is no particular reason to choose five size groups except to ensure that the portfolios have sufficient numbers of stocks. Fama & French (1993) use the median size of NYSE stocks to split the NYSE/AMEX/NASDAQ stocks into two groups. Bali and Cakici (2008) point out that the breakpoints utilized to sort stocks into portfolios could be a factor that causes different empirical results. For this reason we have also tested Fama & French's splitting method. The empirical results remain unchanged in our case. The Sizes 1, 2, and 3 account for 60% of stocks, but only 6% of the combined value of the five groups. This is driven by the fact that a large number of AMEX and NASDAQ stocks have smaller market size. The large number of small-size stocks plays a dominant role in the equally-weighted market return. In contrast, big stocks average more than 90% of total market cap, and they dominate value-weighted market return. Fama & French (1993, 2008) report very close statistics.

The market return used to calculate the simple excess return is the NYSE/AMEX/NASDAQ composite index provided in the CRSP data set. The business cycle dates are obtained from the National Bureau of Economic Research (NBER). The GDP growth time series is collected from the Bureau of Economic Analysis (BEA).

4.2. International Market Data

International stock market data are collected from Compustat Global from its beginning month, January 1989, to December 2009.[2] The non-U.S. markets in the study are: Australia (AUS), Austria (AUT), Belgium (BEL), Switzerland (CHE), Germany (GER), Finland (FIN), France (FRA), United Kingdom (UK), Greece (GRC), Hong Kong (HKG), Ireland (IRL), Italy (ITA), Japan (JPN), Luxembourg (LUX), the Netherlands (NLD), Singapore (SG), and Sweden (SWE). This list covers the twelve major EAFE (Europe, Australia, and the Far East) markets studied in Fama & French (1998) and in the Morgan Stanley Capital International MSCI/EAFE index. This list also covers a majority of the markets studied in King, Sentana and Wadhwani (1994), Bekaert, Hodrick and Zhang (2009), Drew (2003), Griffin (2002), Nijman *et al*. (2004), Coval and Moskowitz (2002), Guo and Savickas (2008), and AHXZ (2009).

The business cycle dates for the European markets are collected from the Center for Economic

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[1] If the autocorrelation of returns is less than -0.5, the second term in Eq. (1) dominates and makes the total variance negative. This occurs sometimes in individual stocks. Following GS and BYCZ, we ignore the second term and compute the first term in Eq. (1) only when the autocorrelation is less than -0.5.

[2] Compustat Global includes all the companies present in the Morgan Stanley Capital International Index, in the Financial Times Actuaries World Index, or in the local market index.

and Policy Research (CEPR).[3] The business cycle dates for the rest of the markets are from the central bank of each market. This study also calibrate the dating with the contribution of Artis, Kontolemis, and Osborn (1997).

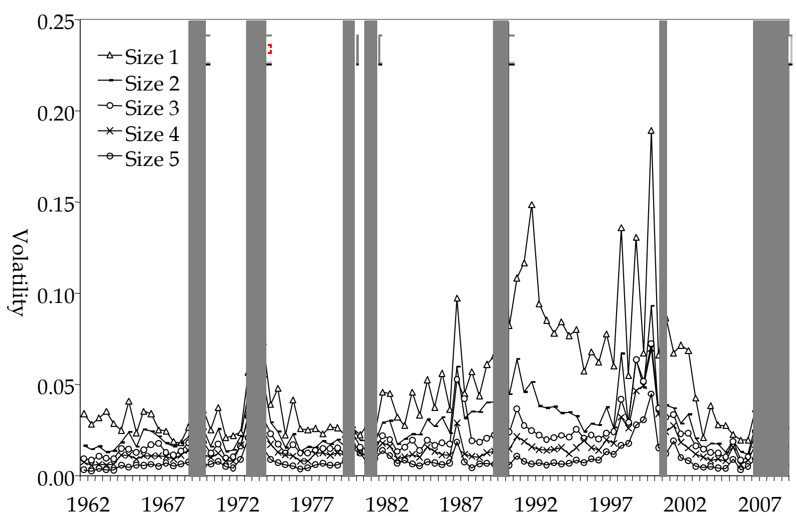
GDP growth time series are collected from the data warehouse of the Organization for Economic Co-operation and Development (OECD). The GDP growth data for Hong Kong is obtained from the Census and Statistics Department of the Government of the Hong Kong Special Administrative Region.[4]

The market-specific interest rates for calculating the excess returns are collected from the European central bank and the central banks of rest of the markets.[5] Fama & French (1998) use the U.S. interest rate to calculate the excess returns for other markets. Since most investors engage in domestic stock markets (Coval & Moskowitz (2002)), it is more relevant to use the interest rates of each market to calculate the excess returns.[6]

4.3. Summary Statistics

Figure 1 plots the time series of idiosyncratic volatility of small to large firm portfolios in the U.S. The volatilities rank monotonically by portfolio size. The stock volatilities of all sizes go up around recessions. That the aggregate return is pro-cyclical and the market volatility is countercyclical is the known feature (*e.g.*, Schwert (1989), CLMX, Brandt & Kang (2004), Adrian & Rosenberg (2008), and Li (2007)). The summary statistics of both the U.S. and international markets are shown in Table 1.

Figure 1
Volatilities of value-weighted NYSE/AMEX/NASDAQ portfolios by size



Notes: The daily volatilities range from 1962 to 2009. NBER recessions are represented by shaded bars.

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[3] CEPR is a recognized business-cycle dating committee in Europe. The CEPR-dated countries are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.

[4] U.S.: *http://www.bea.gov/* , Hong Kong: *http://www.censtatd.gov.hk/hong_kong_statistics/statistical_tables/*, OECD: *http://stats.oecd.org/index.aspx*

[5] UK: *http://www.bankofengland.co.uk/mfsd/iadb/*, Germany: *http://www.bundesbank.de/statistik/statistik.php*, EURO region: *http://sdw.ecb.europa.eu/browse.do*, Israel: *http://www.bankisrael.gov.il/deptdata/monetar/interest/bointcre.htm*, Singapore: *https://secure.sgs.gov.sg/apps/msbs/domesticInterestRatesForm.jsp*, Japan: *http://www.mof.go.jp/english/bonds/interest_rate/data.htm*

[6] In our empirical tests, we have also tested U.S. interest rates as a proxy for the international markets. Although we believe the interest rates of individual markets should provide a higher level of statistical significance, the results show there is not much difference from using the U.S. interest rates.

Table 1
Descriptive Statistics of Volatility Measures by Size

Panel (A) NYSE/AMEX/Nasdaq

	Mean		Median		StdDev.		Skewness		Kurtosis	
Size	ew	vw	ew	vw	ew	vw	ew	vw	ew	vw
1	0.10	0.05	0.07	0.04	0.08	0.03	2.13	1.92	6.4	5.1
2	0.05	0.03	0.04	0.03	0.03	0.02	2.35	2.89	8.7	13.5
3	0.03	0.02	0.03	0.02	0.02	0.02	4.29	4.63	30.3	34.2
4	0.03	0.02	0.02	0.01	0.02	0.01	4.23	4.62	26.0	31.1
5	0.02	0.01	0.01	0.01	0.02	0.01	5.06	5.54	36.3	43.7

Panel (B) International Markets

		Mean		Median		StdDev.		Skewness	
Market	Size	ew	vw	ew	vw	ew	vw	ew	vw
AUS	1	0.15	0.13	0.14	0.12	0.08	0.07	10.42	10.51
	2	0.07	0.07	0.06	0.06	0.05	0.05	10.87	10.96
	3	0.04	0.04	0.03	0.03	0.04	0.04	20.84	20.92
	4	0.03	0.03	0.02	0.02	0.02	0.02	30.47	30.62
	5	0.02	0.01	0.01	0.01	0.02	0.01	50.63	50.56
BEL	1	0.17	0.05	0.09	0.02	0.22	0.09	20.14	50.93
	2	0.02	0.02	0.01	0.01	0.06	0.06	130.88	140.16
	3	0.02	0.02	0.01	0.01	0.06	0.06	140.69	140.67
	4	0.02	0.02	0.01	0.01	0.06	0.06	140.46	140.24
	5	0.02	0.02	0.01	0.01	0.08	0.09	140.53	140.25
GER	1	0.21	0.12	0.07	0.05	0.26	0.14	10.58	10.55
	2	0.05	0.04	0.04	0.04	0.04	0.04	20.02	20.13
	3	0.03	0.03	0.03	0.03	0.03	0.03	30.42	30.52
	4	0.03	0.02	0.02	0.02	0.02	0.02	40.56	40.66
	5	0.02	0.02	0.01	0.01	0.02	0.04	50.56	90.18
FRA	1	0.07	0.05	0.05	0.04	0.06	0.06	40.54	70.11
	2	0.04	0.03	0.03	0.02	0.05	0.05	100.94	110.25
	3	0.03	0.03	0.02	0.02	0.05	0.05	130.53	130.50
	4	0.03	0.03	0.02	0.02	0.05	0.05	130.37	130.35
	5	0.02	0.02	0.02	0.01	0.05	0.06	130.76	140.12
UK	1	0.07	0.05	0.05	0.04	0.06	0.04	20.74	20.59
	2	0.03	0.03	0.02	0.02	0.02	0.02	20.32	20.32
	3	0.02	0.02	0.01	0.01	0.02	0.02	20.84	20.91
	4	0.02	0.02	0.01	0.01	0.01	0.02	40.16	40.15
	5	0.02	0.03	0.01	0.01	0.02	0.08	30.04	80.98
GRC	1	0.07	0.06	0.05	0.05	0.09	0.09	80.67	80.40
	2	0.05	0.05	0.04	0.04	0.09	0.10	90.36	90.51
	3	0.04	0.04	0.03	0.03	0.07	0.07	120.47	120.45
	4	0.04	0.04	0.02	0.02	0.07	0.07	120.61	120.38
	5	0.03	0.03	0.02	0.02	0.07	0.07	120.91	120.82

Table 1 (continued)

		Mean		Median		StdDev.		Skewness	
Market	Size	ew	vw	ew	vw	ew	vw	ew	vw
HK	1	0.09	0.08	0.07	0.06	0.09	0.08	20.71	20.97
	2	0.05	0.05	0.04	0.04	0.04	0.04	20.68	20.28
	3	0.04	0.04	0.03	0.03	0.03	0.03	20.32	20.31
	4	0.03	0.03	0.02	0.02	0.03	0.03	20.85	30.12
	5	0.02	0.02	0.01	0.01	0.03	0.02	40.97	40.15
IRL	1	0.12	0.10	0.09	0.07	0.10	0.11	20.64	40.22
	2	0.05	0.05	0.03	0.03	0.06	0.06	30.67	30.49
	3	0.03	0.03	0.02	0.02	0.03	0.03	30.02	30.32
	4	0.02	0.02	0.01	0.01	0.03	0.03	40.09	40.01
	5	0.02	0.02	0.01	0.01	0.04	0.03	50.25	40.56
ITA	1	0.04	0.04	0.03	0.02	0.07	0.07	100.88	110.00
	2	0.03	0.03	0.02	0.02	0.07	0.07	140.71	140.78
	3	0.02	0.02	0.01	0.01	0.07	0.07	140.00	130.39
	4	0.02	0.02	0.01	0.01	0.06	0.06	140.81	140.77
	5	0.02	0.02	0.01	0.01	0.07	0.07	140.93	140.78
JPN	1	0.05	0.04	0.04	0.04	0.03	0.02	10.54	10.75
	2	0.03	0.03	0.03	0.03	0.02	0.02	20.34	20.33
	3	0.03	0.03	0.03	0.03	0.02	0.02	20.70	20.73
	4	0.02	0.02	0.02	0.02	0.02	0.02	30.32	30.52
	5	0.02	0.02	0.02	0.02	0.02	0.02	40.56	40.26
LUX	1	0.04	0.02	0.01	0.01	0.09	0.04	60.90	40.64
	2	0.02	0.02	0.01	0.01	0.04	0.03	60.39	50.99
	3	0.03	0.02	0.01	0.01	0.05	0.05	50.91	70.82
	4	0.03	0.03	0.01	0.01	0.06	0.06	80.88	90.39
	5	0.02	0.02	0.01	0.01	0.07	0.07	100.60	100.03
NLD	1	0.11	0.06	0.05	0.03	0.14	0.07	20.31	30.29
	2	0.03	0.02	0.02	0.02	0.03	0.03	40.40	40.77
	3	0.02	0.02	0.01	0.01	0.03	0.03	60.90	60.77
	4	0.02	0.02	0.01	0.01	0.02	0.02	70.57	70.61
	5	0.02	0.02	0.01	0.01	0.03	0.03	70.57	70.11
SG	1	0.09	0.09	0.07	0.06	0.09	0.08	10.52	10.58
	2	0.05	0.05	0.05	0.04	0.05	0.05	20.11	20.17
	3	0.04	0.04	0.03	0.03	0.04	0.04	20.14	20.19
	4	0.03	0.03	0.02	0.02	0.03	0.02	20.60	20.75
	5	0.02	0.02	0.01	0.01	0.02	0.02	30.69	20.68
SWE	1	0.08	0.06	0.06	0.05	0.09	0.06	20.31	10.74
	2	0.04	0.04	0.03	0.03	0.03	0.03	10.70	10.81
	3	0.03	0.03	0.02	0.02	0.02	0.02	10.85	10.88
	4	0.02	0.02	0.02	0.02	0.02	0.02	20.12	20.18
	5	0.02	0.02	0.01	0.01	0.02	0.03	20.58	50.17

Notes: The time period for Panel (A) is August 1962 to December 2009 (569 monthly observations), and Panel (B) is January 1989 to December 2009. The international markets are: Australia (AUS), Belgium (BEL), Germany (GER), France (FRA), the United Kingdom (UK), Greece (GRC), Hong Kong (HK), Ireland (IRL), Italy (ITA), Japan (JPN), Luxembourg (LUX), the Netherlands (NLD), Singapore (SG), and Sweden (SWE). The "ew" and "vw" represent the equally- and value-weighted portfolios. Size 1=smallest and 5=largest.

5. Empirical Results

5.1. Empirical Results between Lagged Size-Portfolio Volatility and Future Aggregate Market Excess Return

5.1.1. U.S. Results

This section presents the result of Eq. (4a), which models the aggregate excess return with the size-portfolio volatility. We are aware that the variables calculated by equally-weighted (EW) or value-weighted (VW) might lead to different regression results (GS, BCYZ, Bali, and Cakici (2008)), so we test four combinations between excess return and volatility: VW and VW, EW and VW, EW and EW, and VW and EW. In order to compare the estimates with those in GS and BCYZ, this study tests the same period from 1963:08 to 1999:12 and 1963:08 to 2001:12. The regressions for each size portfolio are shown in Sizes 1 through 5. The results of VW-VW and EW-VW are shown in Table 2; EW-EW and VW-EW are in Table 3.

Table 2
Size Effect on the Relation between the One-Month Ahead Aggregate Excess Returns and the Lagged Value-Weighted Volatilities for the U.S. Market

Panel (A) Value-Weighted Returns on Value-Weighted Volatilities

	1963:8-1999:12		1963:8-2001:12		1963:8-2009:12	
Size	α	β	α	β	α	β
1	-0.007	0.310***	-0.004	0.230**	-0.000	0.129
2	-0.021*	0.967***	-0.015	0.709**	-0.006	0.385
3	-0.025	1.500**	-0.014	0.856	-0.012	0.719*
4	-0.021	1.636	-0.010	0.834	-0.012	0.899
5	-0.020	2.432	-0.013	1.577	-0.015	1.584**

Panel (B) Equally-Weighted Returns on Value-Weighted Volatilities

	1963:8-1999:12		1963:8-2001:12		1963:8-2009:12	
Size	α	β	α	β	α	β
1	-0.007	0.363***	-0.007	0.353***	-0.004	0.277***
2	-0.023**	1.136***	-0.020	0.993***	-0.010	0.632***
3	-0.026	1.686***	-0.017	1.182**	-0.013	0.941**
4	-0.020	1.767	-0.011	1.080	-0.011	1.071
5	-0.018	2.488	-0.012	1.791	-0.012	1.702

Notes: The regressions are run for the sample period of GS (1963:08 to 1999:12), BCYZ (1963:8-2001:12), and the extended sample (1963:08 to 2009:12). Size 1=smallest and 5=largest. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

Both Table 2 and 3 indicate that small-size idiosyncratic volatilities (Sizes 1, 2, and 3) are positively and significantly related to one-month-ahead aggregate market excess return in the U.S. These estimates are significant at 95% statistical level for both weighting methods and for the periods of GS and BCYZ. The positive results still hold for the extended time period 1963:08-2009:12 at 90% statistical level. All *t*-statistics are Newey-West corrected with the optimal lag length chosen according to Newey and West (1994). Contrary to the argument of BCYZ, this study finds the significance of the relation between the two variables emerge when idiosyncratic volatility is specified by size.

Table 3
Size Effect on the Relation between the One-Month Ahead Aggregate Excess Returns and the Lagged Equally-Weighted Volatilities for the U.S. Market

Panel (A) Equally-Weighted Returns on Equally-Weighted Volatilities

	1963:8-1999:12		1963:8-2001:12		1963:8-2009:12	
Size	α	β	α	β	α	β
1	-0.003	0.143***	-0.004	0.143***	-0.002	0.114***
2	-0.021*	0.646***	-0.019	0.579***	-0.011	0.402***
3	-0.025	1.039***	-0.017	0.758**	-0.014	0.631**
4	-0.020	1.187	-0.012	0.763	-0.012	0.751
5	-0.019	1.601	-0.011	0.984	-0.013	1.121

Panel (B) Value-Weighted Returns on Equally-Weighted Volatilities

	1963:8-1999:12		1963:8-2001:12		1963:8-2009:12	
Size	α	β	α	β	α	β
1	-0.005	0.126***	-0.003	0.098**	-0.000	0.056
2	-0.020	0.562***	-0.015	0.426**	-0.007	0.252
3	-0.025	0.953***	-0.014	0.572	-0.013	0.494*
4	-0.022	1.137	-0.011	0.611	-0.013	0.633
5	-0.021	1.577	-0.011	0.845	-0.016	1.036*

Notes: The regressions are run for the sample period of GS (1963:08 to 1999:12), BCYZ (1963:8-2001:12), and the extended sample (1963:08 to 2009:12). Size 1=smallest and 5=largest. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

Tables 4 and 5 exhibit the results of Eq. (4b), which introduce a NBER-dated dummy variable (RECS) to Eq. (4a). The recession dummy is not statistically significant for any of the periods. They present the same conclusion in Tables 2 and 3.

Table 4
Size Effect on the Relation between the Aggregate Market Excess Returns and the Lagged Value-Weighted Volatilities and the Recession Dummy for the U.S.

Panel (A) Equally-Weighted Returns on Value-Weighted Volatilities

	1963:8-1999:12			1963:8-2001:12			1963:8-2009:12		
Size	α	β	RECS	α	β	RECS	α	β	RECS
1	-0.005	0.359***	-0.009	-0.005	0.353***	-0.009	-0.002	0.303***	-0.015
2	-0.022*	1.188***	-0.012	-0.019	1.037***	-0.010	-0.010	0.757***	-0.019
3	-0.026	1.777***	-0.011	-0.017	1.227**	-0.007	-0.013	1.107***	-0.021
4	-0.020	1.836*	-0.006	-0.011	1.081	-0.000	-0.011	1.222**	-0.010
5	-0.018	2.530*	-0.003	-0.012	1.768	0.002	-0.011	1.881**	-0.018

Panel (B) Value-Weighted Returns on Value-Weighted Volatilities

	1963:8-1999:12			1963:8-2001:12			1963:8-2009:12		
Size	α	β	RECS	α	β	RECS	α	β	RECS
1	-0.006	0.307***	-0.006	-0.003	0.230**	-0.006	0.000	0.149	-0.012
2	-0.021**	1.002***	-0.008	-0.015	0.735**	-0.006	-0.006	0.477*	-0.014
3	-0.025	1.555**	-0.007	-0.014	0.869	-0.002	-0.012	0.848*	-0.016
4	-0.021	1.661	-0.002	-0.010	0.809	0.004	-0.012	1.020	-0.014
5	-0.020	2.432	0.000	-0.014	1.526	0.006	-0.014	1.745*	-0.015

Table 5
Size Effect on the Relation between the Aggregate Market Excess Returns and the Lagged Equally-Weighted Volatilities and the Recession Dummy for U.S.

Panel (A) Equally-Weighted Returns on Equally-Weighted Volatilities

	1963:8-1999:12			1963:8-2001:12			1963:8-2009:12		
Size	α	β	RECS	α	β	RECS	α	β	RECS
1	-0.002	0.140***	-0.008	-0.002	0.142***	-0.008	-0.000	0.119***	-0.013
2	-0.020	0.674***	-0.012	-0.018	0.602***	-0.010	-0.010	0.471***	-0.018
3	-0.025	1.088***	-0.011	-0.017	0.782**	-0.006	-0.013	0.733***	-0.020
4	-0.020	1.216	-0.005	-0.011	0.762	0.000	-0.011	0.843**	-0.017
5	-0.019	1.616	-0.001	-0.010	0.961	0.005	-0.012	1.224**	-0.016

Panel (B) Value-Weighted Returns on Equally-Weighted Volatilities

	1963:8-1999:12			1963:8-2001:12			1963:8-2009:12		
Size	α	β	RECS	α	β	RECS	α	β	RECS
1	-0.004	0.125***	-0.005	-0.002	0.098**	-0.005	0.001	0.060	-0.011
2	-0.020	0.580***	-0.008	-0.014	0.441**	-0.006	-0.007	0.304**	-0.014
3	-0.025	0.983**	-0.006	-0.014	0.579	-0.002	-0.013	0.575**	-0.016
4	-0.022	1.145	-0.001	-0.012	0.596	0.004	-0.012	0.707	-0.013
5	-0.021	1.564	0.001	-0.012	0.807	0.008	-0.015	1.125**	-0.014

Notes: The regressions are run for the sample period of GS (1963:08 to 1999:12), BCYZ (1963:8-2001:12), and the extended sample (1963:08 to 2009:12). RECS is 1 in recession months and 0 otherwise. Size 1=smallest and 5=largest. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

5.1.2. International Results

Table 6 presents the regression results of the size-portfolio volatility for the aggregate excess return for the international markets. Panel (A) shows the relations between EW volatility and EW market excess return; Panel (B) shows the relations between VW volatility and VW market excess returns.[7]

Table 6
Size Effect on the Relation between the One-Month Ahead Aggregate Excess Returns and the Lagged Volatilities for the International Markets

Panel (A) Equally-Weighted Measures

	Size 1		Size 2		Size 3		Size 4		Size 5	
	α	β	α	β	α	β	α	β	α	β
AUS	-0.008	0.196	0.016	0.024	0.020	-0.022	0.027**	-0.301	0.024**	-0.351
BEL	-0.003	0.081***	0.004	-0.003	0.005	-0.061	0.006	-0.094	0.008	-0.204**
GER	-0.017**	0.070***	-0.009	0.122	0.005	-0.126	0.013	-0.329	0.016	-0.422**
FRA	-0.001	0.113	0.009	-0.082	0.009	-0.137	0.009	-0.145	0.007	-0.109
UK	-0.010	0.207***	0.004	0.099	0.013*	-0.166	0.014**	-0.211	0.017***	-0.277
GRC	0.010	-0.026	0.014	-0.129	0.012	-0.143	0.010	-0.058	0.009	-0.105
HK	-0.028	0.427***	0.001	0.143	0.020*	-0.244	0.032***	-0.662***	0.027***	-0.644***
IRL	-0.012	0.205***	0.019***	-0.087	0.016*	0.063	0.020***	-0.239	0.022***	-0.323**
ITA	0.003	0.029	0.004	-0.040	0.004	0.000	0.009	-0.102	0.008	-0.075
JPN	-0.011	0.186	0.001	-0.096	0.006	-0.262	0.007	-0.281	0.007	-0.343
LUX	0.004	0.072	0.020***	-0.629***	0.022***	-0.332***	0.010	-0.187	0.008	-0.043
NLD	-0.013	0.109***	0.007	-0.139	0.016**	-0.428**	0.016***	-0.498***	0.014*	-0.384*
SG	-0.133*	0.914*	-0.139*	1.69*	-0.154**	2.74**	-0.145**	3.43**	-0.124**	3.89**
SWE	-0.014	0.222**	0.006	0.164	0.020**	-0.207	0.030***	-0.631**	0.035***	-1.05***

Panel (B) Value-Weighted Measures

	Size 1		Size 2		Size 3		Size 4		Size 5	
	α	β	α	β	α	β	α	β	α	β
AUS	0.001	0.141	0.017	0.011	0.019	0.000	0.026	-0.281	0.018	-0.092
BEL	-0.002	0.115	0.006	-0.041	0.005	-0.067	0.006	-0.096	0.007	-0.214***
GER	-0.017**	0.095***	-0.008	0.113	0.005	-0.143	0.013*	-0.348*	0.009	-0.179
FRA	0.006	-0.007	0.009	-0.092	0.009	-0.133	0.009	-0.155	0.004	-0.068
UK	-0.009	0.250**	0.005	0.092	0.014**	-0.245	0.013*	-0.158	0.022	-0.131
GRC	0.011	-0.057	0.013	-0.124	0.011	-0.142	0.010	-0.062	0.009	-0.092
HK	-0.027***	0.475***	0.002	0.113	0.024**	-0.325	0.032***	-0.645***	0.026***	-0.660***
IRL	-0.005	0.183***	0.019**	-0.104	0.017	-0.033	0.020***	-0.220	0.021***	-0.395**
ITA	0.003	-0.008	0.004	-0.048	0.004	0.027	0.009	-0.111	0.008	-0.100
JPN	-0.008	0.147	0.002	-0.125	0.007	-0.298	0.008	-0.335	0.008	-0.453
LUX	0.014*	-0.133	0.021***	-0.621***	0.019**	-0.258**	0.010	-0.179	0.010	-0.069
NLD	-0.004	0.074	0.009	-0.222	0.016**	-0.432**	0.016***	-0.470***	0.015**	-0.511***
SG	-0.134**	0.998*	-0.140**	1.714*	-0.154***	2.773**	-0.151**	3.847**	-0.116	4.009
SWE	-0.004	0.136	0.007	0.180	0.019*	-0.179	0.030***	-0.637***	0.037***	-1.11***

Notes: The regressions are run for the sample period of January 1989 to December 2009. The countries are: Australia (AUS), Belgium (BEL), Germany (GER), France (FRA), the United Kingdom (UK), Greece (GRC), Hong Kong (HK), Ireland (IRL), Italy (ITA), Japan (JPN), Luxembourg (LUX), the Netherlands (NLD), Singapore (SG), and Sweden (SWE). Size 1=smallest and 5=largest. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

[7] We have also tested equally-weighted (value-weighted) volatilities and value-weighted (equally-weighted) aggregate market excess returns. The results are similar, so they are not tabulated here.

Table 7
Size Effect on the Relation between the One-month Ahead Aggregate Excess Returns and the Lagged Volatilities and the Recession Dummy for the International Markets

Panel (A) Equally-Weighted Measures

	Size 1			Size 2			Size 3			Size 4			Size 5		
	α	β	RECS	α	β	RECS	α	β	RECS	α	β	RECS	α	β	RECS
AUS	-0.018	0.315**	-0.051	0.013	0.096	-0.016	0.019	0.028	-0.008	0.028*	-0.367	0.006	0.025*	-0.522	0.015
BEL	-0.003	0.081**	-0.002	0.006	0.000	-0.006	0.006	-0.061	-0.006	0.008	-0.094	-0.007	0.008	-0.20***	-0.001
GER	-0.015**	0.075**	-0.016	-0.008	0.138	-0.008	0.004	-0.121	-0.001	0.012	-0.333	0.001	0.014**	-0.434**	0.004
FRA	-0.001	0.118	0.004	0.009	-0.080	-0.002	0.009	-0.136	-0.001	0.009	-0.144	-0.003	0.007	-0.109	0.000
UK	0.000	0.143	-0.026**	0.010	-0.040	-0.017	0.020**	-0.587*	-0.006	0.019**	-0.539	-0.006	0.017**	-0.334	-0.002
GRC	0.018	-0.028	-0.036	0.019	-0.131	-0.024	0.018	-0.143	-0.029	0.016	-0.059	-0.030	0.015	-0.105	-0.026
HK	-0.02***	0.42***	-0.010	0.002	0.152	-0.007	0.021**	-0.237	-0.006	0.032**	-0.66***	0.001	0.028**	-0.62***	-0.008
IRL	-0.006	0.22***	-0.05***	0.02***	-0.062	-0.025	0.01***	-0.190	-0.018	0.02***	-0.41**	-0.008	0.02***	-0.54***	-0.002
ITA	0.007	0.028	-0.017	0.008	-0.038	-0.017	0.007	0.002	-0.011	0.011	-0.101	-0.010	0.009	-0.075	-0.008
JPN	-0.011	0.225	-0.011	0.001	-0.077	-0.004	0.006	-0.256	-0.001	0.007	-0.280	0.000	0.007	-0.323	-0.003
LUX	0.006	0.077	-0.014	0.02***	-0.60***	-0.012	0.02***	-0.306**	-0.018	0.012	-0.179	-0.011	0.010	-0.039	-0.015
NLD	0.003	0.033	-0.016	0.010	-0.160	-0.014	0.014**	-0.388**	-0.013	0.014**	-0.443**	-0.013	0.01***	-0.45***	-0.014
SG	0.002	0.13**	-0.03**	0.000	0.28**	-0.04**	-0.001	0.43**	-0.04***	0.002	0.454	-0.03**	0.012	0.088	-0.028
SWE	-0.015	0.32***	-0.039	0.006	0.234	-0.012	0.02*	-0.178	-0.005	0.03***	-0.626	-0.001	0.03***	1.10***	0.011

Panel (B) Value-Weighted Measures

	Size 1			Size 2			Size 3			Size 4			Size 5		
	α	β	RECS	α	β	RECS	α	β	RECS	α	β	RECS	α	β	RECS
AUS	-0.008	0.25	-0.043	0.014	0.074	-0.014	0.017	0.061	-0.009	0.026*	-0.329	0.004	0.017	-0.019	-0.005
BEL	-0.002	0.117	-0.001	0.007	-0.038	-0.005	0.006	-0.066	-0.005	0.008	-0.095	-0.007	0.008	-0.21***	-0.006
GER	-0.015	0.10*	-0.015	-0.007	0.129	-0.006	0.005	-0.140	-0.001	0.013	-0.35*	0.001	0.009	-0.182	0.002
FRA	0.006	-0.004	-0.003	0.009	-0.091	-0.002	-0.002	-0.133	0.000	0.010	-0.154	-0.003	0.004	-0.068	0.002
UK	-0.001	0.191	-0.02**	0.011	-0.054	-0.017	0.02***	-0.63**	-0.005	0.01***	-0.492	-0.006	0.019	-0.101	-0.003
GRC	0.018	-0.057	-0.032	0.018	-0.126	-0.024	0.017	-0.142	-0.031	0.017	-0.063	-0.029	0.014	-0.087	-0.025
HK	-0.02**	0.47***	-0.009	0.003	0.124	-0.008	0.02**	-0.317	0.006	0.03***	-0.64***	0.002	0.02***	-0.58**	-0.021
IRL	0.001	0.21***	-0.05***	0.023	-0.104	-0.019	0.02***	-0.243	-0.017	0.02***	-0.364	-0.011	0.02***	-0.64***	-0.006
ITA	0.007	-0.009	-0.017	0.008	-0.046	-0.017	0.006	0.029	-0.012	0.011	-0.110	-0.009	0.009	-0.099	-0.004
JPN	-0.009	0.192	-0.010	0.002	-0.107	-0.004	0.007	-0.295	-0.001	0.008	-0.335	0.000	0.009	-0.416	-0.007
LUX	0.01*	-0.100	-0.015	0.022	-0.58***	-0.014	0.02*	-0.237	-0.018	0.012	-0.169	-0.014	0.012	-0.065	-0.012
NLD	0.005	0.001	-0.005	0.011	-0.32**	-0.001	0.012	-0.42**	-0.002	0.011	-0.38*	-0.002	0.01*	-0.52***	-0.004
SG	-0.002	0.108	-0.025	0.011	-0.194	-0.010	0.01**	-0.43**	0.002	0.01**	-0.47**	0.002	0.014	-0.51***	0.002
SWE	-0.005	0.231	-0.025	0.006	0.236	-0.010	0.020*	-0.143	-0.007	0.030**	-0.64**	0.003	0.03***	-1.10***	0.005

Notes: The regressions are run for the sample period of January 1989 to December 2009. The countries are: Australia (AUS), Belgium (BEL), Germany (GER), France (FRA), the United Kingdom (UK), Greece (GRC), Hong Kong (HK), Ireland (IRL), Italy (ITA), Japan (JPN), Luxembourg (LUX), the Netherlands (NLD), Singapore (SG), and Sweden (SWE). RECS is 1 in recession months and 0 otherwise. Size 1=smallest and 5=largest. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

Table 7 exhibits the results of Eq. (4b) for the international markets. Different from the results in the U.S., the recession dummy variable in some markets is statistically significant.

In order to facilitate our discussion, Table 8 summarizes the number of markets in Tables 6 and 7, with at least one volatility measure showing statistical significance at the 95% level. Of the 14 non-U.S. markets, 8-10 markets show that lagged size-portfolio volatility has a statistically significant relationship with the one-month-ahead aggregate excess return.

Table 8
Summary of the Results of Tables 6 and 7 for the Number of Countries that the Size Effect is Statistically Significant

Weighting Method	Table 6: No Recession Dummy	Table 7: With Recession Dummy
Equally-Weighted	9	10
Value-Weighted	8	8

Interestingly, careful inspection of Tables 6 and 7 shows that the relationship between the volatility and the market excess return is not always positive. The idiosyncratic volatilities of the large firm portfolios show significant negative relation with the aggregate market excess returns. Those markets include Australia, Belgium, Germany, Ireland, the United Kingdom, Hong Kong, Luxembourg, the Netherlands and Sweden. Positive relations exist in small sizes in the following markets: Hong Kong, Ireland, Sweden, and Singapore. It remains to be explored if there are any market-specific characteristics causing this difference. Nevertheless, we can conservatively say the size-portfolio idiosyncratic volatility contains significant, either positive or negative, information for future market excess returns.

5.2. Empirical Results between Lagged Size-portfolio Volatilities and Future Cross-Sectional Excess Returns

5.2.1. U.S. Results

Table 9 shows the cross-sectional relation between excess return and idiosyncratic volatility for the U.S. stock market. There exists a significant positive relationship in the small firm portfolios between the two variables. The Newey-West *t*-statistics of Sizes 1 and 2 are 3.96 and 2.45 respectively.

Table 9
Size Effect on the Relation between the One-month Ahead Cross-sectional Excess Returns and the Lagged Volatilities for the U.S.

Panel (A) Value-Weighted Measures

Size 1		Size 2		Size 3		Size 4		Size 5	
α	β	α	β	α	β	α	β	α	β
-.006	.382***	-.004	.437**	-.000	.349	.004	.184	.006	-.070

Panel (B) Equally-Weighted Measures

Size 1		Size 2		Size 3		Size 4		Size 5	
α	β	α	β	α	β	α	β	α	β
-.002	.200***	-.005	.280**	-.000	.225	.004	.141	.005	.053

Notes: The regressions are run for the sample of August 1963 to December 2009. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

5.2.2. International results

Table 10 presents the cross-sectional regression estimates for 14 non-U.S. stock markets. Of 14 markets, 9 exhibit significant estimates, either positively or negatively.

Table 10
Size Effect on the Relation between the Cross-Sectional Excess Returns and the Lagged Volatilities for the International Markets

Panel (A) Equally-Weighted Measures

	Size 1		Size 2		Size 3		Size 4		Size 5	
	α	β	α	β	α	β	α	β	α	β
AUS	-0.008	0.196	0.016	0.024	0.020	-0.022	0.027	-0.301	0.024	-0.351
BEL	-0.003	0.081***	0.004	-0.003	0.005	-0.061	0.006	-0.094	0.008	-0.204***
GER	-0.017**	0.070***	-0.009	0.122	0.005	-0.126	0.013	-0.329	0.016**	-0.422**
FRA	-0.001	0.113	0.009	-0.082	0.009	-0.137	0.009	-0.145	0.007	-0.109
UK	-0.010	0.207***	0.004	0.099	0.013	-0.166	0.014**	-0.211	0.017***	-0.277
GRC	0.010	-0.026	0.014	-0.129	0.012	-0.143	0.010	-0.058	0.009	-0.105
HK	-0.028***	0.427***	0.001	0.143	0.020**	-0.244	0.032***	-0.662***	0.027***	-0.644***
IRL	-0.012	0.205***	0.019***	-0.087	0.016*	0.063	0.020***	-0.239	0.022***	-0.323**
ITA	0.003	0.029	0.004	-0.040	0.004	0.000	0.009	-0.102	0.008	-0.075
JPN	-0.011	0.186	0.001	-0.096	0.006	-0.262	0.007	-0.281	0.007	-0.343
LUX	0.004	0.072	0.020***	-0.629***	0.022***	-0.332***	0.010	-0.187	0.008	-0.043
NLD	-0.013	0.109	0.007	-0.139	0.016**	-0.428**	0.016***	-0.498***	0.014**	-0.384**
SG	-0.133**	0.914**	-0.139**	1.669**	-0.154***	2.740**	-0.145**	3.43**	-0.120**	3.820*
SWE	-0.014	0.222**	0.006	0.164	0.020	-0.207	0.030***	-0.631**	0.030***	-1.050***

Panel (B) Value-Weighted Measures

	Size 1		Size 2		Size 3		Size 4		Size 5	
	α	β	α	β	α	β	α	β	α	β
AUS	0.001	0.141	0.017	0.011	0.019	0.000	0.026	-0.281	0.018	-0.092
BEL	-0.002	0.115	0.006	-0.041	0.005	-0.067	0.006	-0.096	0.007	-0.210***
GER	-0.010**	0.095***	-0.008	0.113	0.005	-0.143	0.013*	-0.348*	0.009	-0.179
FRA	0.006	-0.007	0.009	-0.092	0.009	-0.133	0.009	-0.155	0.004	-0.068
UK	-0.009	0.250**	0.005	0.092	0.014**	-0.245	0.013**	-0.158	0.022	-0.131
GRC	0.011	-0.057	0.013	-0.124	0.011	-0.142	0.010	-0.062	0.009	-0.092
HK	-0.027	0.475***	0.002	0.113	0.024**	-0.325	0.032	-0.640***	0.026***	-0.660**
IRL	-0.005	0.180***	0.019**	-0.104	0.017**	-0.033	0.020***	-0.220	0.020***	-0.390**
ITA	0.003	-0.008	0.004	-0.048	0.004	0.027	0.009	-0.111	0.008	-0.100
JPN	-0.008	0.147	0.002	-0.125	0.007	-0.298	0.008	-0.335	0.008	-0.453
LUX	0.014*	-0.133	0.020***	-0.620***	0.020**	-0.250**	0.010	-0.179	0.010	-0.069
NLD	-0.004	0.074	0.009	-0.222	0.010**	-0.430**	0.010***	-0.470***	0.010**	-0.510***
SG	-0.130***	0.990*	-0.140**	1.710**	-0.150***	2.770**	-0.150**	3.840**	-0.116	4.009
SWE	-0.004	0.136	0.007	0.180	0.019*	-0.179	0.030***	-0.630**	0.030***	-1.100***

Notes: The regressions are run for the sample of January 1989 to December 2009. The countries are: Australia (AUS), Belgium (BEL), Germany (GER), France (FRA), the United Kingdom (UK), Greece (GRC), Hong Kong (HK), Ireland (IRL), Italy (ITA), Japan (JPN), Luxembourg (LUX), the Netherlands (NLD), Singapore (SG), and Sweden (SWE). Size 1=smallest and 5=largest. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level. For ease of comparison, a market is marked in a rectangle if at least one lagged volatility is statistically significant.

The cross-sectional relation between the two variables in the 9 markets can be classified into three types: (a) positive, (b) negative, and (c) positive relations in the small firm portfolios and negative in the large firm portfolios. The markets are summarized in Table 11. On the same topic, AHXZ (2009) find a strong negative relation in G7 countries. This negative relationship is found in the large firm portfolios. HLRZ (2010) point out that the negative relation in AHXZ (2009) is attributable to short-horizon return reversals of winner or loser stocks in prior months. We do not rule out this possible explanation, yet the true cause remains to be explored.

Table 11
Summary of the Relations between Lagged Idiosyncratic Volatility and Aggregate Excess Returns for the Markets Showing Statistical Significance

Relation Type	Countries/Markets
(a) Positive	(EW) Singapore (VW) U.K., Luxembourg, Singapore
(b) Negative	(EW) Luxembourg, Sweden (VW) Belgium, Netherlands, Sweden
(c) Positive relations in small firm portfolios and negative relations in large firm portfolios	(EW) Belgium, U.K. Hong Kong, Ireland, Netherlands, Sweden (VW) Germany, Hong Kong, Ireland

Notes: EW=equally-weighted, VW=value-weighted

5.3. Empirical Results between Size-Portfolio Volatilities and Future GDP Growth

5.3.1. U.S. Results

Table 12 shows the regression for the GDP growth on its own lag, the lagged market return and size-portfolio volatilities. Panels (A) and (B) exhibit the GDP growth of the preceding quarter and the same quarter of the prior year, respectively. Stepwise regression is employed to select the one size-portfolio volatility that best explains the GDP growth. All *t*-statistics are Newey-West corrected with the optimal lag length chosen according to Newey and West (1994). In all regressions the volatility variable drives out the lagged market return, whereas lagged GDP growth remains significant. In either value-weighted or equally-weighted measures, the Size-3 volatility remains in the regression result, and is negatively associated with the GDP growth. The Newey-West *t*-statistics for the size-volatilities in Table 12 are -4.89 and -5.05 for equally- and value-weighted. In contrast, the *t*-statistics in CLMX for the market-level, industry-level, and firm-level volatilities are between -2.38 to -2.99.

Table 12
Size Effect on the Relation between the Lagged Volatilities and One-Month Ahead GDP Growth in the United States During 1963-2009

Panel (A): Preceding Quarter

C	GDP_{t-1}	$R_{qtr,t-1}$	VAR_1	VAR_2	VAR_3	VAR_4	VAR_5	Adj. R^2
Equally-Weighted								15.4%
4.04***	0.24***				-18.6***			
Value-Weighted								15.1%
3.81***	0.23***				-20.9***			

Panel B: Same Quarter

C	GDP_{t-1}	$R_{qtr,t-1}$	VAR_1	VAR_2	VAR_3	VAR_4	VAR_5	Adj. R^2
Equally-Weighted								85.4%
0.01***	0.88***				-0.06***			
Value-Weighted								85.3%
0.01***	0.88***				-0.07***			

Notes: This table presents the regression for GDP growth with lagged GDP growth, lagged market return, and all the size-portfolio volatilities. The GDP growth in Panel (A) is GDP percentage change to the preceding quarter; that in Panel (B) is GDP percentage change to the last year in the same quarter. Stepwise regression is employed to select just one size-portfolio volatility that best explains the GDP growth. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

5.3.2. International Results

Table 13 presents the OLS regression for the GDP growth on its own lag, the lagged market return and size-portfolio volatilities for the international markets. This study tests both the results of the value-weighted and equally-weighted returns and volatility measures in Panels (A) and (B), respectively.

Table 13
Size Effect on the Relation between GDP Growth and Lagged Volatilities for the International Markets

Panel (A) Value-Weighted Measures

	C	GDP_{t-1}	$R_{qtr,t-1}$	VAR_1	VAR_2	VAR_3	VAR_4	VAR_5	Adj. R^2
Austria	0.159	0.683***							47.17%
Belgium	0.201	0.558***							31.23%
Switzerland	0.330***	0.552***			-2.710				41.37%
Czech Republic	0.900***	0.388***				-7.300***			34.15%
Germany	0.650***			-2.701*					11.02%
Denmark	1.180***	-0.302**		-6.190***					17.16%
Spain	0.038	0.864***		0.573***					75.53%
Finland	0.206	0.569***							33.33%
France	0.203***	0.538***	-0.470***						25.35%
U.K.	0.400***	0.5659***					-3.950**		54.72%
Hungary	0.130	0.813***							66.46%
Ireland	2.230***	-0.160				-0.953***			10.44%
Iceland	1.200***	-0.383***			-2.970***				14.80%
Israel	0.830***		3.050***						11.84%
Italy	0.102	0.559***							31.10%
Japan	1.080***			-6.220**					11.97%
South Korea	0.770***	0.350***		0.183*					11.85%
Mexico	1.330***	0.238**					-11.210*		29.54%
Netherlands	0.510***	0.392***			-2.100				23.16%
Norway	1.480***	-0.260**				-6.060***			15.34%
New Zealand	0.390***	0.366***							12.43%
Sweden	0.780***	0.233*		-1.450**					13.37%

Panel (B) Equally-Weighted Measures

	C	GDP_{t-1}	$R_{qtr,t-1}$	VAR_1	VAR_2	VAR_3	VAR_4	VAR_5	Adj. R^2
Austria	0.159	0.683***							46.52%
Belgium	0.201	0.558***							30.01%
Switzerland	0.140***	0.553***	0.816						42.64%
Czech Republic	0.900***	0.388***				-7.300**			31.57%
Germany	0.460***			-0.001					7.03%
Denmark	0.940***	-0.381***	4.260***	-0.091***					25.15%
Spain	0.032	0.865***		0.019***					75.54%
Finland	0.206	0.569***							32.46%
France	0.220***	0.488							23.07%
U.K.	0.330***	0.593***						-0.006	55.14%
Hungary	0.130	0.813***							66.46%
Ireland	2.130***	-0.126				-12.740***			58.50%
Iceland	1.480***	-0.402***			-1.750***				19.20%
Israel	0.850***		2.820***						15.38%
Italy	0.102	0.559							31.10%
Japan	0.870***		1.620*	-0.010**					16.71%
South Korea	0.860***	0.360***							11.87%
Mexico	1.090***	0.291***					0.503		24.98%

Table 13 (continued)

	C	GDP_{t-1}	$R_{qtr,t-1}$	VAR_1	VAR_2	VAR_3	VAR_4	VAR_5	Adj. R^2
Netherlands	0.510***	0.388***			-0.049**				24.13%
Norway	1.340***	-0.298**			-0.147***				15.00%
New Zealand	0.263*	0.384***				0.119***			13.44%
Sweden	0.760***	0.241			-0.039**				13.52%

Notes: This table presents the OLS regression for GDP growth with lagged GDP growth, lagged market return, and all the size-portfolio volatilities for the International Markets. GDP growth is the percentage change to the preceding quarter. Panels (A) & (B) present the results of value-weighted and equally-weighted returns and volatility measures respectively. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level. Stepwise regression is employed. The time period is 1989Q1 to 2009Q4. For ease of comparison, markets are marked in a rectangle if the volatility measures are statistically significant.

The size-portfolio idiosyncratic volatilities prove to be significant predictors for 15 out of 22 markets for the value-weighted measures, and 13 out of 22 markets for the equally-weighted measures. All the statistically significant volatilities belong to the small sizes (Size 1, 2, or 3), except the United Kingdom and Mexico. All the volatility measures, except New Zealand in Panel (B), show a significant inverse relation with the GDP growth.

5.3.3. Volatility Correlations between Markets

Baele (2005) examines the volatility spillovers among 13 local European equity markets. He finds that the shock spillover intensity has increased over the 1980s and 1990s for European countries. It would be useful to examine if the correlations of the idiosyncratic volatilities among international markets have increased over time.

We determined that aggregate volatility, instead of size-portfolio volatility, is sufficient to demonstrate the spillovers of idiosyncratic volatilities among international markets. Therefore, we return to the definition of GS for the idiosyncratic volatility in Eq. (7):

$$VAR_{ew,t} = \frac{1}{N_t}\sum_{i=1}^{N_t} V_{it} \tag{7}$$

The only difference between Eqs. (7) and Eq. (2) is that the size factor is not in Eq. (7). The variance of stock *i* in month *t*, *Vit*, is the same as GS in Eq. (8):

$$V_{it} = \sum_{d=1}^{D_t} r_{id}^2 + 2\sum_{d=2}^{D_t} r_{id} r_{i,d-1} \tag{8}$$

Panel (A) in Table 14 shows the correlation coefficients between the international markets in 1989-2009. High levels of interdependence (>=0.80) exist in European markets, including Belgium, Spain, France, Germany, Italy, and the Netherlands.

To see the increased volatility dependence among the markets in 1989-2009, this study splits the time period into two sub-periods and present them in Panels (B) and (C). The correlation coefficients in Panel (C) are marked in rectangles if they are statistically significant and higher than those in Panel (B). Panel (C) illustrates that the volatility dependence among the international markets has increased in many market pairs. The result demonstrates the volatility dependence among the eastern markets, such as Japan, Hong Kong, and Singapore, and the European markets have grown significantly in the past years.

5.4. Contemporaneous Relation between Size-Portfolio Volatility and Returns

Many of the cited papers, such as GS, BCYZ, and AHXZ (2006), assume that the relation between lagged volatility and one-month-ahead return represents the relation between volatility and expected return. Fu (2009) points out that in order to explain expected returns, the theoretically

Table 14
Correlations of Market Volatilities between the International Markets

Panel (A) Period = 1989 – 2009

	AU	BE	GE	SP	FI	FR	UK	GR	HK	IR	IT	JP	LU	NL	SG
BE	0.46														
GE	0.74	0.58													
SP	0.03	0.78	0.19												
FI	0.11	0.78	0.27	0.93											
FR	0.27	0.88	0.46	0.91	0.91										
UK	0.87	0.48	0.74	0.07	0.19	0.32									
GR	0.11	0.08	0.06	0.03	0.06	0.07	0.11								
HK	0.53	0.30	0.38	0.07	0.14	0.23	0.53	0.11							
IR	0.70	0.42	0.64	0.16	0.28	0.33	0.77	0.12	0.34						
IT	0.09	0.81	0.24	0.98	0.93	0.93	0.13	0.03	0.13	0.22					
JP	0.58	0.27	0.43	0.07	0.16	0.25	0.57	0.20	0.57	0.49	0.12				
LU	0.38	0.75	0.52	0.74	0.76	0.85	0.47	0.07	0.29	0.47	0.76	0.36			
NL	0.55	0.67	0.75	0.45	0.51	0.68	0.59	0.11	0.30	0.53	0.50	0.38	0.68		
SG	0.81	0.45	0.66	0.07	0.11	0.28	0.74	0.07	0.60	0.62	0.14	0.61	0.37	0.50	
SW	0.51	0.27	0.48	0.05	0.23	0.28	0.65	0.16	0.39	0.61	0.11	0.45	0.40	0.51	0.41

Panel (B) Period = 1989 – 1999

	AU	BE	GE	SP	FI	FR	UK	GR	HK	IR	IT	JP	LU	NL	SG
BE	0.23														
GE	0.30	0.91													
SP	0.15	0.98	0.88												
FI	0.12	0.94	0.84	0.96											
FR	0.18	0.98	0.90	0.99	0.96										
UK	0.42	0.27	0.39	0.21	0.27	0.26									
GR	0.39	0.11	0.17	0.03	0.03	0.06	0.30								
HK	0.53	0.15	0.30	0.09	0.09	0.15	0.53	0.23							
IR	0.08	0.34	0.28	0.36	0.41	0.35	0.41	0.13	0.07						
IT	0.13	0.97	0.87	0.98	0.95	0.98	0.21	0.01	0.12	0.34					
JP	0.49	0.14	0.28	0.08	0.07	0.13	0.49	0.36	0.51	0.18	0.09				
LU	0.20	0.91	0.85	0.89	0.86	0.90	0.39	0.08	0.21	0.36	0.88	0.18			
NL	0.17	0.84	0.84	0.84	0.81	0.85	0.26	0.03	0.19	0.27	0.83	0.13	0.78		
SG	0.46	0.22	0.34	0.16	0.13	0.21	0.36	0.17	0.65	0.14	0.19	0.66	0.27	0.21	
SW	0.05	0.06	0.08	0.07	0.18	0.07	0.55	0.10	0.21	0.53	0.07	0.11	0.10	0.07	0.10

Panel (C) Period = 2000 - 2009

	AU	BE	GE	SP	FI	FR	UK	GR	HK	IR	IT	JP	LU	NL	SG
BE	0.46														
GE	0.74	0.58													
SP	0.03	0.78	0.19												
FI	0.11	0.78	0.27	0.93											
FR	0.27	0.88	0.46	0.91	0.91										
UK	0.87	0.48	0.74	0.07	0.19	0.32									
GR	0.11	0.08	0.06	0.03	0.06	0.07	0.11								
HK	0.53	0.30	0.38	0.07	0.14	0.23	0.54	0.11							
IR	0.70	0.42	0.64	0.16	0.28	0.33	0.77	0.12	0.34						
IT	0.09	0.81	0.24	0.98	0.93	0.93	0.13	0.03	0.13	0.22					
JP	0.58	0.27	0.43	0.07	0.16	0.25	0.57	0.20	0.57	0.49	0.12				
LU	0.38	0.75	0.52	0.74	0.76	0.85	0.47	0.07	0.29	0.47	0.76	0.36			
NL	0.55	0.67	0.75	0.45	0.51	0.68	0.59	0.11	0.30	0.53	0.50	0.38	0.68		
SG	0.81	0.45	0.66	0.07	0.11	0.28	0.74	0.07	0.60	0.62	0.14	0.61	0.37	0.50	
SW	0.51	0.27	0.48	0.05	0.23	0.28	0.65	0.16	0.39	0.61	0.11	0.45	0.40	0.51	0.41

Notes: The countries are: Australia (AU), Belgium (BE), Germany (GE), Spain (SP), Finland (FI), France (FR), the United Kingdom (UK), Greece (GR), Hong Kong (HK), Ireland (IR), Italy (IT), Japan (JP), Luxembourg (LU), the Netherlands (NL), Singapore (SG), and Sweden (SW). Values more than 0.16 are statistically significant at 99% level. Panels (B) and (C) show the correlations between 1989-1999 and 2000-2009. Values in Panel (C) are marked if the correlation coefficients are statistically significant and higher than those in Panel (B).

correct variable should be the expected idiosyncratic volatility in the same period that the expected return is measured. Up until now we have been very careful not to imply that the relation between lagged volatility and one-month-ahead return equals the relation between volatility and expected return. However, as argued by AHXZ (2009), since the idiosyncratic volatility time series is persistent, the lagged measure is expected to correlate with future idiosyncratic volatility. This section examines the contemporaneous relation between idiosyncratic volatility and return as a type of robustness test.

5.4.1. Contemporaneous Relation between Idiosyncratic Volatilities and Aggregate Excess Returns

Table 15 presents the contemporaneous relation between the two for equally-weighted and value-weighted measures for the U.S. in 1963-2009. Small size volatilities still show strong positive and significant relation with the aggregate excess returns.

Table 15
Size Effect on the Contemporaneous Relation between Lagged Idiosyncratic Volatilities and Aggregate Excess Returns in U.S. 1963-2009

Panel (A) : Value-Weighted Idiosyncratic Volatilities with Value-Weighted Aggregate Excess

	Size 1		Size 2		Size 3		Size 4		Size 5	
	α	β	α	β	α	β	α	β	α	β
Coef.	-0.006	0.147***	-0.012	0.432***	-0.007	0.429	-0.006	0.504	-0.004	0.563

Panel (B): Equally-Weighted Idiosyncratic Volatilities with Equally-Weighted Aggregate Excess Returns

	Size 1		Size 2		Size 3		Size 4		Size 5	
	α	β	α	β	α	β	α	β	α	β
Coef.	-0.006	0.383***	-0.000	0.277	0.008	-0.052	0.014***	-0.381	0.010***	-0.482

Notes: The regressions are run for the sample of August 1963 to December 2009. Size 1=smallest and 5=largest. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

5.4.2 Contemporaneous Relation between Idiosyncratic Volatilities and Cross-Sectional Excess Returns

Table 16 displays the contemporaneous relation between the two for equally-weighted and value-weighted measures for the U.S. in 1963-2009. Like Table 9, the small firm portfolios still show a strong and positive relation. In sum, this study finds the contemporaneous relation is very similar to the lagged relation between idiosyncratic volatilities and cross-sectional excess returns.

Table 16
Size Effect on the Contemporaneous Relation between Lagged Volatilities and Cross-Sectional Excess Returns in the U.S. 1963-2009

Panel (A) Value-Weighted Volatilities with Value-Weighted Cross-Sectional Excess Returns

	Size 1		Size 2		Size 3		Size 4		Size 5	
	α	β	α	β	α	β	α	β	α	β
Coef.	-0.006	0.147***	-0.012	0.432***	-0.007	0.429	-0.006	0.504	-0.004	0.563

Panel (B) Equally-Weighted Volatilities with Equally-Weighted Cross-Sectional Excess Returns

	Size 1		Size 2		Size 3		Size 4		Size 5	
	α	β	α	β	α	β	α	β	α	β
Coef.	-0.003	0.210***	-0.002	0.209	0.008	-0.016	0.013***	-0.213	0.012***	-0.355*

Notes: The regressions are run for the sample of August 1963 to December 2009. Size 1=smallest and 5=largest. *** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

The international results show similar statistics to Tables 6 and 10 and the same conclusion. In order to save space, the international results for aggregate excess returns and cross-sectional excess returns are not tabulated here.[8]

6. Conclusions

Firm size is an important factor in examining the relation between excess return and idiosyncratic volatility. The size-portfolio idiosyncratic volatility derived in this paper helps to explain some inconclusive findings in the empirical literature. Significant empirical evidences are found between the size-portfolio idiosyncratic volatilities and excess aggregate returns, or cross-sectional returns. The size-portfolio idiosyncratic volatility also is very useful in predicting future GDP growth. This paper documents that small-size volatilities contain significant information for future GDP growth, both for the U.S. and international markets. It would be interesting to understand the theoretical and empirical relations between the size-portfolio idiosyncratic volatility and other macroeconomic variables. This is left for future research.

[8] Tables are available upon request.

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