International Evidence On Currency Adjusted Stock Indexes

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ABSTRACT

Recent literature examines currency value adjusted indexes. The extant research examines U.S. stock indexes as adjusted for the value of the U.S. dollar and the value of gold. The literature examines only U.S. stock indexes. This paper extends the existing literature by examining currency adjusted stock indexes from eight countries. The analysis includes daily closing data from 1993-2016. The results show that currency adjusted indexes produce significantly different return distributions than original indexes. Further, currency value changes explain as much as 31 percent of total wealth changes, a result substantially higher than previously reported for U.S. currency adjusted indexes. The combined evidence indicates that currency value changes impact total wealth changes more for international indexes than for U.S. indexes.

JEL: F31; G11; G15

Keywords: Stock Indexes Currency; Wealth Changes; Dow Jones Industrial Average

INTRODUCTION

An underlying currency provides the basis for stock indexes. Currency value fluctuations distort investor wealth changes implied by stock indices. Currency adjusted stock indices control for these effects by reflecting both stock value changes and underlying currency value changes in a single index. Currency adjusted indices provide investors an enhanced view of how their total wealth changes in response to market developments. Currency adjusted indexes also provide a potential tool for the creation of new index funds and new tools to test asset pricing models.

Currency adjusted indexes were first introduced by Jalbert (2012). Jalbert extended the analysis with several follow up papers (Jalbert, 2014, 2015a, 2015b, 2016 and 2017). His work examines only U.S. indexes. Moreover, most of his work utilizes the U.S. dollar value relative to a basket of currencies to create currency adjusted indexes. However, his most recent work controls for dollar value fluctuations relative to the value of gold (Jalbert 2017). The current research extends this series of work. This paper examines indexes that measure stock performance outside the U.S. Results indicate that currency adjusted indexes from outside the U.S. produce substantially different return distribution properties than currency adjusted U.S. indexes.

The remainder of the paper is organized as follows. The next section discusses the relevant literature. The following section presents the data and methodology used in the analysis. The analysis continues with the presentation and discussion of the empirical results. The paper closes with some concluding comments.

LITERATURE REVIEW

Stock index research is not new. The research examines a variety of issues including stock index futures and stock index volatility. Some research exists on what constitutes a good index. Carr-Hill and Chalmers-Dixon (2005) identify nine characteristics required of a good index and three desirable characteristics. The required characteristics are technical robustness, transparency, objectivity, plausibility, freedom from perverse incentives, reliability of calculation, comprehensibility to non-specialists, durability and practicality. Desirable characteristics are clarity of contribution, flexibility and stability. Mark and Goldberg (1984) lay out several criteria for a good price index. They argue the index should be conceptually sound and rooted in straightforward theory. Good indexes should not rely upon

difficult sampling procedures and require simple administration. Finally, good indexes should be somewhat stable, and not be excessively dependent on period-to-period changes. The currency adjusted indexes developed in the current research include each of these characteristics and thus offer a viable option to mainstream stock indexes.

King (1966) examined the role of macroeconomic factors on stock index returns. He found that macroeconomic factors explain some 52 percent of variations in stock price. Chung and Ariff (2016) examine the roles of money supply and bank liquidity on stock index returns in four countries. They find strong links between money supply and liquidity on stock index returns.

Another relevant line of literature examines stock index relationships. Huang, Yang and Hu (2000) examine stock indices from six countries. They examine the influence of U.S. and Japanese markets on South China region markets. Their results reveal that U.S. stock price changes exhibit a larger impact on South China region indexes. Lin (2012) examines the relationship between exchange rates and stock prices in Asian markets. He finds stronger co-movement during crisis periods. He also finds most spillovers run from stock price shocks to exchange rates. Tsai (2012) finds the negative relationship between stock and foreign exchange is more pronounced when exchange rates are relatively high or low. Gay (2016) examines the Brazil, Russia, India, and China markets. He finds no relationship between respective exchange rates and oil prices on stock market index levels for any country examined.

Levy and Yagil (2013) explore the effects of a 2010 methodology change for equity indexes on the Tel-Aviv Stock Exchange. Their results show the change increased index quality and reduced return volatility. However, the mean return remained the same. Changes in index composition affect stock prices. Prices of stocks added to an index increase and prices of stocks removed from an index decline (Shleifer, 1986, Beneish & Gardner, 1995).

Jalbert (2012) first developed currency adjusted stock indexes. He used Broad and Major currency indices as complied by the United States Federal Reserve to develop his indexes. Examination of annual data reveals large differences between raw stock index returns and currency value adjusted index returns. For example, in 2007, the raw and adjusted annual returns for Dow Jones Industrial Average differed by more than 18 percentage points. He further finds differences in return distributions between raw and adjusted indexes. His results reveal that currency value changes explain up to 8.4 percent of total wealth changes. Jalbert (2014) used a different measure to control for dollar value. The Dollar Index (DXY), used in this paper, is more widely reported and offers certain other advantages over the Broad and Major currency indexes used in his earlier work. The results suggest that currency value changes explain a larger portion of total wealth changes than found in his earlier work.

Jalbert (2015a) examines tick-by-tick trading data. He identifies deviations from symmetry among intra tick high and low values. Using this data, dollar index changes explain as much as 15.41 percent of wealth changes. Jalbert (2015b) also examined tick by tick data using cointegration and Granger causality techniques. The results indicate bidirectional cointegration between the matched index pairs.

Hammes and Willis (2005) contend that gold provides a better measure of asset value then currencies. To that end, Jalbert (2017) uses gold as a metric for currency value. He adjusts eight U.S. stock indexes to reflect their gold adjusted values. The results reveal that annual returns of paired raw and adjusted indexes differ by more than 15 percent in more than 65 percent of the years examined and reach differences as high as 32 percent.

DATA AND METHODOLOGY

Basket equivalent index creation requires three pieces of information, the original stock index, the exchange rate between the U.S. dollar and the underlying stock index currency and the DXY. This paper uses data available from EOD data. The analysis uses data for the Dow Jones Industrial average and seven international stock indexes. Collected data includes exchange rates for the U.S. dollar relative to the corresponding international stock index currency. Finally, the data includes the DXY which indicates the U.S. dollar value compared to a basket of six currencies. The daily data starts as early as January 1, 1993, with the exact date depending upon data availability for each index and currency. The data extends through August 1, 2016. Table 1 presents specific time coverage for each index, currency pair and the dollar index.

Table 1. Summary Statistics

Country	Index	Index Symbol	Currency	Currency Pair	Currency Symbol	First Date in Analysis
Japan	Nikkei 225	NI225	Japanese Yen	Dollar/Yen	USDJPY	Jan 1, 1993
China	Shanghai Composite	SSEC	Chinese Yuan Renminbi	US Dollar / Yuan Renminbi	USDCNY	Dec. 2, 1994
Brazil	Bovespa	BVSP	Brazilian Real	US Dollar / Brazil Real	USDBRL	Dec 1, 1994
UK	FTSE 100	FTSE	British Pound	US Dollar / Pound Sterling	USDGBP	Jan. 1, 1993
Germany	Frankfurt DAX	DAX	Euro	US Dollar / Euro Dollar	USDEUR	Dec. 10, 1996
Korea	Seoul Composite	KS11	South Korean Won	US Dollar / Korean Won	USDKRW	Nov. 21, 1994
USA	Dow Jones Industrial	DJI	U.S. Dollar			Jan. 1, 1993
India	BSE 30 India	BSESN	Indian Rupee	US Dollar / Indian Rupee	USDINR	Sept. 8, 1994

This table shows summary data of the sample.

This paper compares international stock indexes based on a common currency. No known index exists to compare the underlying currencies of non-U.S. indexes to a common basket of currencies. Thus, creation of the indices requires a two-step process. The first step involves converting each original international index, *Original Index,* at each time *t,* to a U.S. dollar equivalent index, *DEI,* using Equation 1:

$$DEI_t = \frac{Original\ Index_t}{USD\ to\ Foreign\ Currency\ Exchange\ Rate_t} \quad (1)$$

The second step adjusts the dollar equivalent index to reflect U.S. dollar purchasing power changes. Equation 2 shows the computations for this basket equivalent index, *BEI,* at each time *t*:

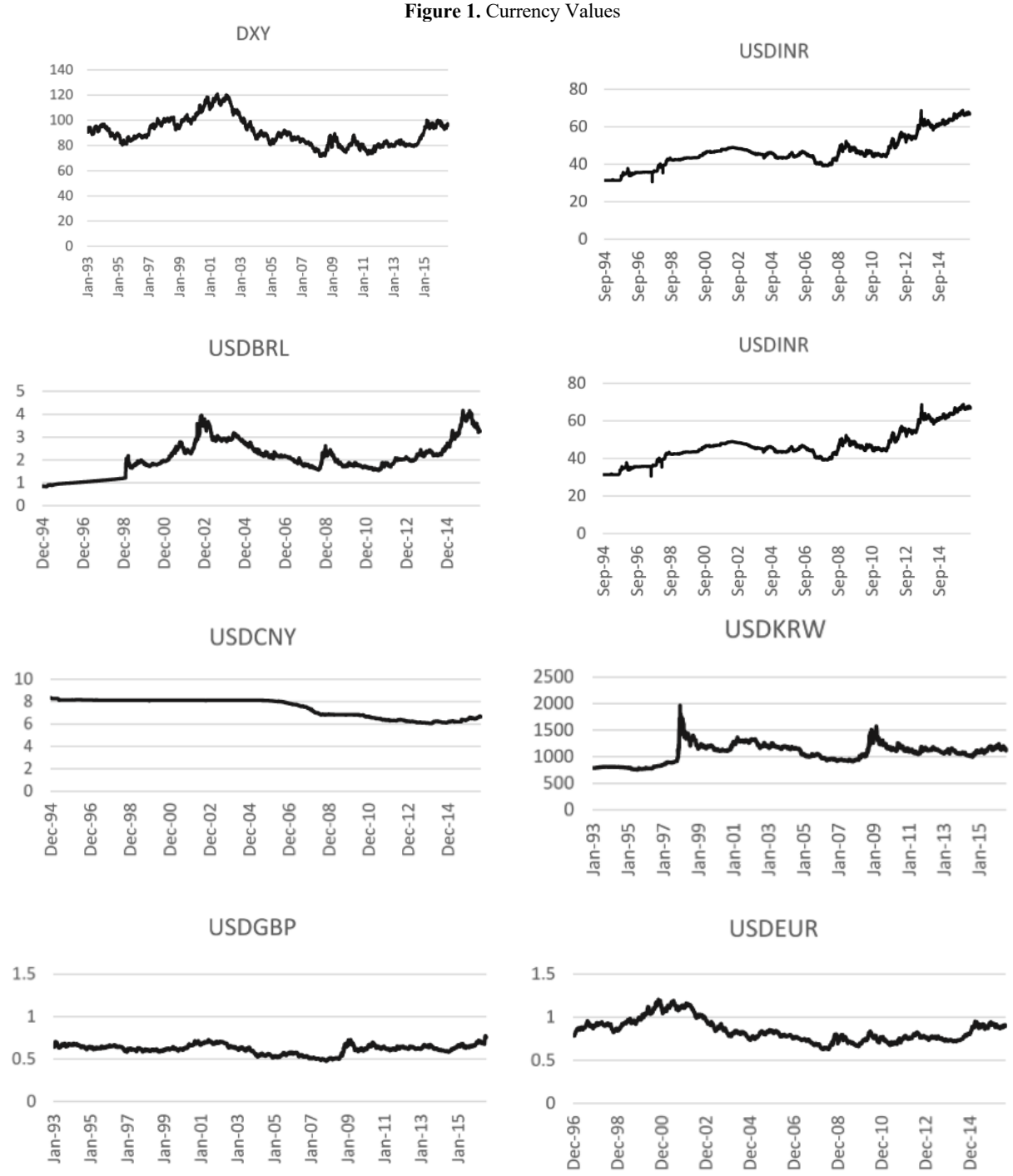
$$BEI_t = DEI_t * \frac{DXY_t}{100} \quad (2)$$

The process involves completing these computations for each trading day, for each index examined. The BEI value places all indexes on a common currency footing, allowing direct comparison of index performance.

For some indexes, the BEI value dramatically differed from the original index. To facilitate comparability, it was necessary to transform some BEI. The transformation involved multiplying each BEI daily value for the Seoul Composite index, Nikkei 225, BSE 30 India, and Shanghai Composite indexes by factors of 1,000, 100, 100 and 10 respectively. These transformations place the original and BEI indexes at an approximately equal starting mean. This paper utilizes these transformed BEI figures for the remainder of the analysis.

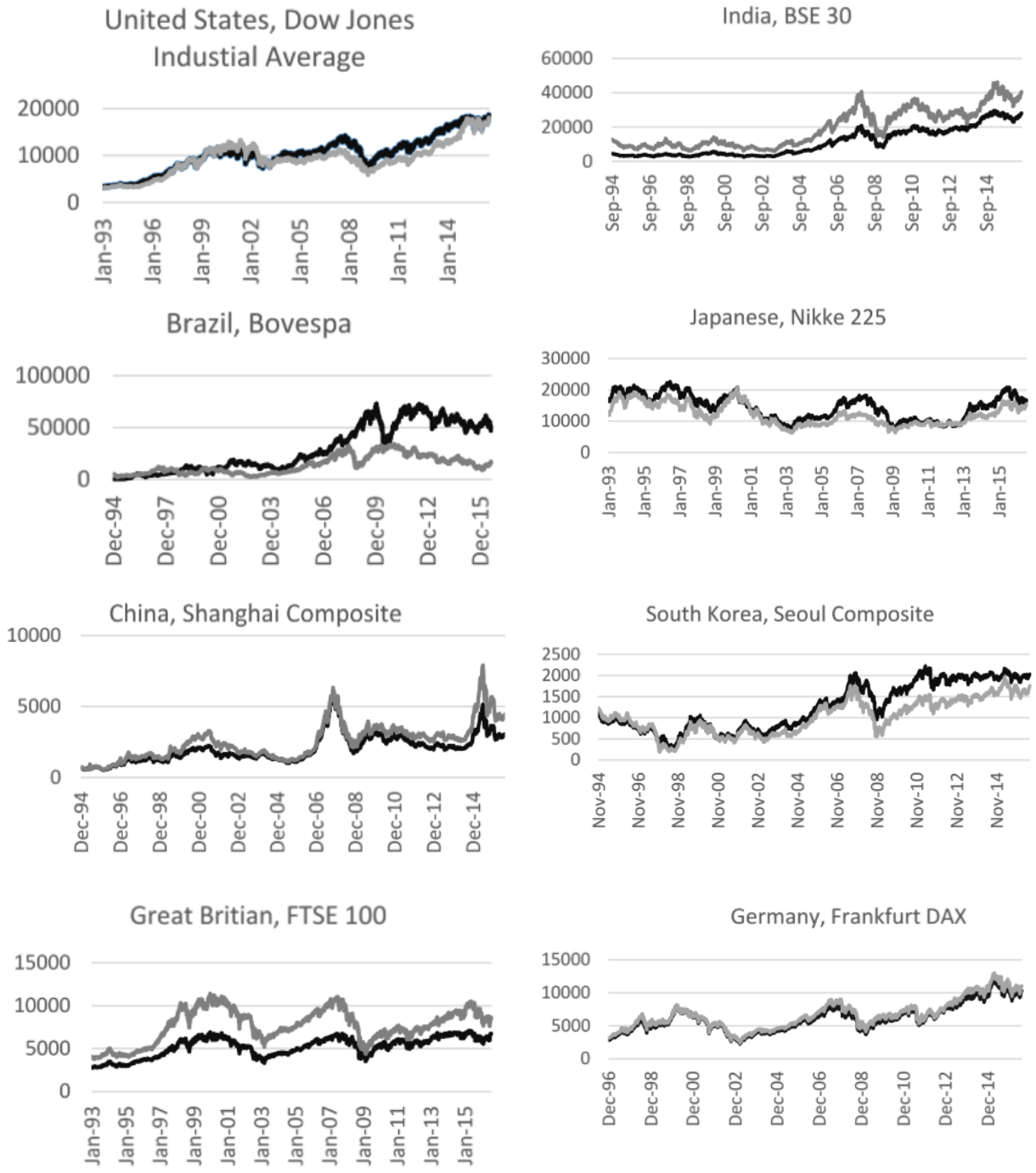
Figure 1 shows graphs of the DXY index and the currency values. Figure 2 shows the paired original and basket of currency adjusted indexes. Table 2 shows original and BEI levels on the close of trading for each year.

Figure 1. Currency Values



DXY signifies the Dollar Index.
USDINR signifies the U.S. Dollar to Indian Rupee exchange rate.
USDBRL signifies the US Dollar to Brazil Real exchange rate.
USDJPY signifies the U.S. Dollar to Japanese Yen exchange rate.
USDCNY signifies the U.S. Dollar to Chinese Yuan exchange rate.
USDKRW signifies the U.S. Dollar to Korean Won exchange rate.
USDGPB signifies the U.S. Dollar to British Pound exchange rate.
USDEUR signifies the U.S. Dollar to Euro Dollar exchange rate.

Figure 2. Original and Benchmark Adjusted Stock Indexes



This figure shows the time progression of original and currency basked adjusted indexes. The darker line in each figure is the original index. The lighter line depicts the currency basket equivalent index.

Table 2. Index Levels and Adjusted Index Levels

DATE	DXY	BSESN	beBSESN	DJI	beDJI	BVSP	beBVSP	DAX	beDAX
Data Start	92.36	4,550.9	12,873.2	3,301.1	3,048.9	4,652.3	4,884.915	2,891	3,237.131
30-Dec-93	96.84			3,754.1	3,635.5				
30-Dec-94	88.73	3,926.9	11,110.8	3,834.4	3,402.3	4,353.9	4,561.6		
29-Dec-95	84.76	3,110.5	7,522.0	5,117.1	4,337.3	4,299	3,749.0		
31-Dec-96	88.12	3,085.2	7,594.1	6,448.3	5,682.2	7,039.9	5,971.3	2,888.7	3,243.5
31-Dec-97	99.65	3,659.0	9,325.3	7,908.2	7,880.6	10,197.0	9,104.3	4,224.3	4,601.1
31-Dec-98	94.17	3,055.4	6,782.8	9,181.4	8,646.2	6,784.0	5,287.2	5,002.4	5,559.7
31-Dec-99	101.87	5,005.8	11,739.0	11,497.1	11,712.1	17,092.0	9,708.2	6,958.1	7,164.2
29-Dec-00	109.56	3,972.1	9,334.7	10,788.0	11,819.3	15,259.0	8,573.2	6,433.6	6,644.0
31-Dec-01	116.82	3,262.3	7,910.0	10,021.6	11,707.2	13,578.0	6,865.1	5,160.1	5,366.4
31-Dec-02	101.85	3,377.3	7,172.1	8,341.6	8,496.0	11,268.0	3,241.9	2,892.6	3,093.1
31-Dec-03	86.92	5,839.0	11,144.5	10,453.9	9,086.5	22,236.0	6,699.3	3,965.2	4,342.9
31-Dec-04	80.85	6,602.7	12,322.9	10,783.0	8,718.1	26,196.0	7,974.2	4,256.1	4,665.8
30-Dec-05	91.17	9,397.9	19,048.7	10,717.5	9,771.1	33,455.9	13,060.1	5,408.3	5,844.2
29-Dec-06	83.72	13,786.9	26,078.6	12,463.2	10,434.1	44,440.2	17,414.1	6,596.9	7,290.0
31-Dec-07	76.69	20,287.0	39,482.5	13,264.8	10,172.8	63,644.9	27,482.7	8,067.3	9,025.3
31-Dec-08	81.15	9,647.3	16,166.8	8,776.4	7,122.0	37,550.3	13,066.9	4,810.2	5,454.1
31-Dec-09	77.86	17,464.8	29,143.0	10,428.1	8,119.3	68,588.4	30,691.3	5,957.4	6,644.4
31-Dec-10	79.00	20,509.1	36,311.3	11,577.5	9,146.2	69,304.8	32,994.3	6,914.2	7,315.1
30-Dec-11	80.23	15,454.9	23,361.2	12,217.6	9,802.1	56,754.1	24,462.1	5,898.4	6,133.0
31-Dec-12	79.77	19426.7	28,242.9	13,104.1	10,453.2	60,952.0	23,732.8	7,612.4	8,013.2
31-Dec-13	80.15	21170.7	27,438.9	16,576.7	13,286.2	51,507.2	17,498.0	9,552.2	10,531.0
31-Dec-14	90.27	27499.4	39,335.5	17,983.1	16,233.3	50,007.4	17,007.6	9,805.6	10,709.6
31-Dec-15	98.63	26117.5	38,940.7	17,425.0	17,186.3	43,350.0	10,806.3	10,743.0	11,504.7
01-Aug-16	95.75	28003.1	40,168.1	18,404.5	17,622.3	56,755.8	16,680.1	10,330.5	11,044.5

DATE	FTSE	beFTSE	KS11	beKS11	NI225	beNI225	SSEC	beSSEC
Data Start	2,846.5	3,960.6	1,117.1	1,241.5	16,925.0	12,530.6	677.91	728.1557
30-Dec-93	3,418.4	4,889.8			17,417.0	15,082.4		
30-Dec-94	3,065.5	4,262.7	1,027.4	1,156.2	19,723.0	17,551.1	647.9	694.5
29-Dec-95	3,689.3	4,851.2	882.9	964.8	19,868.0	16,276.9	555.3	577.4
31-Dec-96	4,118.5	6,224.0	651.2	679.1	19,361.4	14,716.8	917.0	993.7
31-Dec-97	5,135.5	8,444.8	376.3	221.2	15,258.7	11,678.4	1,194.1	1,466.5
31-Dec-98	5,882.6	9,217.4	562.5	439.9	13,842.2	11,446.4	1,146.7	1,331.0
31-Dec-99	6,930.2	11,408.9	1,028.1	921.1	18,934.3	18,876.9	1,366.6	1,715.7
29-Dec-00	6,222.5	10,182.8	504.6	437.2	13,785.7	13,209.4	2,073.5	2,800.4
31-Dec-01	5,217.4	8,870.6	693.7	617.2	10,542.6	9,357.2	1,646.0	2,370.6
31-Dec-02	3,940.4	6,469.9	627.6	539.1	8,579.0	7,356.8	1,357.7	1,704.8
31-Dec-03	4,476.9	6,945.1	810.7	591.2	10,676.6	8,656.0	1,497.0	1,604.3
31-Dec-04	4,814.3	7,473.8	895.9	700.1	11,488.8	9,055.0	1,266.5	1,262.4
30-Dec-05	5,618.8	8,832.2	1,379.4	1,248.8	16,111.4	12,478.8	1,161.2	1,311.7
29-Dec-06	6,220.8	10,201.9	1,434.5	1,291.3	17,225.8	12,123.0	2,675.5	2,869.8
31-Dec-07	6,456.9	9,830.8	1,897.1	1,554.4	15,307.8	10,511.3	5,261.6	5,521.0
31-Dec-08	4,434.2	5,259.2	1,141.0	733.5	8,859.6	7,928.0	1,820.8	2,164.2
31-Dec-09	5,412.9	6,806.3	1,682.8	1,125.7	10,546.4	8,825.3	3,277.1	3,735.6
31-Dec-10	5,899.9	7277.1	2051.0	1,475.0	10,228.9	9,962.0	2,808.1	3,365.5
30-Dec-11	5,572.3	6,942.0	1,825.7	1,263.4	8,455.4	8,826.8	2,199.4	2,797.7
31-Dec-12	5,897.8	7,642.4	1,997.0	1,499.1	10,395.2	9,563.8	2,269.1	2,905.3
31-Dec-13	6,747.8	8,963.2	2,011.3	1,528.5	16,291.3	12,404.9	2,116.0	2,800.9
31-Dec-14	6,566.0	9,233.8	1,915.6	1,582.6	17,450.8	13,164.0	3,234.7	4,705.5
31-Dec-15	6,262.9	9,104.1	1,961.3	1,661.4	19,033.7	15,606.5	3,539.2	5,377.0
1-Aug-16	6,694.0	8,450.2	2,029.6	1,756.8	16,635.8	15,567.9	2,953.4	4,257.9

This table shows close of year index levels. DXY indicates Dollar Index levels. The remaining columns without prefix, and with 'be' prefix show original and basket equivalent index levels respectively. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

Continuously compounded returns provide additional insights into the data. Consider an index having level IL_t at some time point and has level IL_{t-1} one period earlier. Then the continuously compounded return, R_t, equals:

$$R_t = ln\frac{IL_t}{IL_{t-1}} \quad (3)$$

I calculated continuously compounded close-of-day returns for each index series based. I also calculated annual returns based on close of year index levels.

Table 3 shows annual returns for each original and basket equivalent index. The average difference between original and BEI annual returns ranges from 2.05 percent for the DAX to 13.68 percent for the BVSP. The largest single year difference between original and BEI annual returns occurred for the KS11 index at 57.32 percent in 1997. The smallest single year difference occurred for the BSESN index at 0.03 percent in 1994. Overall, the evidence indicates clear return differences between original index returns and BEI returns.

The analysis continues with an examination of index changes. Of interest is the extent to which original and BEIs have sign congruence on any given day. Sign agreement occurs when both indexes produced a positive daily change, or both indexes produced a negative daily change. Sign disagreement occurs when one index produced a positive daily change, but the other produced a negative daily change. The results in Table 4 reveal substantial elements of disagreement. The Dow Jones Industrial Average produced the largest degree of disagreement, with 16.89 percent of all daily observations resulting in sign disagreement. The DAX index produced the least amount of disagreement at only 6.54 percent of observations producing opposite signs.

Currency value adjusting indices might increase or decrease variation in index levels. The analysis continues by providing an examination of index variation as reported in Table 5. Data shows the original and BEIs produce different means. As a result, a direct comparison of variances produces meaningless results. To adjust for different means, this paper uses the coefficient of variation, *CV,* to compare index variances. The coefficient of variation indicates the amount of variance produced per united of mean as specified by Equation 4:

$$CV = \frac{Standard\ Deviation}{Mean} \quad (4)$$

Panel A shows the daily index level results. A higher (lower) BEI coefficient of variation indicates that currency adjusting the indexes increases (decreases) variation. The data produces mixed results. Currency adjusting increased the coefficient for five indexes and decreased the CV for three indexes. The largest change occurred for the BSESN index. For the BSESN, the original CV equals 0.3138, but the corresponding BEI equals 0.5746. The difference of 0.2608 equals 83 percent of the original index CV. Thus, currency adjusting this index nearly doubled the CV. Panel B shows results for the annual data. Results show that the index adjustment process increased the CV for three indexes but decreased the CV for five indexes. Overall, the data produces mixed results for the index level examination.

Table 3. Annual Returns

YEAR	DXY	BSESN	beBSESN	DJI	beDJI	BVSP	beBVSP	DAX	beDAX
1993	0.0474			0.1286	0.1760				
1994	-0.0875	-0.1475	-0.1472	0.0212	-0.0663	-0.0663	-0.0686		
1995	-0.0458	-0.2331	-0.3901	0.2886	0.2428	-0.0127	-0.1961		
1996	0.0389	-0.0082	0.0095	0.2312	0.2701	0.4932	0.4655	-0.0008	0.0020
1997	0.1230	0.1706	0.2054	0.2041	0.3271	0.3705	0.4218	0.3800	0.3496
1998	-0.0566	-0.1803	-0.3183	0.1493	0.0927	-0.4075	-0.5435	0.1691	0.1893
1999	0.0786	0.4937	0.5485	0.2249	0.3035	0.9240	0.6077	0.3300	0.2535
2000	0.0728	-0.2313	-0.2292	-0.0637	0.0091	-0.1134	-0.1243	-0.0784	-0.0754
2001	0.0642	-0.1969	-0.1656	-0.0737	-0.0095	-0.1167	-0.2222	-0.2206	-0.2136
2002	-0.1371	0.0346	-0.0979	-0.1835	-0.3206	-0.1865	-0.7503	-0.5788	-0.5510
2003	-0.1585	0.5475	0.4407	0.2257	0.0672	0.6797	0.7258	0.3154	0.3394
2004	-0.0724	0.1229	0.1005	0.0310	-0.0414	0.1639	0.1742	0.0708	0.0717
2005	0.1201	0.3530	0.4355	-0.0061	0.1140	0.2446	0.4933	0.2396	0.2252
2006	-0.0852	0.3832	0.3141	0.1509	0.0657	0.2839	0.2877	0.1987	0.2211
2007	-0.0877	0.3863	0.4147	0.0623	-0.0254	0.3592	0.4563	0.2012	0.2135
2008	0.0565	-0.7433	-0.8929	-0.4131	-0.3565	-0.5276	-0.7435	-0.5171	-0.5037
2009	-0.0414	0.5935	0.5893	0.1724	0.1310	0.6024	0.8539	0.2139	0.1974
2010	0.0145	0.1607	0.2199	0.1046	0.1191	0.0104	0.0724	0.1489	0.0962
2011	0.0154	-0.2829	-0.4411	0.0538	0.0693	-0.1998	-0.2992	-0.1589	-0.1763
2012	-0.0058	0.2287	0.1898	0.0701	0.0643	0.0714	-0.0303	0.2551	0.2674
2013	0.0048	0.0860	-0.0289	0.2351	0.2398	-0.1684	-0.3048	0.2270	0.2732
2014	0.1189	0.2615	0.3602	0.0814	0.2003	-0.0295	-0.0284	0.0262	0.0168
2015	0.0886	-0.0516	-0.0101	-0.0315	0.0570	-0.1429	-0.4535	0.0913	0.0716
2016	-0.0296	0.0697	0.0310	0.0547	0.0251	0.2695	0.4341	-0.0392	-0.0408

YEAR	FTSE	beFTSE	KS11	beKS11	NI225	beNI225	SSEC	beSSEC
1993	0.1831	0.2108			0.0287	0.1854		
1994	-0.1090	-0.1372	-0.0837	-0.0711	0.1243	0.1516	-0.0453	-0.0473
1995	0.1852	0.1293	-0.1515	-0.1810	0.0073	-0.0754	-0.1542	-0.1846
1996	0.1101	0.2492	-0.3044	-0.3511	-0.0258	-0.1008	0.5016	0.5428
1997	0.2207	0.3051	-0.5484	-1.1216	-0.2381	-0.2312	0.2640	0.3892
1998	0.1358	0.0875	0.4019	0.6874	-0.0974	-0.0201	-0.0405	-0.0969
1999	0.1639	0.2133	0.6031	0.7390	0.3133	0.5003	0.1754	0.2539
2000	-0.1077	-0.1137	-0.7116	-0.7451	-0.3173	-0.3570	0.4169	0.4899
2001	-0.1762	-0.1380	0.3182	0.3448	-0.2682	-0.3448	-0.2309	-0.1666
2002	-0.2807	-0.3156	-0.1002	-0.1352	-0.2061	-0.2405	-0.1926	-0.3297
2003	0.1276	0.0709	0.2561	0.0921	0.2187	0.1626	0.0977	-0.0608
2004	0.0727	0.0734	0.0999	0.1691	0.0733	0.0451	-0.1672	-0.2396
2005	0.1545	0.1670	0.4315	0.5788	0.3382	0.3207	-0.0869	0.0382
2006	0.1018	0.1442	0.0392	0.0335	0.0669	-0.0289	0.8348	0.7829
2007	0.0373	-0.0370	0.2796	0.1854	-0.1180	-0.1427	0.6763	0.6543
2008	-0.3758	-0.6256	-0.5084	-0.7510	-0.5469	-0.2820	-1.0611	-0.9365
2009	0.1994	0.2579	0.3885	0.4284	0.1743	0.1072	0.5877	0.5459
2010	0.0862	0.0669	0.1979	0.2702	-0.0306	0.1212	-0.1545	-0.1043
2011	-0.0571	-0.0471	-0.1163	-0.1548	-0.1904	-0.1210	-0.2443	-0.1848
2012	0.0568	0.0961	0.0897	0.1711	0.2065	0.0802	0.0312	0.0377
2013	0.1346	0.1594	0.0071	0.0194	0.4493	0.2601	-0.0699	-0.0366
2014	-0.0273	0.0298	-0.0488	0.0348	0.0688	0.0594	0.4244	0.5188
2015	-0.0473	-0.0142	0.0236	0.0486	0.0868	0.1702	0.0900	0.1334
2016	0.0666	-0.0745	0.0342	0.0558	-0.1347	-0.0025	-0.1809	-0.2333

This table shows annual index returns for each trading year from 1993-2015 and the partial year ending June 12, 2015.DXY indicates Dollar Index returns. The original index is expressed without a prefix. The prefix 'be' indicates basket equivalent index. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

Table 4. Daily Change Analysis

Index	Observations	Sign Agreement	Sign Disagreement	Percentage Agreement	Percent Disagreement
BSESN	5,712	4,921	791	86.15	13.85
Dow Jones Industrial	6,151	5,112	1,039	83.11	16.89
BVSP	5,652	4,834	818	85.53	14.47
DAX	5,124	4,789	335	93.46	6.54
FTSE	6,151	5,253	898	85.40	14.6
KS11	5,660	4,807	853	84.93	15.07
NI225	6,151	5,139	1,012	83.55	16.45
SSEC	5,651	4,815	836	85.21	14.79

This table shows daily return statistics. Sign Agreement indicates the number of daily observations when the original and adjusted indices both have positive, or both have negative returns. Sign Disagreement equals the number of daily observations where the original and adjusted daily returns have opposite signs. Percentage Agreement indicates the percentage of daily observations where original and adjusted indexes have equal signs. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

Table 5. Variance Analysis for Index Levels

Panel A: Daily Data

Index	Nobs.	Original Mean	Original STD	Original Coefficient of Variation	Basket Equivalent Mean	Basket Equivalent STD	Basket Equivalent Coefficient of Variation
BSESN	5,826	25,577.4	8,026.4	0.3138	19,228.7	11,066.0	0.5746
DJI	6,152	10,344.5	3,766.7	0.3641	9,307.2	3,423.5	0.3678
BVSP	6,070	31,023.8	22,680.9	0.7311	13,986.5	8,765.2	0.6267
DAX	6,152	5,524.3	2,438.7	0.4415	6,670.1	2,249.0	0.3372
FTSE	6,152	5,201.7	1,154.2	0.2219	7,653.9	1,949.8	0.2548
KS11	5,661	1,254.0	563.4	0.4493	1,019.9	411.0	0.4038
NI225	6,152	14,472.9	3,975.4	0.2747	12,170.1	3,334.2	0.2740
SSEC	6,152	1,933.5	1,001.1	0.5178	2,511.0	1281.3	0.5103
DXY	6,152	90.56	11.02	0.1217			

Panel B: Annual Data

Index	Nobs.	Original Mean	Original STD	Coefficient of Variation	Basket Equivalent Mean	Basket Equivalent STD	Basket Equivalent Coefficient of Variation
BSESN	24	11,592.2	8,819.9	0.7608	19,939.6	12,183.0	0.6110
DJI	25	10,574.7	4,234.2	0.4004	9,500.9	3,923.8	0.4130
BVSP	24	32,469.4	23,055.8	0.7101	13,396.5	8,881.9	0.6630
DAX	22	6,198.6	2,385.2	0.3848	6,701.2	2,559.1	0.3819
FTSE	25	5,261.7	1,217.3	0.2313	7,669.8	2,003.4	0.2612
KS11	24	1,271.0	580.2	0.4566	1,051.2	451.9	0.4299
NI225	25	14,517.8	3,854.0	0.2655	12,110.3	3,162.7	0.2612
SSEC	24	1,985.9	1,122.6	0.5653	2,460.9	1,446.0	0.5878
DXY	25	90.28	10.49	0.1162			

This table provides variance analysis for index levels. The column labeled Nobs show the number of observations in the sample. The Original Mean and Original STD columns indicate the mean and standard deviation for the original indexes. The Original Coefficient of Variation equals the Coefficient for the unadjusted series. The column. Adjusted Mean, Adjusted STD and Basket Equivalent Coefficient of Variation indicate values for the basket equivalent series. DXY indicates Dollar Index returns. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

Return data provides additional insights into the effect of currency adjustments on index variance. Table 6, Panel A presents the daily return data results. For seven of the eight indexes, the currency adjustment process increased the CV. The largest increase resulted for the BVSP with a 145 percent increase over the original CV. The original index had a CV of 47.64 but the basket equivalent index had a CV of 116.57. Nikkei 225 (NK225) results are not particularly meaningful because of a negative original index mean. Table 6, Panel B provides annual data results. In six of eight cases the currency adjustment process increased return CV. The largest CV increase occurred for the basket equivalent Seoul Composite Index with an increase of 134 percent over the original index.

Combined, the index level and return variance examination results point to substantial differences between original and BEIs. This finding has important implications for asset pricing models based on stock indexes. New tests of asset pricing models based on currency equivalent indexes may resolve asset pricing model anomalies.

Table 6. Variance Analysis for Index Returns

Panel A: Daily Data

Index	Obs.	Original Mean	Original STD	Original Coefficient of Variation	Basket Equivalent Mean	Basket Equivalent STD	Basket Equivalent Coefficient of Variation
BSESN	5712	0.0003	0.0151	47.6321	0.0002	0.0174	87.42
DJI	6151	0.0003	0.0111	40.9649	0.0003	0.0120	42.3215
BVSP	5652	0.0004	0.0211	47.6392	0.0002	0.0253	116.5686
DAX	5124	0.0002	0.0153	61.4189	0.0002	0.0155	64.6112
FTSE	6151	0.0001	0.0115	88.4806	0.0001	0.0124	106.9579
KS11	5660	0.0001	0.0172	163.0097	0.0001	0.0220	358.2240
NI225	6151	-0.0001	0.0149	-471.4905	-0.0001	0.0158	-688.2736
SSEC	5651	0.0002	0.0176	67.6270	0.0003	0.0183	55.5139
DXY	6151	0.0001	0.0051	380.7225			

Panel B: Annual Data

Index	Obs.	Original Mean	Original STD	Original Coefficient of Variation	Basket Equivalent Mean	Basket Equivalent STD	Basket Equivalent Coefficient of Variation
BSESN	23	0.079	0.3172	4.015	0.0495	0.3613	7.3020
DJI	24	0.0716	0.3613	2.1636	0.0731	0.1672	2.2869
BVSP	23	0.1088	0.3543	3.2575	0.0534	0.2507	4.2902
DAX	21	0.0606	0.2573	4.2428	0.0584	0.2507	4.2902
FTSE	24	0.0356	0.1553	4.3578	0.0316	0.2045	6.4778
KS11	23	0.0260	0.3280	12.6335	0.0151	0.4479	29.6720
NI225	24	-0.0007	0.2307	-321.2050	0.0090	0.2146	23.7281
SSEC	23	0.06399	0.4006	6.2608	0.0768	0.3969	5.1687
DXY	24	0.0015	0.0819	54.5151			

This table provides variance analysis for index returns. The column labeled Nobs indicates the number of observations in the sample. The Original Mean and Original STD columns indicate the mean and standard deviation for the original indexes. The Original Coefficient of Variation equals the coefficient for the original series. The column, Basket Equivalent Mean, Basket Equivalent STD and Basket Equivalent Coefficient of Variation indicate values for the currency value adjusted series. DXY indicates Dollar Index returns. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

The analysis moves on to correlation analysis. Table 7 shows correlation levels between original and basket equivalent indexes. The columns provide correlation analysis for level, change and return series respectively. As expected, the data indicates high and significant Pearson's Correlation Coefficient. With the exception of the Seoul Composite Index, all correlations exceed 0.90.

The paper proceeds by examining return distribution statistics. Table 8 shows the sample return statistics. Panel A presents results for the original indexes. Panel B presents results for the Basket Equivalent indexes. Some interesting results appear. Results indicate skewness direction agreement for seven of eight indexes. Skewness direction differs for the BSESN index. The original BSESN index possesses negative skewness, however, the basket equivalent index reveals positive skewness. Fifteen of sixteen tests reject the null hypotheses of a normal distribution. However, the Seoul Composite index fails to reject the null hypothesis of a normal distribution. The finding of non-normal stock index return distributions has been previously document in the literature by numerous authors including Hora and Jalbert (2006). The results here confirm that currency value adjusting indexes does not result in normal return distributions.

Table 7. Daily Correlation Analysis

Correlation between Original and Adjusted Indexes			
	Level Correlation	**Change Correlation**	**Returns Correlation**
BSESN	0.9784 0.0001***	0.9253 0.0001***	0.9193 0.0001***
DJI	0.9362 0.0001***	0.8838 0.0001***	0.9016 0.0001***
BVSP	0.9452 0.0001***	0.8953 0.0001***	0.9148 0.0001***
DAX	0.9962 0.0001***	0.9841 0.0001***	0.9850 0.0001***
FTSE	0.9020 0.0001***	0.9296 0.0001***	0.9337 0.0001***
KS11	0.9473 0.0001***	0.8965 0.0001***	0.8985 0.0001***
NI225	0.9241 0.0001***	0.9030 0.0001***	0.9083 0.0001***
SSEC	0.9538 0.0001***	0.9483 0.0001***	0.9590 0.0001***

This table shows correlation analysis between original indices and basket equivalent indices. Correlation calculations were completed from daily data. The first figure in each cell equals the Pearson's correlation level. The second figure in each cell is the correlation significance. *** and ** indicate significance at the 1 and 5 percent levels respectively. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

Table 8. Return Distribution Statistics

Panel A: Original Index Distribution

Index	Mean	Std. Dev.	Skewness	Kurtosis	Normality
BSESN	0.000344	0.0151	-0.1187	6.4515	12.0258***
DJI	0.000280	0.0108	-0.1726	8.6037	18.1051***
BVSP	0.001277	0.0226	0.5264	10.8252	15.1853***
DAX	0.000309	0.0144	-0.1051	4.2667	12.4159***
FTSE	0.000139	0.1127	-0.1647	6.1749	13.2108***
KS11	0.000106	0.0172	-0.2044	5.7657	22.4197***
NI225	-0.000028	0.0147	-0.2737	5.8683	11.0696***
SSEC	0.000216	0.0206	0.9138	20.1272	35.0620***

Panel B: Basket Equivalent Index Distribution

Index	Mean	Std. Dev.	Skewness	Kurtosis	Normality
BSESN	0.000199	0.01742	0.02937	7.8348	8.4854***
DJI	-0.000071	0.02579	-55.1145	3840.7875	133.267***
BVSP	0.000217	0.02533	0.0093	6.8876	10.4367***
DAX	0.000240	0.01547	-0.1280	4.0014	8.7438***
FTSE	0.000038	0.01386	-8.988	336.4755	23.3129***
KS11	0.000061	0.0220	-0.0447	14.7009	23.9342
NI225	-0.000011	0.0160	-0.9911	20.6975	9.1027***
SSEC	0.000313	0.0183	0.1514	13.7807	15.5837***

This table shows return distribution statistics. Panel A shows the results for the original, unadjusted, indexes. Panel B shows results for the basket equivalent, adjusted indexes. DXY indicates Dollar Index returns. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

To further explore return distribution differences, we conduct three tests of distribution equality. Table 9 shows the results. The t-test for differences in means utilizes the Satterhwaite unequal variance methodology. Seven indexes fail to reject the null hypotheses of no difference in means, suggesting the index scaling approach used to create the indexes was effective. The BVSP index rejects the hypothesis, indicating the scaling approach may not have been effective for this index. The F-test for equality of variances, between each index pair, rejects the null hypotheses of no difference in variance. Finally, the Kolmogrov-Smirnov detects overall distribution differences. The results indicate rejection of overall distribution equality for seven indexes. The DAX index fails to reject distribution equality. Overall, the return

distribution results indicate the paired original and BEIs possess different distributions. This finding suggests further examination of BEI indexes to fully identify the return generating process.

Table 9. Return Distribution Difference Tests

	T-Test	F-Test	Kolmogrov-Smirnov Test
BSESN	-0.48	1.34***	2.0684***
DJI	-0.80	5.68***	2.1347***
BVSP	-2.38**	1.25***	2.3832***
DAX	-0.24	1.15***	1.1833
FTSE	-0.44	1.51***	1.3780**
KS11	-0.12	1.63***	2.7445***
NI225	-0.03	1.19***	1.7814***
SSEC	0.27	1.27***	2.0595***

This table shows the results of distribution difference tests. The T-tests identifies difference in means. The F-test detects differences in variance. The Kolmogrov-Smirnov test identifies overall distribution differences. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

Next, we examine the extent to which each component contributes to explaining variance in the basket equivalent indexes. We do this utilizing ordinary least squares regression. As noted earlier, three components combine to create each BEI: 1.) the original stock index, 2.) the U.S. dollar and original index currency exchange rate, and 3.) the Dollar Index. We complete four regressions to identify the contribution of each element in explaining variations in the BEIs. Consider a BEI, with level *BEIL* at time *t* and an original index with level *OIL* at time *t*. The *BEI* at time *t* is calculated using the U.S. dollar Value DAX at time *t*, original index exchange rate, *ER,* at time *t*, and the Dollar Index, *DI,* at time *t*. Regressions specified by equations 5, 6 and 7 identify the extent to which original index variation, exchange rate variation and dollar index variation, respectively, explain variation in the BEI. The equations suppress the intercept terms to provide better insights. Equation 8 explores the combined ability of these variables to explain variation in the BEI.

$$BEIL_t = \beta_1 OIL_t + \varepsilon \quad (5)$$

$$BEIL_t = \beta_1 ER_t + \varepsilon \quad (6)$$

$$BEIL_t = \beta_1 DI_t + \varepsilon \quad (7)$$

$$BEIL_t = \beta_1 OIL_t + \beta_2 ER_t + \beta_3 DI_t + \varepsilon \quad (8)$$

In an analogous fashion, we explore the extent to which changes the explanatory variables explain changes in the basket equivalent index. Regressions specified by Equations 9-12 examine this relationship.

$$(BEIL_t - BEIL_{t-1}) = \beta_1 (OIL_t - OIL_{t-1}) + \varepsilon \quad (9)$$

$$(BEIL_t - BEIL_{t-1}) = \beta_1 (ER_t - ER_{t-1}) + \varepsilon \quad (10)$$

$$(BEIL_t - BEIL_{t-1}) = \beta_1 (DI_t - DI_{t-1}) + \varepsilon \quad (11)$$

$$(BEIL_t - BEIL_{t-1}) = \beta_1 (OIL_t - OIL_{t-1}) + \beta_2 (ER_t - ER_{t-1}) + \beta_3 (DI_t - DI_{t-1}) + \varepsilon \quad (12)$$

Finally, we use the natural log, *LN,* to examine how returns of the explanatory variables explain returns on the basket equivalent index using Equations 13-15.

$$LN\left(\frac{BEIL_t}{BEIL_{t-1}}\right) = \beta_1 LN\left(\frac{OIL_t}{OIL_{t-1}}\right) + \varepsilon \quad (13)$$

$$LN\left(\frac{BEIL_t}{BEIL_{t-1}}\right) = \beta_1 LN\left(\frac{ER_t}{ER_{t-1}}\right) + \varepsilon \quad (14)$$

$$LN\left(\frac{BEIL_t}{BEIL_{t-1}}\right) = \beta_1 LN\left(\frac{DI_t}{DI_{t-1}}\right) + \varepsilon \quad (15)$$

Table 10 shows the results. One would expect significant coefficients given the methodology used to construct the variables. This is indeed the case. Among all regressions conducted only two coefficients failed to reject the null hypothesis. Moreover, the coefficient levels do not offer a great deal of insight. Thus, I do not report the coefficient levels or significance. However, the R2 statistics provide meaningful insights. Panel A shows results for Equations 5-8 estimations with the indexes in level form. The results show that the original indexes explain at least 96.74 percent of the BEI variance. The exchange and dollar index levels explain at least 61.17 percent of variance. As one would expect the combined variables explain just short of 100 percent of BEI level variance. I do not report DJI exchange rate regression results because the underlying currency for the DJI equals the U.S. Dollar. As a result, exchange rate regressions are not meaningful.

Panel B shows the results for index change regressions estimated using Equations 9-12. The original index explains between 78.11 and 96.85 percent of BEI changes. The DAX index appears to be something of an outlier in this case explaining more variance than other indexes. Changes in the Dollar Index explain a surprisingly small portion of the BEI changes. The most explanatory power occurs for the Dow Jones Industrial average at 17.11 percent. For the BVSP, the results indicate no explanatory power for the Dollar Index. The combined effects show explanatory power between 88.57 percent and 95.95 percent.

Panel C reports return analysis results estimated using equations 13-15. Original index returns explain between 80.72 and 97.02 percent of BEI returns. As for the level and change regressions, the best explanatory power occurs for the DAX index. Exchange rate returns explain between 0.6 percent to 38.4 percent of BEI returns. Dollar index returns explain a small amount of return variation. The best explanatory power lies with the Dow Jones Industrial Average at 16.13 percent. We do not present combined effects results for the return regressions. The combined effects return regressions create linear combinations that cannot be estimated by OLS.

In general, the results suggest the original indexes have prime explanatory power for the BEIs for change and return regressions. As such, the original index is the prime determinant of wealth changes. However, exchange rates make a substantial contribution to overall wealth. Dollar Index levels provide less explanatory power, but nevertheless provides substantial explanatory power for some indexes.

CONCLUDING COMMENTS

This paper is one in a series of papers to examine currency adjusted stock indexes. The existing literature examines only U.S. stock indexes as adjusted for the U.S. dollar purchasing power against a basket of currencies or against gold. I argue here that basket equivalent indexes (BEI) provide a better measure of overall investor wealth changes than standard stock indexes. The paper examines eight international indexes as adjusted for the underlying currency value against a basket of currencies. The paper examines close of trading day data from 1993-2016.

The results indicate substantial differences in level change and return variances between original indexes and BEI. In some instances, the BEI has more than twice the variance per unit of return than original stock indexes. The analysis included several return distribution difference tests. The results show that BEI indexes have significantly different return distributions than original indexes. Regression analysis indicates that original indexes possess more explanatory power than exchange rates or the dollar index for BEI changes or returns. However, for some indexes, the explanatory power of exchange rates and the Dollar Index are substantial and thus should not be ignored. The different index distribution characteristics noted here have implications for investor wealth and for asset pricing models.

This research has limitations. The methodology used to create the variables for analysis, combined with the regression methodology used could result in biased regression estimates. No known method exists to estimate the seriousness of this bias. Future research might address this limitation by utilizing more sophisticated statistical techniques. A second potential limitation lies in using the DXY to establish the basket equivalent index. DXY calculations rely on a base of

only six currencies. A more comprehensive currency index might provide additional insights. We specifically recommend utilizing gold as a currency base in future research.

Table 10. Index Regressions

Panel A: Index Level Regressions

Dependent Variable	Original Index	Exchange Rate	Dollar Index	Combined Effects
BSESN	0.9762	0.8266	0.6859	0.9949
DJI	0.9850	-	0.8839	0.9879
BVSP	0.9674	0.6117	0.6357	0.9928
DAX	0.9992	0.8588	0.8638	0.9999
FTSE	0.9886	0.9210	0.9417	0.9996
KS11	0.9824	0.8017	0.7985	0.9974
NI225	0.9894	0.9263	0.9346	0.9996
SSEC	0.9813	0.7276	0.7678	0.9952

Panel B: Index Change Regressions

Dependent Variable	Original Index	Exchange Rate	Dollar Index	Combined Effects
BSESN	0.8562	0.2205	0.0363	0.9544
DJI	0.7811	-	0.1711	0.9639
BVSP	0.8015	0.2443	0.0000	0.8857
DAX	0.9685	0.0045	0.0001	0.9956
FTSE	0.8641	0.0285	0.0179	0.9796
KS11	0.8038	0.1905	0.0351	0.9084
NI225	0.8154	0.0602	0.0137	0.9769
SSEC	0.8992	0.0118	0.0530	0.9595

Panel C: Index Return Regressions

Dependent Variable	Original Index	Exchange Rate	Dollar Index	
BSESN	0.8451	0.1952	0.0483	
DJI	0.8130	-	0.1613	
BVSP	0.8368	0.3118	0.0087	
DAX	0.9702	0.0068	0.0003	
FTSE	0.8719	0.0368	0.0109	
KS11	0.8072	0.3804	0.0284	
NI225	0.8250	0.0554	0.0162	
SSEC	0.9197	0.0060	0.0663	

This table shows results of index level, change and return regressions. Panel A shows results of regressions original index levels on basket equivalent index levels. Panel B shows results of regressions of original index level changes on basket equivalent index level changes. Panel C shows results of regressions of original index level returns on basket equivalent index returns. The figure in each cell is the coefficient of determination, R2, for each regression. BSESN = BSE 30, DJI = Dow Jones Industrial Average, BVSP = Bovespa. DAX = Frankfurt DAX. FTSE = FTSE 100. KS11 = Seoul Composite. NI225 = Nikkei 225. SSEC = Shanghai Composite.

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