WORKING PAPER SERIES

Constructing and Using National and Regional TWEXS: The Case for Chaining.

Cletus C. Coughlin
Patricia S. Pollard

Working Paper 1998-012A
http://research.stlouisfed.org/wp/1998/1998-012.pdf

PUBLISHED: Journal of Economic and Social Measurement, 1998.

FEDERAL RESERVE BANK OF ST. LOUIS
Research Division
411 Locust Street
St. Louis, MO 63102

CONSTRUCTING AND USING NATIONAL AND REGIONAL TWEXS: THE CASE FOR CHAINING

September 1998

Abstract

The breakdown of the Bretton Woods system of fixed exchange rates spurred the development of trade-weighted exchange rates (TWEXs). These indexes measure changes in the average foreign exchange value of a currency over time. The construction of a TWEX index requires numerous decisions. Producers of TWEXs are revisiting many of their construction decisions because, with the advent of the single currency in Europe, all TWEXs will have to be modified. In addition, countries adopting the single currency may find it useful to develop their own TWEXs, similar to those that exist for regions within the United States. All commonly-used TWEXs are based on either a Laspeyres or Paasche price index. In the present paper we argue that producers of TWEXs should consider using the chain approach for the construction of their indexes because of an issue that affects TWEXs based on either Laspeyres or Paasche price indexes – the choice of base period. We illustrate this problem and show how it leads to different measures of exchange rate changes. A chain index, which links together the exchange rates and trade weights from year-to-year, eliminates the need for a base period.

Keywords: Trade-Weighted Exchange Rates, Chain Indexes

JEL Classifications: F0, R0

Cletus C. Coughlin
Vice President
Federal Reserve Bank of St. Louis
411 Locust Street
St. Louis, MO 63102
coughlin@stls.frb.org

Patricia S. Pollard
Senior Economist
Federal Reserve Bank of St. Louis
411 Locust Street
St. Louis, MO 63102
pollard@stls.frb.org

Prepared for the June 1998 Workshop on Regional Economic Indicator Models, Braga, Portugal. We would like to thank Richard Sprinkle for providing crucial data. Eran Segev and Heidi Beyer provided research assistance.

Constructing and Using National and Regional TWEXs: The Case for Chaining

I. INTRODUCTION

The breakdown of the Bretton Woods system of fixed exchange rates spurred the development of trade-weighted exchange rates (TWEXs).[1] These indexes measure changes in the average foreign exchange value of a currency over time. Such changes are frequently used to infer how the international competitiveness of a country's production has changed. TWEXs, often expressed in real terms, are also used in studies analyzing the effect of exchange rate changes on a country's trade balance. The persistence of trade imbalances in a flexible exchange-rate environment led to a further use of TWEX indexes: to study the effect of exchange rate changes on traded-goods prices.[2] Finally, since exchange rate changes stimulate changes in production, consumption, and trade, TWEXs are used in forecasting and simulation models.

The construction of a TWEX index requires numerous decisions. Because many of the decisions have more than one defensible alternative, more than one TWEX may be constructed for a particular country or region. For example, a recent paper by Coughlin and Pollard (1996) discusses six TWEXs for the U.S. dollar. A key difference among the various TWEXs is the number of foreign currencies used. For example, ten foreign currencies are used in the index as of mid-1998 produced by the Federal Reserve Board, while the index produced by the Federal Reserve Bank of Dallas comprises 129 foreign currencies.

---

[1] See Hirsch and Higgins (1970) for a seminal discussion of the construction of a TWEX.

[2] See Antzoulatos and Yang (1996) for a recent pass-through study and Menon (1995) for a literature survey.

Producers of TWEXs are revisiting many of their construction decisions because, with the advent of the single currency in Europe, all TWEXs will have to be modified. In addition, countries adopting the single currency may find it useful to develop their own TWEXs, similar to those that exist for regions within the United States.

All commonly-used TWEXs are based on either a Laspeyres or Paasche price index. In the present paper we argue that producers of TWEXs should consider using the chain approach for the construction of their indexes. Our argument for using the chain approach focuses on an issue that affects TWEXs based on either Laspeyres or Paasche price indexes – the choice of base period.

Two interrelated base period decisions are relevant. First, a decision is required as to the base period for the trade weights. Analogous to measuring the growth of gross domestic product by a fixed-base-year method, a major concern with fixed trade weights is that over time the weights are less likely to reflect the prevailing pattern of trade. For example, as U.S. trade patterns shift, fixed trade weights may cause a biased picture of changes in the foreign exchange value of the dollar. On the other hand, if the base period for trade weights is altered, the economic history described by the index is likely to change. An annual updating of the trade weights solves this problem, but does not eliminate the problem associated with the second base period decision.

This second base period decision occurs because, in all TWEXs, changes in the bilateral exchange rates are calculated relative to exchange rates in a reference period. Ideally this reference period should reflect a period of long-run equilibrium in the exchange rates. Given the difficulty of finding such a period, particularly when a large number of currencies are included, the reference period is often chosen because it marks some important event in exchange rate history.[3] For a TWEX with annually updated trade weights, altering the reference period for the exchange rate changes the economic history described by the TWEX.

In the next section we provide an overview of constructing a TWEX. In section III we highlight some recent developments involving regional TWEXs in the United States, as well as the likely implications for constructing TWEXs for European Union countries adopting the euro. In section IV we illustrate the base problem and show how this problem leads to different measures of exchange rate changes. In section V we discuss the chain approach and how it can be implemented. A statement of the major implication of our analysis completes the paper.

II. OVERVIEW OF CONSTRUCTING A TWEX

Constructing a real TWEX requires the following seven decisions: 1) which method to use to calculate the average; 2) which foreign currencies to use in the calculation; 3) which price index to use in converting nominal into real exchange rates; 4) which measure of trade to use to weight the individual currencies; 5) how to calculate the weights for individual currencies; 6) which base period to use for calculating the weights; and 7) which base period to use for calculating exchange rate changes. Of these seven decisions, there is general agreement only on the choice of the method to calculate the average. Because of the bias inherent in an index based on arithmetic averaging, all

[3] For example, the Federal Reserve Bank of Dallas currently uses the first quarter of 1985 as its reference period, while the Federal Reserve Board uses March 1973. The first quarter of 1985 marks the peak of the substantial appreciation of the dollar during the early 1980s, while March 1973 marks the beginning of the floating exchange-rate period.

TWEXs use a geometric averaging technique. Thus, the generic formula for the value of a nominal TWEX index for the U.S. dollar at time t using n foreign currencies is:

$$(1)\ \text{Nominal Index}_t = 100\prod_{i=1}^{n}\left(\frac{e_t^i}{e_b^i}\right)^{w_t^i}$$

where b is the base period for the exchange rates, e^i is the number of units of currency i per dollar, and w^i is the weight assigned to currency i. Similarly, the generic formula for constructing a real TWEX index for the U.S. dollar is:

$$(2)\ \text{Real Index}_t = 100\prod_{i=1}^{n}\left[\left(\frac{e_t^i}{e_b^i}\right)\left(\frac{p_t^{us}/p_t^i}{p_b^{us}/p_b^i}\right)\right]^{w_t^i}$$

where p^{us} is a price index for the United States and p^i is a price index for country i.

The remaining decisions have more than one defensible alternative. Ideally, a dollar TWEX should include the currencies of each of the United States' trading partners. In practice, most indexes use data on the dollar's value relative to the currencies of between 10 and 20 countries, generally concentrating on the principal industrial countries. Two major exceptions are the "broad index" produced by J.P. Morgan, which includes 44 foreign currencies, and the indexes produced by the Federal Reserve Bank of Dallas, which include the currencies of 129 countries in its nominal index and 111 currencies in its real index.

To construct a real TWEX, nominal exchange rates are adjusted for relative inflation rates. A producer price index is generally preferred to a consumer price index as the measure of inflation because the latter includes a much larger percentage of nontradeable goods and services. Consumer price indexes are often used, however, because of the limited availability of producer price indexes.

Once the choice of which currencies to include in the index is made, weights must be assigned to the currencies. Since these exchange rate indexes are weighted by trade flows, an issue is which measure of trade to use. Because of data availability, most indexes are constructed using merchandise trade and do not include service trade, which has increased rapidly in recent years. The indexes produced by J.P. Morgan and the International Monetary Fund are more exclusive, using only trade in manufactures.

A closely related issue involves the selection of the weighting scheme. Ideally, the weights should reflect the responsiveness of a country's trade flows to changes in exchange rates; however, model-based attempts to construct weights have proven to be unreliable and have been, at least temporarily, abandoned. Many other methods remain in use. Three of these methods bilateral, multilateral, and double weights. With bilateral weighting, each country's currency is weighted by its level of total trade flows to and from the United States, relative to the total trade flows between the United States and all the countries included in the index. Thus, the weight for currency *i* is simply the sum of U.S. exports to and imports from country *i*, divided by the sum of U.S. exports to and imports from all the countries included in the index. With multilateral weighting, the currency of each country is weighted by the proportion of its share of total trade flows throughout the entire world. Thus, the weight of currency *i* is the sum of the associated country's worldwide exports and imports divided by the sum of the worldwide exports and imports of all the countries included in the index.

The multilateral weighting approach attempts to capture the competition between two countries in countries outside of their domestic markets; however, this approach might give too much weight to nations that trade more extensively with each other than with the United States. For example, European Union countries that trade extensively with each other might receive higher-than-warranted weights in the construction of a U.S. dollar index, while Canada, the largest U.S. trading partner, might receive a lower-than-warranted weight.

A third weighting method, double weighting, attempts to combine the advantages of the bilateral and multilateral weighting approaches. This method recognizes competition in third markets, as well as the strength of links between particular trading partners.[4] However, this more complicated method cannot be demonstrated superior to either the bilateral or multilateral approaches.

The first of the two base period choices involves the choice of a base period for the trade weights. TWEXs may use fixed weights or weights updated on an annual basis. If fixed weights are used, the producer must decide which year or years to use. For example, the TWEX index produced by the Board of Governors of the Federal Reserve System uses trade data from 1972-74 to determine the weights, while a TWEX index produced by the IMF currently uses 1989-1991 trade data. Fixing the base period for the trade weights means that the index does not incorporate the effect of changing trade patterns. Thus, a changing pattern of trade raises the possibility that a fixed-weight index becomes a less reliable indicator over time. When the trade weights are updated annually, the value of the index in period *t* reflects both the exchange rates and trading patterns relevant for that period.

The exchange rate indexes in equations 1 and 2 calculate changes in the value of the dollar relative to each foreign currency from a base exchange rate, e^i_b.[5] When the weights are updated annually, the calculated percent changes in the value of the TWEX index are sensitive to this reference base period for the exchange rates. If fixed trade weights are used, the base period for exchange rates does not affect the behavior of the index. These two base period issues are examined in more detail in Section IV.

III. REGIONAL TWEXs

TWEX indexes have been used extensively since the early 1970s. As noted above, these indexes are useful for examining the behavior of a currency against a group of currencies. Recently, some researchers have argued that a national TWEX index for the United States may not provide an accurate picture of the effects of changes in the value of the dollar on different regions of the country. Hervey and Strauss (1998) and Clark et al. (forthcoming) assert, despite the fact that exchange rates between a given foreign currency and the dollar are the same throughout the United States, different regions of the country effectively face different trade-weighted exchange rates. The reason for this is that the foreign markets served by different regions of the United States vary. This variation can be attributed to differences in the industrial mix across regions, as well as a region's proximity to particular foreign markets.

Hervey and Strauss (1998) construct TWEXs for eight geographic regions based on aggregations of states by the Bureau of Economic Analysis, as well as a national index for the United States. Their indexes use the exchange rates for 44 foreign currencies

[4] See Turner and Van 't dack (1993) for a general analysis of the double weighting method.

[5] In a real exchange rate index the changes in relative inflation rates are calculated using the same base period as the exchange rate.

relative to the dollar.[6] Trade weights applied to the individual currencies are based on a region's average of the 1993-1994 manufactured goods exports to the 44 countries.[7] Thus, the index is a fixed-weight index. Producer prices are used to translate the nominal exchange rates into real ones. Clark et al. (forthcoming) also construct a fixed-weight index. They construct TWEXs for nine geographic regions based on aggregations of states by the Bureau of the Census, as well as a national index.[8] Their indexes use the currencies of 50 countries relative to the dollar. The share weights for each region's exports are based on 1994 manufactured exports.

In table 1, suggestive evidence on the differences of export markets across regions is presented. For example, comparing the East North Central region with the Pacific region, one sees that 51 percent of the former region's exports were to Canada, while the Pacific region's exports to Canada were only 12 percent of its total. Meanwhile, Japan received 8 percent of the East North Central's exports and 22 percent of the Pacific's exports. For the United States as a whole, 25 percent of exports went to Canada and 12 percent went to Japan. Consequently, a TWEX based on national trade figures would put too little (much) weight on the Canadian dollar/U.S. dollar exchange rate and too much (little) weight on the yen/U.S. dollar exchange rate for the East North Central (Pacific) region.

[6] The currencies are the same as those used in the J.P. Morgan "broad" index.

[7] The lack of import data at the regional level means that the index is an "export-only" bilateral index.

[8] The nine Census regions and the associated states are: New England–Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; Middle Atlantic–New Jersey, New York, and Pennsylvania; East North Central–Illinois, Indiana, Michigan, Ohio, and Wisconsin; West North Central–Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota; South Atlantic–Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia; East South Central–Alabama, Kentucky, Mississippi, and Tennessee; West South Central–Arkansas, Louisiana, Oklahoma, and Texas; Mountain–Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; and Pacific–Alaska, California, Hawaii, Oregon, and Washington.

European TWEXs in a Single Currency Europe

In the near future, at least eleven of the European Union countries will have a common monetary authority and currency. The yen/euro exchange rate will be the same in Portugal as in Germany. Nevertheless, the effects on each country of a change in the value of the yen relative to the euro will depend in part on the trade ties of each with Japan. A euro TWEX that depends on the trading patterns of all the single currency countries will provide information on exchange rate changes relevant for the single currency area as a whole. The extent to which such a TWEX is a useful indicator for an individual country depends on the extent to which that country's trade patterns mimic those of the single currency area as a whole. Differences in industrial mix across these countries, proximity to foreign markets, and ties with former colonies all affect the trading patterns of individual European Union countries.

In table 2 we present evidence on the differences in trading patterns among the eleven prospective members of the European Monetary Union. The table indicates the percentage of the total merchandise trade of each of the eleven countries that is conducted with various regions and countries of the world. The data cover the period 1994-96 and exclude trade among these eleven countries since such trade is irrelevant for a TWEX.

There are many similarities among the trading patterns. Most notably, the most important trading region for all eleven countries with the exception of Austria is the "other EU," the four European Union countries that are not among the initial entrants to the monetary union. There are also some clear differences. Finland, Germany, Italy and particularly Austria have strong trade ties with Eastern Europe, while Ireland and Portugal trade relatively little with this region. At the same time, Portugal conducts nearly 13 percent of its total merchandise trade with Africa, while Ireland conducts less than 2 percent of its merchandise trade with Africa. Spain has the relatively strongest trade ties with the "other Western Hemisphere" region (predominantly Latin America).

A monetary union consisting of all fifteen European Union countries displays even greater variety in its trading patterns, as shown in table 3. For example, Greece conducts nearly 19 percent of its merchandise trade with the Middle East, while Finland and Ireland both conduct less than 4 percent of their trade with that region. Nearly 40 percent of Ireland's merchandise trade is with the United States, while the United States accounts for only 12 percent of Austria's merchandise trade. Furthermore, no longer is there a dominant trading partner. Eastern Europe is the major trading partner for Austria, Finland, Germany, Greece and Italy. The United States is the major trading partner for Belgium, France, Ireland, Spain and the United Kingdom. Norway and Switzerland combined is the major trading partner for Denmark and Sweden. The "other Asia Pacific" is the major trading partner for the Netherlands, while Africa is the major trading partner for Portugal.

IV. THE BASE PROBLEM

TWEX indexes are based on either a Laspeyres or a Paasche price index. A Laspeyres TWEX index uses trade weights for a fixed year, while a Paasche TWEX index uses annually updated weights. With a Laspeyres index, as trade patterns shift over time the weights become less accurate, which may lead producers to update the weights to reflect more recent trade patterns. Updating the weights, however, changes the history described by the index. In addition, while the new weights may be more relevant for recent periods, they are less relevant for previous periods. The following numerical example illustrates these problems.[9]

Consider the interaction among three currencies: A, B and C. Table 4 provides the information required to construct a TWEX index for currency A.[10] Column 2 shows the units of currency B required to purchase a unit of currency A in each of the 14 years listed, and column 4 shows the units of currency C required to purchase a unit of currency A. Columns 3 and 5 list trade shares for country B and country C in each of the 14 years.

If the trade shares in year 2 (.62, .38) are used as the base weights, the trade-weighted value of currency A rises between years 1 and 7 and falls between years 7 and 14, as shown in table 5. If the trade shares in year 12 (.45, .55) are used for the base weights, a similar pattern is observed: currency A appreciates between years 1 and 6 and depreciates between years 6 and 14. However, the magnitudes of the appreciations and depreciations differ substantially across the two constructed indexes. Using year 2 as the base year for the weights the index shows a 43 percent appreciation for currency A between years 1 and 7, while using year 12 as the base year currency A shows only a 20 percent appreciation.[11] Likewise, the former index shows a 22 percent depreciation of currency A between years 7 and 14, while the latter index shows a 44 percent depreciation of currency A. Thus, using year 2 for the base weights, the effective value of currency A is 21 percent *higher* in year 14 than in year 1, while using year 12 for the

[9] The examples in this section can be found, with additional detail, in Coughlin et al. (1998).
[10] For simplicity, we focus on a nominal TWEX index, although the problems are the same in a real index.
[11] All percentage changes in this example are calculated using log changes. To calculate the change over time, such as between years 1 and 7, add the year-over-year changes for years 2 through 7.

base weights, the foreign exchange value of currency A is 24 percent *lower* in year 14 than in year 1.

An important difference between TWEXs based on a Laspeyres formula and a Paasche formula is that in the Paasche-based index the weights vary from year to year.[12] Thus, the value of a Paasche-based index in year t depends on the weights assigned to each currency in year t.

This weighting method eliminates the rewriting of economic history caused by updating the trade weights in a Laspeyres-based index. Before concluding that the Paasche index is the better method for calculating a TWEX, however, we need to consider the choice of the reference base for the bilateral exchange rates.

TWEXs based on either a Laspeyres or a Paasche index require a base period for the bilateral exchange rates. With a Laspeyres index the choice of a reference base period for the exchange rates does not affect the behavior of the index, but the behavior of the Paasche index is sensitive to this choice. These results can be illustrated using the data in table 4. Two Laspeyres and two Paasche indexes are constructed from these data. Both Laspeyres indexes use the trade weights from year 1 (.60, .40), while both Paasche indexes use trade weights that are updated annually. For the illustration, Laspeyres and Paasche indexes are constructed first using the bilateral exchange rates in year 2 as the reference exchange rates. Next, the indexes are recalculated using the bilateral exchange rates in year 12 as the reference exchange rates. Table 6 shows the value of the indexes in each year and their year-to-year percent changes.

---

[12] While TWEX indexes are calculated as frequently as daily, the trade weights are generally updated no more frequently than annually.

First, consider the two Laspeyres indexes. The level of the two indexes in any year differs. However, the index based on the year 2 exchange rates can be rescaled by dividing the value of the index in each year by the value of the index in year 12 and then multiplying by 100. Rescaling in this way creates an index identical to the index based on the year 12 exchange rates. This ability to transform the reference base for the index explains why the year-to-year percent changes in the two Laspeyres indexes are identical.

Next, consider the two Paasche indexes. In this case neither the levels nor the year-to-year changes in the indexes are identical. Both Paasche indexes display a roughly similar pattern over time: currency A appreciates between years 1 and 7 and depreciates between years 7 and 14. However, the magnitudes of the movements in the indexes differ. The index using year 2 as the reference base shows currency A appreciating 51 percent through year 7, while using year 12 as a reference base the appreciation is 30 percent. Between years 7 and 14 the former index shows currency A depreciating 82 percent, while the latter index shows it depreciating only 20 percent. Over the entire period, the effective value of currency A declines 31 percent when calculated using year 2 as the reference base, but rises 10 percent when calculated using year 12 as the reference base.

What explains the different effects of the reference base on the Laspeyres and Paasche indexes? The difference arises from the existence of fixed weights in the Laspeyres index and the varying weights in the Paasche index. While rescaling the Laspeyres index using a year 2 reference base can transform it into an index using year 12 as the reference base, the same cannot be accomplished with the Paasche index.

Because the choice of the reference base year affects the behavior of the Paasche index, it is no longer clear that the Paasche index is a better choice than the Laspeyres index.

An important issue is whether the preceding illustrations are of practical importance. Coughlin et al. (1998) show that the behavior of U.S. TWEXs is sensitive to the base year. For example, a TWEX using a Laspeyres price index produced by the Federal Reserve Bank of Atlanta was examined using every year between 1976 and 1995 as a base year for the trade weights. The resulting TWEXs generated a depreciation of the dollar in nominal terms ranging from 4 to 17 percent between 1976 and 1995. In addition, a TWEX using a Paasche price index produced by the Federal Reserve Bank of Dallas was examined using every year between 1976 and 1995 as a reference base. The resulting TWEXs generated an appreciation of the dollar in nominal terms ranging from 260 to 424 percent between 1976 and 1995. These TWEXs also revealed a nominal appreciation of the dollar between 1984 and 1985 ranging from 11.5 to 20.6 depending on the reference base year. Furthermore, in some cases whether the dollar appreciated or depreciated was affected by the reference base year. For example, the nominal change in the foreign exchange value of the dollar between 1977 and 1978 ranged from a depreciation of 2.2 percent to an appreciation of 6.5 percent.

To explore whether a base problem might exist for a regional TWEX, we use data from Clark et al. (forthcoming). Recall that the Clark et al. index is a fixed weight (Laspeyres) index using 1994 trade weights. We explore the consequences of changing the base year by using 1987 trade weights. If the trade patterns and hence the trade weights of the U.S. regions changed over the period 1987-1994, then this index might give much different views of exchange rate changes for the period of this index.

Table 7 contains information on the foreign destinations of 1987 exports from Census regions. To see how the 1987 trade pattern varies from the 1994 trade pattern, which was presented in table 1, we constructed table 8. Clearly the weights for the regions have changed over time. Only the East North Central region did not have an export market destination with a more than three percentage point change. Especially large shifts occurred in the New England, South Atlantic and West South Central regions. The share of New England exports to Canada increased 11.9 percentage points, while the share of its exports to Europe decreased by 9.3 percentage points. Substantial declines in Europe's share were also experienced by the South Atlantic (12.4 percentage points) and West South Central (10.6 percentage points) regions. The share of exports to Mexico from the West South Central region increased by 15 percentage points. These trade shifts are at best suggestive evidence because bilateral exchange rate changes could have occurred so that using 1987 trade weights yields regional TWEXs very similar to the ones based on 1994 trade weights. Consequently, we recalculate the Clark et al. index using 1987 trade weights and explore statistically the relationship between these two indexes.

Table 9 contains the simple correlations between each regional TWEX using 1987 trade weights and the corresponding regional TWEX using 1994 trade weights. The correlation for the national TWEXs based on both years is also computed. These TWEXs are highly correlated, but for empirical purposes a high correlation is not enough to indicate that the indexes can be viewed as identical. As indicated by an augmented Dickey-Fuller test, none of the regional or national TWEXs are stationary in levels; however, each TWEX is stationary in first-differences. Given the stationarity results, a Johansen test of cointegration was performed. The results, presented in table 10, reveal that not one of the regional indexes is cointegrated. Only the national index is cointegrated. Thus, the use of different weights produces different indexes for a particular region.

A final result, presented in table 11, explores the interchangeability of the indexes using orthogonal least squares. Orthogonal least squares allows an assessment of difference preservation, which requires that two series differ by no more than a constant over time. Slope estimates "close" to one indicate that one TWEX series can be reliably used in lieu of the other series. A chi-square statistic is used for conducting the relevant hypothesis test that the slope is equal to one. Generally speaking, this hypothesis is rejected. As indicated by the lack of statistical significance, the indexes using different years' weights are interchangeable with each other only for the United States and two regions, the West North Central and West South Central regions. For the other seven regional indexes the results indicate that using different weights alters the informational content of the indexes.

V. THE CHAIN SOLUTION

One way to eliminate the base problem for TWEXs is to eliminate the need for a base period. A straightforward solution is to construct a chain index, which links together the exchange rates and trade weights from year-to-year. Chain versions of both Laspeyres and Paasche indexes are possible. The Laspeyres chain uses trade weights from the prior period, while the Paasche chain uses trade weights from the current period. The most appropriate weights for a TWEX are unknown, but a solution is to combine the two by taking their geometric average, constructing what is known as a Fisher chain. The formula for a real TWEX using a Fisher chain approach is:

$$(3)\ Index_t^{FC} = \left[\prod_{i=1}^{n} \left[\left(\frac{e_t^i}{e_{t-1}^i} \right) \left(\frac{p_t^{us} / p_t^i}{p_{t-1}^{us} / p_{t-1}^i} \right) \right]^{w_{it-1} + w_{it}} \right]^{1/2} * Index_{t-1}^{FC}$$

Implementation Issues

The calculation of a chain TWEX at the national level in the United States is not difficult. Coughlin et al. (1998) have already shown that this can be done. In fact, the staff of the Board of Governors of the Federal Reserve System is planning to unveil a set of chain-weighted TWEXs before the end of 1998. Problems arise, however, in implementing a chain solution at the regional level in the United States. The reason is that timely export statistics at the state level did not exist until recently. Consequently, the chain solution can be used to generate TWEXs for a short timespan, but it cannot be used to reconstruct the complete time series that Hervey and Strauss (1998) and Clark et al. (forthcoming) have generated.

Turning to the European Union, the availability of trade data for European Union countries will likely not be a problem. As long as these countries continue to collect trade data at the national level, constructing TWEXs similar to the regional TWEXs in the United States will be possible. Relative to currently constructed TWEXs for U.S. regions, an attractive characteristic is that such TWEXs would likely be constructed using price indexes conforming to the geographic area of the TWEX. This is not possible for TWEXs for U.S. regions because price indexes do not exist that match the regions covered by these TWEXs.

VI. CONCLUSION

A recent development in regional economic analysis in the United States has been the construction of regional TWEXs. These indexes are potentially valuable for examining and forecasting how international activity has affected and is likely to affect regional economic activity. In the near future such indexes will likely be developed for European nations adopting the euro. Our message is straightforward. Due to the base problem associated with TWEXs based on either Laspeyres or Paasche indexes, producers of TWEXs should give serious consideration to using a chain approach.

REFERENCES

Antzoulatos, Angelos A., and Jiawen Yang. 1996. "Exchange Rate Pass-Through in U.S. Manufacturing Industries: A Demand-Side Story," *International Trade Journal*, Vol. 10, No. 3, Fall, 325-52.

Clark, Don P., W. Charles Sawyer, and Richard L. Sprinkle. Forthcoming. "Regional Exchange Rate Indexes for the United States," *Journal of Regional Science*.

Coughlin, Cletus C., and Patricia S. Pollard. 1996. "A Question of Measurement: Is the Dollar Rising or Falling?" Federal Reserve Bank of St. Louis *Review*, Vol. 78, No. 4, July/August, 3-18.

Coughlin, Cletus C., Patricia S. Pollard, and Jerram C. Betts. 1998. "To Chain or Not to Chain Trade-Weighted Exchange Rate Indexes," *International Trade Journal*, Vol. 12, No. 3, Fall, 363-91.

Hervey, Jack L., and William A. Strauss. 1998. "A Regional Export-Weighted Dollar: An Examination of the Regional Impact of Exchange Rate Change," *International Regional Science Review*, Vol. 21, No. 1, 79-98.

Hirsch, Fred, and Isle Higgins. 1970. "An Indicator of Effective Exchange Rates," *IMF Staff Papers*, Vol. 17, No. 1, March, 453-87.

Menon, Jayant. 1995. "Exchange Rate Pass-Through," *Journal of Economic Surveys*, Vol. 9, No. 2, June, 197-232.

Turner, Philip, and Jozef Van 't dack. 1993. "Measuring International Price and Cost Competitiveness," *BIS Economic Papers*, November.

Table 1 Foreign Destination of Regional Exports 1994 (Percentage Shares)								
Region of the United States	Trading Partner							
	Canada	Japan	Mexico	Europe	Africa	Rest of America	Oceania	Asia
East North Central	50.8	8.0	5.9	19.9	0.9	4.7	3.8	6.1
East South Central	30.0	10.1	7.8	26.1	0.9	10.9	5.7	8.5
Middle Atlantic	27.8	8.0	4.4	32.7	1.7	6.0	5.8	13.6
Mountain	12.7	14.2	16.6	29.7	0.5	2.9	11.4	11.9
New England	33.9	8.3	4.0	34.7	0.8	5.4	6.2	6.7
Pacific	11.7	22.1	8.2	25.1	0.7	4.3	13.0	15.0
South Atlantic	19.6	8.9	5.5	22.7	1.3	24.2	7.3	10.4
West North Central	35.2	12.9	8.2	23.0	1.1	5.5	5.7	8.3
West South Central	10.8	7.2	35.3	16.4	2.7	10.3	8.8	8.7
U.S.	24.6	11.5	10.9	24.6	1.3	8.2	7.8	11.1

Source: Clark et al. (forthcoming), table 1.

Table 2
External Trade of the European Union 11
1994-96 (Percentage Shares)

Country	Trading Partner										
	Africa	Asia Pacific			Europe			Middle East	Western Hemisphere		
		Japan	ANZ[1]	Other	Other EU[2]	NSZ[3]	Other		Canada	U.S.	Other
Austria	2.9	6.0	0.8	11.0	15.5	13.6	32.3	3.7	1.6	10.1	2.5
Belgium	7.1	5.2	1.1	12.9	34.3	6.2	8.2	6.1	1.3	13.9	3.8
Finland	1.3	5.9	1.7	11.5	36.2	7.6	18.6	2.3	1.0	10.9	3.0
France	10.1	5.7	1.0	14.8	24.4	8.7	7.8	5.5	1.5	15.1	5.5
Germany	3.1	7.1	1.1	15.5	21.4	11.0	18.2	3.7	1.2	13.5	4.3
Ireland	1.7	6.0	0.7	9.8	49.7	4.0	4.6	1.9	1.2	18.9	1.4
Italy	6.6	4.3	1.4	13.0	19.1	8.9	16.9	9.6	1.7	12.2	6.3
Netherlands	4.2	5.5	0.8	15.7	31.4	6.8	9.0	5.9	1.1	14.3	5.3
Portugal	12.5	5.0	0.7	8.4	33.9	8.0	4.9	6.9	1.2	11.3	7.2
Spain	9.6	5.6	0.9	12.6	25.1	4.3	7.8	7.3	1.2	13.4	12.2
Total EU11	5.2	6.3	1.3	14.8	23.2	9.4	12.9	5.4	1.5	15.1	4.9

1. Australia and New Zealand.
2. Denmark, Greece, Sweden and the United Kingdom.
3. Norway and Switzerland.

Source: International Monetary Fund, *Direction of Trade Statistics Yearbook*, various years.

Table 3
External Trade of the European Union 15
1994-96 (Percentage Shares)

Country	Trading Partner									
		Asia Pacific			Europe			Western Hemisphere		
	Africa	Japan	ANZ[1]	Other	NSZ[2]	Other	Middle East	Canada	U.S.	Other
Austria	3.5	7.1	0.9	13.0	16.1	38.2	4.4	1.9	12.0	2.9
Belgium	10.9	7.9	1.6	19.6	9.4	12.4	9.2	1.9	21.1	5.8
Denmark	3.2	10.1	1.5	17.5	22.6	17.7	4.1	1.3	14.3	7.6
Finland	2.0	9.3	2.7	18.0	11.8	29.2	3.5	1.5	17.1	4.7
France	13.4	7.5	1.3	19.6	11.6	10.3	7.2	1.9	20.0	7.2
Germany	3.9	9.0	1.4	19.7	14.0	23.1	4.7	1.5	17.1	5.5
Greece	4.3	7.5	0.9	12.7	5.7	32.7	18.9	1.1	10.7	5.5
Ireland	3.4	12.0	1.4	19.6	8.0	9.1	3.8	2.4	37.5	2.9
Italy	8.2	5.3	1.8	16.0	11.0	20.9	11.8	2.1	15.1	7.8
Netherlands	6.2	8.1	1.2	22.8	9.9	13.1	8.6	1.6	20.8	7.7
Portugal	18.9	7.6	1.1	12.7	12.1	7.4	10.4	1.8	17.1	10.9
Spain	12.9	7.4	1.2	16.9	5.8	10.4	9.7	1.6	17.9	16.3
Sweden	2.0	7.8	2.5	16.3	24.3	17.7	4.2	2.0	18.6	4.4
U.K.	5.1	9.2	3.1	22.5	10.3	7.5	6.9	3.0	28.1	4.3
Total EU15	6.8	8.2	1.7	19.3	12.2	16.8	7.1	1.9	19.6	6.4

1. Australia and New Zealand
2. Norway and Switzerland.
Source: International Monetary Fund, *Direction of Trade Statistics Yearbook*, various years.

Table 4
Exchange Rates and Trade Weights for Countries B and C Relative to A

	Country B		Country C	
Year	Exchange Rate*	Trade Weight	Exchange Rate*	Trade Weight
1	25	.60	55	.40
2	32	.62	50	.38
3	39	.64	48	.36
4	49	.66	45	.34
5	61	.68	39	.32
6	61	.69	39	.31
7	65	.70	36	.30
8	68	.68	28	.32
9	72	.65	25	.35
10	75	.60	22	.40
11	78	.50	17	.50
12	80	.45	16	.55
13	82	.42	15	.58
14	85	.40	13	.60

* The exchange rate is the number of units of the currency of country B(C) per unit of the currency of country A.

Table 5
Laspeyres Exchange Rate Indexes for Country A
Varying Base Year for Weights

	Indexes		Percent changes*	
Year	Year 2 Weights	Year 12 Weights	Year 2 Weights	Year 12 Weights
1	100.0	100.0	--	--
2	112.4	106.0	11.7%	5.9%
3	125.1	113.3	10.7	6.7
4	140.6	121.2	11.7	6.7
5	152.6	123.7	8.1	2.0
6	152.6	123.7	0.0	0.0
7	153.9	121.8	0.9	-1.5
8	143.9	108.2	-6.8	-11.8
9	142.8	104.3	-0.8	-3.7
10	139.5	99.0	-2.3	-5.2
11	129.6	87.5	-7.4	-12.4
12	128.7	85.6	-0.7	-2.2
13	127.5	83.5	-0.9	-2.4
14	123.4	78.5	-3.2	-6.3

* Percent changes are calculated on a logarithmic basis from the preceding to the current year.

Table 6
Exchange Rate Indexes for Country A for Different Exchange Rate Reference Years

	Level				Percent Change*			
	Laspeyres Index		Paasche Index		Laspeyres Index		Paasche Index	
Reference Base	Year 2	Year 12	Year 2	Year 12	Year 2	Year 12	Year 2	Year 12
Year 1	89.6	81.5	89.6	81.5	--	--	--	--
2	100.0	91.0	100.0	87.4	11.0%	11.0%	11.0%	6.9%
3	110.8	100.8	111.8	93.8	10.2	10.2	11.2	7.1
4	123.8	112.7	127.8	102.8	11.1	11.1	13.4	9.2
5	133.3	121.4	143.2	110.6	7.4	7.4	11.4	7.3
6	133.3	121.4	144.5	109.3	0.0	0.0	0.9	-1.2
7	134.2	122.1	148.8	110.3	0.6	0.6	2.9	0.9
8	124.6	113.5	138.7	107.1	-7.3	-7.3	-7.1	-2.9
9	123.3	112.2	132.9	109.2	-1.1	-1.1	-4.3	1.9
10	120.0	109.3	120.0	109.3	-2.7	-2.7	-10.2	0.1
11	110.9	100.9	91.0	101.8	-8.0	-8.0	-27.7	-7.1
12	109.9	100.0	80.7	100.0	-0.9	-0.9	-12.0	-1.8
13	108.7	98.9	73.9	97.3	-1.1	-1.1	-8.9	-2.7
14	104.8	95.4	65.9	90.5	-3.6	-3.6	-11.4	-7.3

* Percent changes are calculated on a logarithmic basis from the preceding to the current year.

Table 7
Foreign Destination of Regional Exports
1987 (Percentage Shares)

Region of the United States	Trading Partner							
	Canada	Japan	Mexico	Europe	Africa	Rest of America	Oceania	Asia
East North Central	53.6	6.0	4.5	20.7	1.6	3.5	4.0	6.0
East South Central	26.3	11.6	3.6	35.5	1.9	7.5	5.6	8.0
Middle Atlantic	23.5	9.1	3.0	36.3	1.8	8.1	4.8	13.4
Mountain	16.5	13.8	11.7	31.9	0.7	3.2	9.3	12.9
New England	22.0	11.2	1.8	44.0	0.8	3.4	8.2	8.6
Pacific	11.0	24.1	5.0	30.4	1.1	3.6	11.4	13.5
South Atlantic	17.1	9.7	2.0	35.1	1.9	18.7	4.7	10.7
West North Central	35.1	11.5	5.1	28.3	1.6	3.8	4.8	9.8
West South Central	8.9	12.1	20.3	27.0	3.3	11.6	5.8	11.0
U.S.	24.0	12.7	6.6	30.3	1.8	7.5	6.6	10.6

Source: Clark et al. (forthcoming).

Table 8
Change in Foreign Destination of Regional Exports
1994 less 1987 (Percentage Shares)

Region of the United States	Trading Partner							
	Canada	Japan	Mexico	Europe	Africa	Rest of America	Oceania	Asia
East North Central	-2.8	2.0	1.4	-0.8	-0.7	1.2	-0.2	0.1
East South Central	3.7	-1.5	4.2	-9.4	-1.0	3.4	0.1	0.5
Middle Atlantic	4.3	-1.1	1.4	-3.6	-0.1	-2.1	1.0	0.2
Mountain	-3.8	0.4	4.9	-2.2	-0.2	-0.3	2.1	-1.0
New England	11.9	-2.9	2.2	-9.3	0.0	2.0	-2.0	-1.9
Pacific	0.7	-2.0	3.2	-5.3	-0.4	0.7	1.6	1.5
South Atlantic	2.5	-0.8	3.5	-12.4	-0.6	5.5	2.6	-0.3
West North Central	0.1	1.4	3.1	-5.3	-0.5	1.7	0.9	-1.5
West South Central	1.9	-4.5	15.0	-10.6	-0.6	-1.3	3.0	-2.3
U.S.	0.6	-1.2	4.3	-5.7	-0.5	0.7	1.2	0.5

Source: Clark et al. (forthcoming).

Table 9 Simple Correlations	
Region*	Correlation
U.S.94 and U.S.87	.995
ENC94 and ENC87	.984
ESC94 and ESC87	.987
MATL94 and MATL87	.911
MTN94 and MTN87	.995
NE94 and NE87	.994
PAC94 and PAC87	.991
SATL94 and SATL87	.802
WNC94 and WNC87	.978
WSC94 and WSC87	.997

* The abbreviations for the Census Regions are as follows: ENC-East North Central; ESC- East South Central; MATL-Middle Atlantic; MTN-Mountain; NE-New England; PAC-Pacific; SATL-South Atlantic; WNC-West North Central; and WSC-West South Central. The numbers identify the years, 1987 and 1994, for the trade weights.

Source: Richard Sprinkle, based on data used in Clark et al. (forthcoming).

Table 10 Cointegration Analysis			
Region		Eigenvalue	Likelihood Ratio
U.S.94	U.S.87	0.28	30.73**
ENC94	ENC87	0.05	4.15
ESC94	ESC87	0.07	8.19
MATL94	MATL87	0.06	4.97
MTN94	MTN87	0.06	4.93
NE94	NE87	0.06	7.41
PAC94	PAC87	0.07	6.74
SATL94	SATL87	0.09	10.22
WNC94	WNC87	0.11	12.86
WSC94	WSC87	0.07	8.67

The 5% (1%) Critical Value for the likelihood ratio test is 15.41 (20.04).

* denotes significant at the .05 level

** denotes significant at the .01 level

Source: Richard Sprinkle, based on data used in Clark et al. (forthcoming).

Table 11 Orthogonal Least Squares Analysis			
Region		Slope Estimates	Chi-Square Statistic
U.S.94	U.S.87	0.99	1.81
ENC94	ENC87	0.96	4.36*
ESC94	ESC87	0.92	23.88**
MATL94	MATL87	1.12	5.76*
MTN94	MTN87	1.06	32.01**
NE94	NE87	0.94	24.09**
PAC94	PAC87	1.11	48.20**
SATL94	SATL87	1.24	7.37**
WNC94	WNC87	0.98	0.81
WSC94	WSC87	1.00	0.26

* denotes significant at the .05 level
** denotes significant at the .01 level
Source: Richard Sprinkle, based on data used in Clark et al. (forthcoming).