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Exchange rate volatility and Currency Union: Some theory and New Zealand evidence

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Exchange rate volatility and Currency Union: Some theory and New Zealand evidence[1]

Abstract[2]

This paper considers the effect of currency union on exchange rate volatility. At a theoretical level, a simple framework is developed for thinking about volatility and exchange rate arrangements and some inferences are drawn from it. Empirically, the interaction between currency areas and exchange rate volatility is analysed by constructing counterfactual exchange rate series for the scenarios of currency union with Australia or with the United States from 1985 to 2001. We cannot confidently conclude that New Zealand's quarter-to-quarter exchange rate volatility would have been lower in a currency union with the United States or Australia. By contrast, cyclical variability in the New Zealand exchange rate has been greater over the last sixteen years than it would have been in a currency union with either Australia or the United States.

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2 The views expressed in this paper are those of the author and do not necessarily represent the views of the Reserve Bank of New Zealand. The author would like to thank Nils Björksten, John McDermott and Weshah Razzak for their advice. All errors and omissions are the responsibility of the author.

1 Introduction

The topic of optimal currency areas has become increasingly prominent in recent debates about economic policy. There has been monetary union in Europe and dollarization in Latin America. In New Zealand, a number of studies, such as Coleman (1999), Grimes, Holmes and Bowden (2000) and Hargreaves and McDermott (1999), have discussed the possibility of a currency union.

Each of these has claimed that exchange rate volatility would be lower in a currency union. In particular, Grimes, Holmes and Bowden (2000) analyse counterfactual exchange rates that would have applied in a currency union and conclude that New Zealand would not have had a less volatile exchange rate in a currency union with Australia or the United States, but would have experienced lower exchange rate volatility in a three-way currency union with both Australia and the United States.

This paper revisits the issue of exchange rate volatility and currency union. It discusses how currency union affects exchange rate volatility before presenting some new evidence for New Zealand. While the approach taken here is similar to that of Grimes, Holmes and Bowden (2000), there are important differences. In particular, this study takes into consideration some time series properties of exchange rate data which were not accounted for in the study by Grimes et al.

This paper considers quarter-on-quarter changes in the exchange rate as well as measures of cyclical volatility based on a band-pass filter. The key results are that volatility of the exchange rate at high frequencies would not have been markedly different in a currency union with either Australia or the United States. At cyclical horizons New Zealand would have had a less volatile exchange rate had it replaced the New Zealand dollar with the Australian or American dollar in 1985:2. The effect of currency union on volatility in output, interest rates or inflation is beyond the scope of this paper.[3]

3 Drew et al. (2001) find that inflation and output variability would have been higher in a currency union with Australia over the 1990s.

The remainder of this paper is structured as follows. Section 2 briefly provides a context for the debate about currency unions and exchange rate volatility. Section 3 develops a framework for analysing the effect of currency union on volatility followed by an empirical analysis in section 4. Section 5 concludes.

2 Exchange rate volatility, currency union and their interaction

This paper is contained in the intersection of research on exchange rate volatility and currency unions. Each of these topics has been prominent in recent debates about New Zealand's economic performance.

Rogoff (2001) states the consensus view when he says that 'exchange rates fluctuate wildly in comparison with goods prices' (p 243) But what are the consequences of variable exchange rates? The case for having flexible exchange rates is usually based on the idea that the exchange rate can buffer the economy from external shocks. However, there is considerable doubt as to whether allowing exchange rates to float has led to greater stability in other parts of the economy. It has been difficult to relate exchange rate movements to fundamentals, such as interest rate differentials or inflation differentials, especially over short periods of time.

Foreign exchange markets facilitate the exchange of goods and flow of capital between currency areas. Exchange rate volatility could reduce international trade and cause differences in real interest rates for contracts denominated in different currencies. However, as McKenzie's (1999) survey shows, the literature relating exchange rate volatility to trade is inconclusive when taken as a whole. Some studies find negative relationships while others find no relationship or even a positive relationship between volatility and trade.[4]

Volatility may also have implications for interest rate risk premia. Debt denominated in a currency with a volatile exchange rate is typically sold at a lower price (higher interest rate) to compensate for

[4] Arize and Malindretos (1998) find that exchange rate volatility reduces New Zealand exports.

the currency risk from investing in that currency area. Thus the cost of international capital is likely to be higher for countries with volatile exchange rates.

Hawkesby, Smith and Tether (2000) investigate New Zealand's currency risk premium and suggest that long term interest rates would be around 1.5 to 2 percentage points lower in a currency union with the United States but would be similar in a currency union with Australia. As Hawkesby et al. point out, the interest rate differential attributed to currency risk may instead be due to other factors that are not related to the monetary arrangements.

Policies that result in reduced exchange rate volatility *may* result in increased trade and lower interest rates. One policy that may reduce exchange rate volatility is entering a currency union.

Research into currency unions, initiated in the 1960s, has undergone a renaissance recently. The topic is prominent in both the academic context and the policy arena, especially with the introduction of the Euro. Running an independent monetary policy gives a country macroeconomic flexibility. This is traded for microeconomic efficiency gains, due to lower transactions costs and increased integration when a country enters a currency union.

The effect of currency union on exchange rate volatility is seldom disputed: going into a currency union would reduce volatility. At least, that is the conventional wisdom. Each of Coleman (1999), Hargreaves and McDermott (1999) and Grimes, Holmes and Bowden (2000) claim that currency unions lead to lower exchange rate uncertainty. The purpose of this study is to focus on this issue and give a more thorough assessment of the link between currency unions and exchange rate volatility with particular reference to New Zealand.

3 Some theory

This section considers some basic models of exchange rate volatility and the effect of currency union on it. The currency union considered is effectively dollarization. The anchor is a relatively large country so that when the client country begins using the anchor's currency, there are no significant effects on the anchor's exchange rates.[5] Moreover, the client has no effective control over the anchor's monetary policy.

In the rest of this section volatility is interpreted as the variance of point-to-point percentage changes in the trade-weighted index (TWI). This is one of many possible measures of exchange rate volatility. McKenzie (1999) states that 'whilst economists generally agree that it is uncertainty in the exchange rate which constitutes exchange rate volatility, no generally accepted technique exists by which one may quantify such risk' (p 76). In the empirical section below I consider several conceptions of volatility. Appendix 1 derives more formally the arguments that are presented below.

3.1 A tale of two currencies

Consider a world in which there are only two countries. Let us call these countries New Zealand and Australia. Australia and New Zealand each have their own currencies, which are often exchanged to facilitate trade between the two countries. Some people – mainly New Zealanders – say they do not sell or buy in the other country because of volatility in the exchange rate between the Australian and New Zealand dollars. They say we should have the same currency as Australia and then they would have nothing to fear – at least, nothing to fear from exchange rate volatility. In fact, they are right. Given that there is only one exchange rate, a currency union would eliminate all exchange rate volatility.

3.2 A tale of three currencies

Of course, the model above is not an entirely realistic portrayal of the 'real world'. Its conclusion – that currency union eliminates all exchange rate volatility – is misleading. So consider a world in which there are three countries. Let us call these countries New Zealand, Australia and the United States of America. Each country has its own currency, and these currencies are often exchanged to

5 I have adopted Alesina and Barro's (2001) anchor and client terminology. The client country withdraws its own currency and replaces it with the anchor's currency.

facilitate trade between the three countries. Some people in New Zealand say they do not buy and sell in the other countries because the exchange rate at which New Zealand dollars are exchanged for Australian or American dollars is too volatile. They say we should have the same currency as Australia or America and then they would have less exchange rate volatility to be afraid of. Again, these people may have a point. If New Zealand entered into a currency union with Australia, then there would be only one exchange rate to worry about instead of two. Typically such a currency union would result in lower exchange rate volatility.

However, the choice of a currency union anchor is not so clear as when there is only one other country. What should determine the choice of anchor? One view is that New Zealand should form a currency union with the United States because our exchange rate with the American dollar is more volatile than our exchange rate with the Australian dollar. However, this view is not based on a complete view of what a currency union would do to our exchange rates. We would still have to buy another country's currency occasionally. The relevant exchange rate would be either the AUD/USD or the USD/AUD depending on which country is the anchor in the currency union arrangement. The volatility of the exchange rate is the same regardless of which side of it we are on. The volatility in the bilateral exchange rate is weighted according to how important the other country is. Therefore, our TWI obtains the lowest volatility when we go into union with the more important partner country.

What matters is the relative importance of the two countries. The analysis above indicates that, on the basis of leading to lower volatility, the currency union should be formed with the more important country.

In addition, a currency union in a three country world would lower volatility from the base case of an independent currency unless the anchor country is relatively unimportant and the NZD/USD and NZD/AUD exchange rates tend to move in opposite directions.

While a currency union with the only other country in the world (the Two Country Case) eliminates exchange rate volatility, when there are three countries a currency union will probably reduce volatility but will not eliminate it entirely. A country such as Canada, with fewer important trading partners, stands to gain more from a currency union in terms of exchange rate volatility reduction.

3.3 Then there were four

The examples above only deal with the possibility of New Zealand entering a currency union with Australia or the United States which are the only two other countries in the world. Let us now consider the case where there are more countries: New Zealand, Australia, the USA and the Rest of the World. The standard complaints are made about exchange rate volatility and the same request that a currency union be formed are lodged. The two possible anchor countries remain the USA and Australia.

The volatility in the TWI (measured as the variance of point-to-point percentage changes in the TWI) consists of volatility in weighted exchange rates plus weighted covariances of exchange rates. The applicable exchange rates in a currency union are effectively the cross rates at which the anchor currency is exchanged for other currencies. A currency union could reduce volatility overall either because the cross rates are less volatile or because they do not all move together. That is, if the covariances of the cross-rate series are close to zero or negative[6].

The anchor currency in a currency union should ideally have a high weight in our (possibly trade-weighted) exchange rate index. Currently the NZD/USD exchange rate has the highest weight in the TWI. This makes the US dollar the preferable currency to adopt. In addition, the anchor currency should also have cross rates that have low volatility and low covariances between bilateral exchange rates.

[6] There is a well-known analogue to this point in portfolio management. From a volatility perspective, it is sensible to have a diversified portfolio of assets so that when one asset yields subnormal returns, another is likely to be more profitable than normal.

3.4 Lessons from the theory

The theory section above suggests the following lessons:

- Currency union can decrease exchange rate volatility.
- The more currencies that are important to us, the less we gain from currency union in terms of volatility reduction. (Canada would gain more as it trades mostly with the United States.)
- The anchor currency should be that of the most important other country, ceteris paribus.[7]
- The covariances of the cross rates of the anchor country also matter. This may overturn other lessons.

The practical significance of the covariances of the bilateral exchange rates with each other is limited. I explain this further in the empirical section. Also, note that the lessons above are based on analysis that precludes weight drift. It is unclear what effect weight drift has on the results stated above, though it should not be significant. (Grimes, Holmes and Bowden (2000) work with a fixed-weight exchange rate index that is strongly correlated with the historical TWI, despite the weights in the historical TWI changing periodically.)

4 Evidence

Having discussed some theory about how currency union could affect exchange rate volatility, the following material attempts to provide some light on the issue from an empirical perspective. I have done this by constructing and then analysing volatility in exchange rate indices for New Zealand, both with her own currency and in a monetary union with either Australia or the United States. This section begins by mentioning some related work by Grimes, Holmes and Bowden (2000), abbreviated to GHB.

[7] The relative importance of each country could be determined in many ways. New Zealand's official TWI formerly used weights based on merchandise trade, but has since used weights that are derived from nominal GDPs as well as merchandise trade flows.

GHB is a wide-ranging study into the possibility of currency union. As part of their work, GHB consider exchange rate volatility in a currency union. The authors analyse three alternative monetary unions made up of the following combinations of countries:

- New Zealand and Australia;
- New Zealand and the United States; and
- New Zealand, Australia and the United States.

They analyse volatility in bilateral series as well as weighted index series. They conclude that a currency union with either Australia or the United States would not deliver more stability in New Zealand's exchange rates with third countries. However, a three-way currency union with Australia and the United States would produce a less volatile trade-weighted index exchange rate.

However, their analysis could be broadened in several ways. First, their findings may not be robust to small changes in their sample, which begins in the third quarter of 1986. An earlier start would show up significant falls in the New Zealand and Australian dollars in 86:3.[8] Starting in 85:2, to coincide with the float of the NZD, appears to be preferable. Furthermore, this study uses more recent data that had not been realised when GHB was published. As such, while their series finished in 99:2, those used here proceed until 01:2.

GHB make allowance for the possible non-stationarity of nominal exchange rates, despite the widespread belief that such rates have unit roots. If nominal exchange rates do follow a random walk then the statistic that GHB use–the standard deviation of the level of the exchange rate–is meaningless. The unit root hypothesis is an important reason for considering quarter-on-quarter deviations in the exchange rate as well as detrended data. My study uses a wider range of measures of volatility than GHB, consistent with the

[8] Dungey and Pagan (2000) state that this fall in the Australian dollar is related to the flow-on effects of the 'infamous "banana republic" statement by former [Australian] Treasurer Paul Keating' (p 329). While some may argue that such an event is a one-off, it is part of history and it is fair to expect political events to have an ongoing impact on exchange rates.

difficulty of arriving at a satisfactory statistical definition of volatility.

While GHB compare point estimates of volatility, they do not appear to subject these to tests of statistical significance. By contrast, I conduct some tests to assess the validity of conclusions based on comparisons of point estimates.

In building index exchange rates, this study uses varying weights, rather than fixed weights as in GHB. The difference may be minor as GHB show their fixed weight TWI follows the actual TWI very closely. GHB do not consider larger baskets of currencies, such as the TWI14 I construct.

4.1 The counterfactual TWIs

I have constructed TWI series for currency unions with the US and Australia as well as the independent currency base case. The formula for the TWI is

$$TWI = A\prod_i e_i^{w_i} \tag{1}$$

where the e's are nominal exchange rates for each country included in the TWI basket. The w's are weights, which sum to one. A is a constant chosen so that each TWI is 100 in the initial period (June quarter 1985).

The counterfactual TWIs – those calculated to represent the exchange rate New Zealand would have had in a currency union – use cross-rates as the exchange rates. For example, the applicable Yen exchange rate would be the AUD/JPY exchange rate if New Zealand had been in a currency union with Australia.

I have produced TWIs based on a basket of five major currencies (Australian dollar, US dollar, German Deutschemark, Japanese Yen and British Pound) as well as a 14 country basket[9]. The weights for

[9] The five country basket contains Australia, Germany, Japan, the UK and the USA. In addition to these, the fourteen country basket has China, France, Hong Kong, Indonesia, Italy, South Korea, Malaysia, Taiwan and Thailand. In 1999 the Euro replaces the Deutschemark, French Franc and Italian Lira in the TWI basket. Due to the sudden weight changes that result, the constant, A, is adjusted

the fourteen country basket are based on trade flows alone. For the five currency basket I construct one series with trade weights and another with hybrid weights that are half due to trade and half due to nominal GDP of the respective currency areas.

The weights used are the same across regimes. Rose and van Wincoop (2001) argue that Australasian trade would increase by 125 per cent if a currency union were formed between the two countries. If true, this would imply large errors in the trade-weights used in creating the counterfactual exchange rate indices. For example, if Australia had a weight of 0.35 before the currency union proceeded and trade with Australia increased by 125 per cent, then its weight would increase to 0.55. Another country with a weight of 0.20 would see its weight fall to 0.14.

There remains a considerable degree of controversy about the data and methods Rose (2000) and Rose and van Wincoop (2001) use to arrive at their different estimates of the impact of currency union on trade. For example, whether Rose (2000) has correctly classified regions in terms of the countries and currency areas they are part of is a matter of debate. However, the conservative approach taken in this paper–assuming trade patterns are invariant to monetary union arrangements–could be revisited should a consensus emerge regarding the impact of currency union on trade flows.

The name of each series begins with the weighting scheme used, TWI for trade-weights or HWI for hybrid-weights, followed by a number to show how many countries are in the basket, five or 14, and the country whose currency New Zealand uses, either NZ, AU or US.

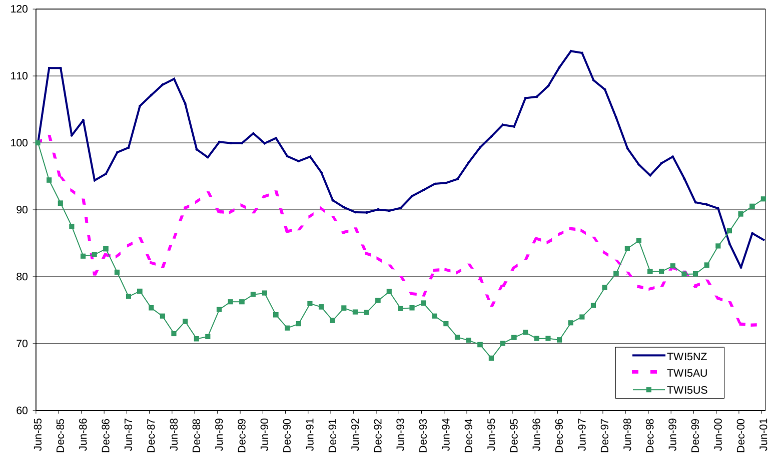
I use quarterly data from 1985:2 to 2001:2 in which time the New Zealand dollar has been freely floating.[10] This yields 65

to prevent a large change in the series for a reason other than changes in bilateral exchange rates.

[10] Exchange rate data are averaged daily rates for each quarter taken from Datastream. Nominal GDP statistics are also from Datastream. Trade figures are sourced from Statistics New Zealand. A more complete description of data sources is available on request from the author.

observations. Due to data unavailability prior to 1986, the fourteen country TWI starts in 1986:1. Figure 1 depicts the TWI5 series.

Figure 1
Levels of hypothetical TWI5s for New Zealand in alternative currency unions



Notes: Quarterly data, base: 1985:2=100, five country basket.

Figure 1 illustrates the appreciation of the New Zealand dollar and its subsequent fall during the 1990s. Figure 1 also shows the American dollar's appreciation during the second half of the 1990s. Had we been linked with the United States in a monetary union we would have had a strong appreciation then as well.

I could not reject the unit root hypothesis for any of the exchange rate series with the exception of TWI14AU. Appendix 2 contains results from tests for unit roots in the nine exchange rate series I have constructed.

4.2 Analysing volatility in the TWIs

As a measure of volatility, table 1 reports the variance of the quarter-on-quarter percentage change in each TWI.[11] The statistics are

[11] Percentage change is calculated as the difference in natural logarithms.

reported for the entire period covered by the data and over the business cycle of the 1990s[12] – 1991:4 to 1998:2.

Table 1
Variance of percentage change in TWI5s in various currency union scenarios

	Independent Currency	Union with Australia	Union with USA
1985:3-2001:2	10.85	9.11	7.27
1991:4-1998:2	4.90	6.02	5.04

Notes: The significance of the differences between cases has been assessed using an F-test. In no case has the difference been found to be significant, even at the 10% level.

The F-test used to compare the point estimates in table 1 presumes that the sampling is at random from normally distributed populations. In this case the assumptions are unlikely to hold. The F-test should be treated as a 'first pass', and may not be the best test. The sample generalised variance (Anderson, 1957) – outlined in appendix 3 – tests for the equality of two variances when the series are not independent.

The results from the sample generalised variance test, applied over the whole sample, are similar to the F-test, though there are some notable exceptions. For table 1 the volatility in a currency union with the USA becomes significantly different from New Zealand's over the 1990s' business cycle.

Based on the point estimates in table 1, a currency union with the United States would have led to the least exchange rate volatility over the whole sample. By contrast, New Zealand's exchange rate volatility during the business cycle of the 1990s was less than it would have been in a currency union with Australia.

In theory the nature of the covariances between a country's bilateral exchange rates influence its desirability as an anchor currency – see

[12] The business cycle is dated according to a growth rates approach.

lesson four above. If the covariance between bilateral exchange rates is high, then swings in one exchange rate are compounded by swings in the others. If the covariances are low or negative, then temporary competitiveness losses against one currency bloc are offset by competitiveness gains against another bloc.

In practice the covariances among bilateral exchange rates of potential currencies have not altered the rankings. In the case of a currency union with the United States the (weighted) covariances are lower than would have been obtained with either an independent currency or in a currency union with Australia. The lower volatility in bilateral exchange rates would be accentuated by their relative lack of co-movement.

Another measure of volatility is the difference between the log of maximum and minimum values of the series. This gives an idea of the magnitude of the exchange rate cycle. Table 2 presents these figures for the three series over the entire floating exchange rate period, as well as over the business cycle of the 1990s. The measure reported in table 2 is constructed as

$$100\left[\ln(\max(x)) - \ln(\min(x))\right] \qquad (2)$$

where x is the exchange rate index.

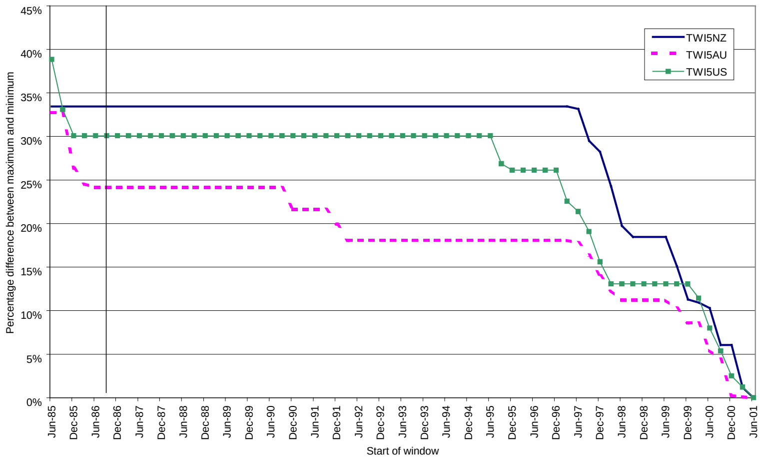
Table 2
Size of exchange rate cycle for alternative currency union scenarios

	Independent Currency	Union with Australia	Union with USA
1985:2-2001:2	33.4%	32.7%	38.8%
1991:4-1998:2	23.9%	16.0%	21.7%

Taking the figures in table 2 at face value would lead to the conclusion that adopting the Australian dollar would give New Zealand smaller exchange rate cycles. However, the statistics presented in the table may be misleading. Several of the extrema occur at or very near to the end-points of the sample. This indicates that the results may be sensitive to small changes in the sample period, that is, non-robust.

Figure 2 shows how the statistic reported in table 2 changes as the sample is shortened. The end point of the sample is fixed at 2001:2, but the initial observation is brought closer to the end of the data set. The initial period for each window is shown on the horizontal axis. Initially the ranking of the three alternatives changes as the sample is shortened.

Figure 2
Sensitivity of the 'size of cycle' to changes in the sample



Notes: Five country, trade weighted indices.

One could take either of two opposing views on how to interpret the figure above. According to one view, the first five quarters are noisy and unrepresentative, so that dropping them gives more appropriate results. These results are that New Zealand's exchange rate has been more volatile than it would have been in a currency union. An alternative view would say that omitting the first five observations conveniently ignores foreign exchange market turbulence that New Zealand would have experienced had we adopted either the Australian or American dollar instead of floating the New Zealand dollar in March 1985.

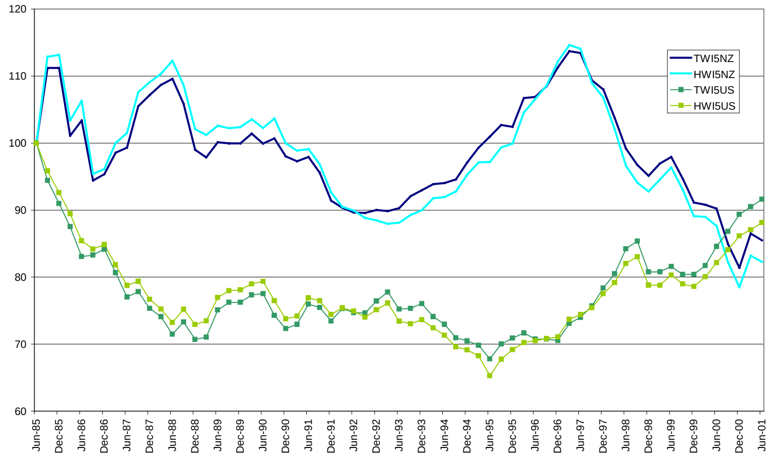
Ultimately it is unclear whether the earlier observations should be included or not. It is important to note that their inclusion or exclusion affects the conclusions drawn about which currency has the least volatile exchange rate.[13]

4.3 Analysis based on a hybrid weighting scheme

The results presented above may depend on how the exchange rate index is constructed. Exchange rate indices based on hybrid weights are analysed in this section. The following section presents trade-weighted indices that are based on a basket of fourteen countries. Figure 3 shows the relationship between the TWI and the HWI. Changing the weighting scheme used has a small impact on the time-path of the exchange rate. The correlation coefficient between the TWI and HWI is around 0.97 for both an independent currency and currency union with the United States. For a currency union with Australia–omitted from figure 3 for clarity–the correlation is similar.

[13] Given the serial correlation in exchange rates–appendix 2 shows that most series considered are indistinguishable from random walks–a short sample will show less variability from min to max. As the initial period increases towards the last observation the difference between min and max tends to zero for each series.

Figure 3
TWIs versus HWIs: New Zealand dollar and US dollar



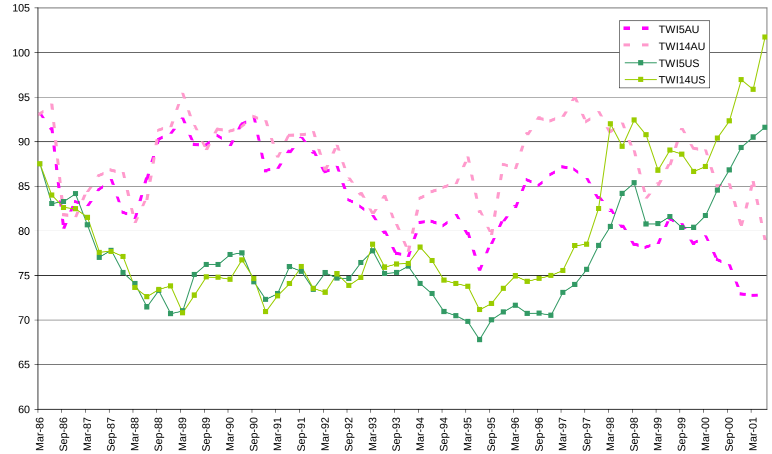
Notes: Quarterly data, base: 1985:2=100, five country baskets.

While the time paths of the trade- and hybrid-weighted exchange rate indices are close together, the volatilities are a little different. In particular, compared with the TWIs in the previous section, the United States dollar index is less volatile on a HWI basis, while the Australian dollar and New Zealand dollar indices are more volatile. According to these indices, adopting the USD would have provided New Zealand with a more stable exchange rate from quarter-to-quarter.

4.4 Analysis based on a fourteen country basket

In addition to analysing exchange rate indices based on five country baskets, I have constructed indices using 14 countries. Figure 4 shows the TWI14 series alongside TWI5 series. The relevant data for all fourteen countries was only available from 1986:1 onwards so the expanded basket series apply from then on. Each is set to be equal to the value of the respective five country index in 86:1.

Figure 4
Fourteen country TWIs and five country TWIs



Notes: Quarterly data, base: 1985:1=100 for TWI5s, 1986:1 for TWI14 set equal to TWI5 for the same period.

The fourteen country indices exhibit considerably more divergence from their five country counterparts than the HWIs do. At times the indices are ten per cent different from each other. The independent currency series–not shown for clarity–are much closer together compared with the currency union alternatives.

Volatility in the TWI14s is typically larger than for the five country indices. Over the whole sample the currency union with the United States delivers lower volatility than the independent New Zealand dollar. While this difference is significant according to the F-test, the sample generalised variance test cannot reject the null hypothesis that the two volatilities are equal.

Comparisons based on different baskets of currencies, different weight schemes and different time horizons give conflicting conclusions as to the effect of currency union on quarter-to-quarter volatility in the exchange rate.

4.5 Analysis based on a filtering approach

Most of the results reported so far are based on analysis of high frequency (quarter-to-quarter) variability. Uncertainty about exchange rate movements from quarter-to-quarter may be resolved by hedging exposures so that such volatility may not impact on international trade. McKenzie argues that 'international trading contracts are typically long term in nature and firms generally do not know the magnitude nor the timing of their foreign exchange transactions with certainty.' (p 95) Brookes *et al.* (2000) state 'longer horizon volatility – that is cycles over 5 to 10 years – are likely to be the more serious exchange rate issues for firms.' (p 33) This section analyses cyclical variability in exchange rates.

Time series can be decomposed into cycles of various periods. Some cycles are very long and evolve slowly, while others are shorter and evolve rapidly. Any given time series can be thought of as having slow moving and fast moving components. Brookes *et al.* (2000) suggest that exposures up to one year ahead can be hedged cheaply and effectively to protect businesses from exchange rate risk. Hedging may not be effective for more distant cashflows. So an important role of a decomposition is to remove high frequency fluctuations in the exchange rate, as these are unlikely to be problematic for firms.

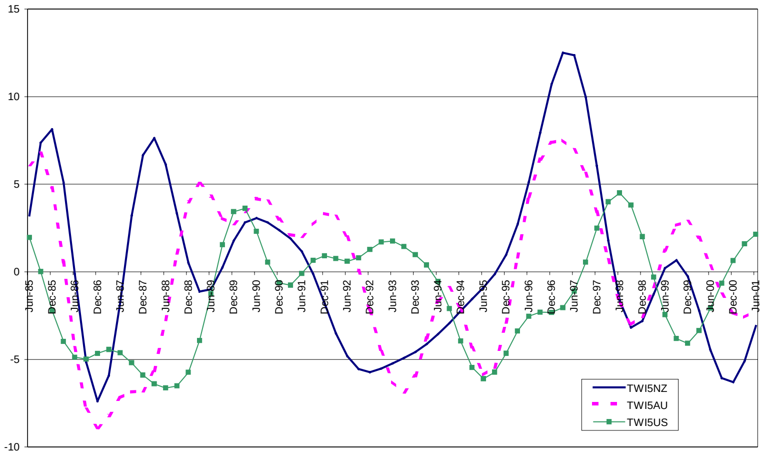
This section reports on results from using a band-pass filter on the three TWI5 series calculated over the 1985:2 to 2001:2 period. Band-pass filters can be used to isolate variability at business cycle frequency by removing both high frequency and low frequency components. Band-pass filters are only approximate in practice because we do not have the infinite amount of data that is needed to obtain the optimal band-pass filter. An approximate band-pass filter, such as that of Baxter and King (1999), is a moving average. It is not a simple moving average, where each observation in the moving window is given equal weight, but a weighted moving average. In general, if an observation is more distant from the centre of the moving window, it has a lower weight.

We applied the band-pass filter to each exchange rate index.[14] Each series can be decomposed into components that represent trend, cycle and noise. We think of noise as being components with a short cycle – between two and six quarters. The business cycle component captures variation due to cycles between six and 32 quarters. The trend component is made up of lower frequency cycles. The cycles of the TWI5 series are shown in figure 5.

Brook, Collins and Smith (1998) find that business cycles in New Zealand are typically shorter than 32 quarters. They describe the business cycle of the 1990s as notable for its durability, yet the period from 1991:4 to 1998:2 is only 27 quarters. Pedersen (1999), having analysed data from a sample of 11 OECD countries, argues that business cycles are shorter than six years for most countries. However, the purpose of this paper is not to argue about how long the business cycle is or how to obtain cyclical components of time series. Hence the use of the standard band-pass filter with the cycle defined as components with periods between six and 32 quarters.

[14] That the different exchange rate series have different means is not relevant to the matter of exchange rate volatility. However, it does affect the variance of the band pass filter's measure of the exchange rates cycle. Thus, before being filtered, each currency union based series is multiplied by a constant so that its sample mean is equal to that of the comparable series based on an independent currency.

Figure 5
Business cycle components of TWI in alternative currency areas



Notes: Quarterly data; five country basket; data is generated with $BP_{12}(6,32)$.

Figure 5 presents the business cycle components of each TWI5 exchange rate. The business cycle component of the exchange rate when New Zealand has an independent currency appears to be more variable than the currency union based alternatives.

Figure 5 illustrates the strong appreciation of the New Zealand dollar through the 1990s. The business cycle component rises from 1992 to 1997. The amplitude of the cyclical component is for the independent currency scenario is larger than for either currency union.

The variance of the cyclical component is 24 for an independent currency, 20 for a currency union with Australia and ten for a currency union with the United States. The point estimate that New Zealand's independent currency had higher exchange rate variability can be tested for statistical significance. F-tests suggest that the

cyclical component *is* more variable when we have an independent currency when compared with adopting the US dollar.[15]

Confirming this result, the sample generalised variance test rejects the null hypothesis that the variance of each currency union series is equal to that for New Zealand. In fact, regardless of which basket is used, and regardless of whether the timeframe considered is 85:2 to 01:2 or 91:4 to 98:2, New Zealand's exchange rate is found to be more volatile at business cycle horizons when the nation has an independent currency.

The analysis of cyclical components of the counterfactual exchange rate series suggests that New Zealand could have had a less volatile exchange rate over the business cycle if it had been in a currency union. This finding is robust to changes in the sample size and the way the exchange rate index is constructed.

5 Conclusions

How would a currency union affect exchange rate volatility? This paper considers counterfactual exchange rate series that cover sixteen years at quarterly frequency. These are constructed in a variety of ways, allowing for different weighting schemes and different countries in basket. The analysis in this paper is based on historical data and it is unclear to what extent these results for historical counterfactual currency unions apply to any future actual currency union.

At high frequencies, New Zealand's exchange rate does not appear to have been more volatile that it would have been in a currency union. While some measures indicate a currency union would have delivered a tamer exchange rate, others suggest the opposite. Findings about exchange rate volatility at high frequencies are non-robust.

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[15] The F-test presumes that the data are generated by random sampling from normally distributed populations. Given that this assumption is unlikely to hold the F-test can only be treated as indicative. The sample generalised variance test is more appropriate.

Exchange rate volatility at cyclical frequencies has been analysed using a band-pass filter. At cyclical frequencies, New Zealand would have had a less variable exchange rate had it been in a currency union with either Australia or the United States. This finding is robust to different ways of constructing the exchange rate index and to different samples.

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Appendix 1
Technical material

This appendix provides technical material in support of the earlier discussion of exchange rate volatility and currency union. The approach taken has been based around analysing volatility in a trade-weighted index (TWI) of exchange rates.

The TWI is constructed as a geometrically weighted average of five exchange rates (with the Australian dollar, the American dollar, the Deutschemark, the Yen and the Pound Sterling). For the currency union scenarios, the TWI is calculated based on the premise that currency union is observationally equivalent to permanently fixing exchange rates with another (the anchor) country. The TWI is recomputed using cross rates of the anchor currency with others in the TWI basket and a fixed exchange rate with the anchor.

The essence of volatility is deviation from a predictable path. Under the random walk hypothesis, any change in the exchange rate is seen as volatility. One measure of volatility is the variance of point-to-point percentage changes in the TWI. This is the measure that I focus on in this paper. Other measures of volatility may be appropriate but are not so tractable analytically.

A1.1 Calculating the TWI

After rebasing the bilateral exchange rates so that they are equal to one in the initial period, the (natural logarithm of the) TWI is calculated as:

$$twi = \sum_i w_i x_i \qquad \text{(A1.1)}$$

where $w_i \in (0,1)$ are weights and x_i are logged exchange rates. In practice these weights change over time, but I have ignored weight drift in this analysis.

Now the percentage change in the TWI is

$$\begin{aligned} p &= \Delta twi \\ &= \sum_i w_i \Delta x_i \end{aligned} \quad \text{(A1.2)}$$

The variance of this series (a measure of volatility) is

$$\begin{aligned} \text{var}(p) &= \text{var}\left(\sum_i w_i \Delta x_i \right) \\ &= \sum_i \text{var}(w_i \Delta x_i) + \sum_{i \neq j} \text{cov}(w_i \Delta x_i, w_j \Delta x_j) \quad \text{(A1.3)}^{16} \\ &= \sum_i w_i^2 \ \text{var}(\Delta x_i) + \sum_{i \neq j} w_i w_j \ \text{cov}(\Delta x_i, \Delta x_j) \end{aligned}$$

So TWI volatility depends on the volatility of individual exchange rate series as well as the correlation of volatility in the exchange rates. If one bilateral exchange rate is less volatile then, ceteris paribus, the TWI is less volatile. And if two exchange rates exhibit less covariance in their movements, ceteris paribus, the exchange rate is less volatile.

Intuitively, the New Zealand dollar can appreciate against the American dollar while simultaneously depreciating against the Australian dollar so that the TWI remains constant. Volatility in the TWI would seem smaller than trade-weighted volatility in individual exchange rates. More realistically, the New Zealand dollar could appreciate against both the Australian and American currencies at the same time. Volatility in the TWI would be greater than trade-weighted volatility in individual exchange rates.

This raises a question regarding the appropriateness of these measures of exchange rate volatility. A related measure could consider only the trade-weighted sum of volatilities in individual exchange rates rather than including covariances.

[16] The assumption of fixed weights is invoked here to obtain the equality of line three with line two. When the weights drift, they contribute to the variance in a non-constant manner and cannot be taken outside of the bracket term as they have been here.

In a currency union we have

$$\begin{aligned} twi' &= \sum_i w_i x_i' \\ \Rightarrow \text{var}(p') &= \text{var}\left(\sum_i w_i \Delta x_i' \right) \quad \text{(A1.4)} \\ &= \sum_i \text{var}(w_i \Delta x_i') + \sum_{i \neq j} \text{cov}(w_i \Delta x_i', w_j \Delta x_j') \end{aligned}$$

where the x's are the cross-rates of the anchor adjusted by the exchange rate of New Zealand with the anchor country at the date the currency union is formed.

A1.2 The Two Country Case

Consider a two country world. The TWI basket has only one currency in it. Thus TWI volatility is given by:

$$\begin{aligned} v &= \text{var}(p) \\ &= \text{var}(\Delta x) \end{aligned} \quad \text{(A1.5)}$$

If we were to go into a currency union with the other country volatility would become

$$\begin{aligned} v' &= \text{var}(p') \\ &= \text{var}(\Delta x') \quad \text{(A1.6)} \\ &= 0 \end{aligned}$$

as the exchange rate is now a constant. All exchange rate volatility is eliminated by this policy.

A1.3 Three Country Case

One of the decisions New Zealand would have to make if we went into a currency union is who the anchor country should be. The optimal anchor is not the one against which we have the most volatility prior to currency union, but the one that is most important (that is, has the higher weight)[17].

In a currency union with country *i* the (log) exchange rate with currency *j* is

$$x'_j = x_j - x_i \qquad \text{(A1.7)}$$

TWI volatility in a currency union with country one is

$$\begin{aligned} v'_1 &= \mathrm{var}(w_2 \Delta x'_2) \\ &= \mathrm{var}(w_2(\Delta x_2 - \Delta x_1)) \\ &= w_2^2 \,\mathrm{var}(\Delta x_2 - \Delta x_1) \\ &= w_2^2 \,\mathrm{var}(\Delta x_1 - \Delta x_2) \end{aligned} \qquad \text{(A1.8)}$$

TWI volatility in a currency union with country two is

$$\begin{aligned} v'_2 &= \mathrm{var}(w_1 \Delta x'_1) \\ &= \mathrm{var}(w_1(\Delta x_1 - \Delta x_2)) \\ &= w_1^2 \,\mathrm{var}(\Delta x_1 - \Delta x_2) \end{aligned} \qquad \text{(A1.9)}$$

The difference between a currency union with country one versus country two in terms of volatility is

$$\begin{aligned} &v'_1 - v'_2 = (w_2^2 - w_1^2)\mathrm{var}(\Delta x_1 - \Delta x_2) \\ &< 0 \Leftrightarrow w_1 > w_2 \end{aligned} \qquad \text{(A1.10)}$$

That is, if country one has a higher weight, then volatility will be lower in a currency union with that country. Conversely, if country one's weight is lower, country two is the preferred currency union anchor on volatility grounds.

When there are two countries, currency union will eliminate all exchange rate volatility. However, when there are more countries, a currency union will only reduce some of the volatility, if any. As the number of countries grows, the amount to be gained by currency union, in terms of volatility reductions, falls.

[17] Note that the criterion used for deciding on the appropriate anchor is based on the metric of exchange rate volatility alone. In practice, many other considerations will enter the formula.

Under what circumstances would a currency union result in higher volatility? The change in volatility from the base case of an independent currency is given by

$$\begin{aligned} v'_1 - v &= w_2^2[\mathrm{var}(\Delta x_1) + \mathrm{var}(\Delta x_2) - 2\,\mathrm{cov}(\Delta x_1, \Delta x_2)] \\ &\quad - w_1^2 \,\mathrm{var}(\Delta x_1) - w_2^2 \,\mathrm{var}(\Delta x_2) - 2 w_1 w_2 \,\mathrm{cov}(\Delta x_1, \Delta x_2) \\ &= -\left(1 + \frac{w_1}{w_2}\right) w_2^2 \left[\left(\frac{w_1}{w_2} - 1\right)\mathrm{var}(\Delta x_1) + 2\,\mathrm{cov}(\Delta x_1, \Delta x_2)\right] \end{aligned}$$

(A1.11)

If the right-hand side of equation 10 were positive, then currency union with country one would increase exchange rate volatility. An example of when this would occur is when country one is relatively unimportant (that is, w_1 is smaller than w_2) and the two exchange rates x_1 and x_2 tend to move in opposite directions.

A1.4 Four Country Case

In the three country case there is only one other currency after the currency union is formed. When there are four or more countries, there are still several other currency areas to trade with even after a currency union has been formed.

With four countries in the TWI basket, volatility in the TWI after currency union is given by

$$\begin{aligned} v'_1 &= \sum_i \mathrm{var}(w_i \Delta x'_i) + \sum_{i \neq j} \mathrm{cov}(w_i \Delta x'_i, w_j \Delta x'_j) \\ &= \sum_i w_i^2 \,\mathrm{var}(\Delta x_i - \Delta x_1) + \sum_{i \neq j} w_i w_j \,\mathrm{cov}(\Delta x_i - \Delta x_1, \Delta x_j - \Delta x_1) \end{aligned}$$

(A1.12)

Thus the difference between an independent currency and a currency union is

$$
\begin{aligned}
v_1' - v &= \sum_i w_i^2 \operatorname{var}(\Delta x_i - \Delta x_1) + \sum_{i \neq j} w_i w_j \operatorname{cov}(\Delta x_i - \Delta x_1, \Delta x_j - \Delta x_1) \\
&\quad - \sum_i w_i^2 \operatorname{var}(\Delta x_i) + \sum_{i \neq j} w_i w_j \operatorname{cov}(\Delta x_i, \Delta x_j) \\
&= \operatorname{var}(\Delta x_1) + 2w_1(w_1 - 2)\operatorname{var}(\Delta x_1) + 2w_2(w_2 - 2)\operatorname{cov}(\Delta x_2, \Delta x_1) \\
&\quad + 2w_3(w_3 - 2)\operatorname{cov}(\Delta x_3, \Delta x_1) + 2w_4(w_4 - 2)\operatorname{cov}(\Delta x_4, \Delta x_1)
\end{aligned}
\tag{A1.13}
$$

The coefficient of each covariance term (and of the second variance of Δx_i) is negative as each w is between zero and one. If the covariances are each positive then the only positive contribution to the expression on the right-hand side of (12) is the variance of Δx_1. In this case it is highly likely that the volatility will fall in a currency union. If the weight for country one is relatively small and the covariances are negative, then a currency union would probably result in higher volatility.

It is unlikely that New Zealand would contemplate such an arrangement though. The above condition describes a country that is a relatively unimportant trading partner. Furthermore our exchange rate with that country tends to move in opposite directions to our exchange rate with each other country. Equation (12) does serve to highlight the relevance of covariances. The higher the covariances are, the more volatility that a currency union removes.

Furthermore, the difference between a currency union with one or another country would depend on the relative importance of the two countries (with the more important country a better choice for the anchor country) and the volatility of the anchor's exchange rates with other countries.

Appendix 2
Testing for unit roots in TWI series

This appendix provides information about tests for unit roots. Two types of tests have been used on each of the nine exchange rate series: Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests.

Table A2.1 gives relevant statistics for the ADF tests applied to each exchange rate series. In applying the ADF test, a decision must be made regarding the appropriate model to test in. Should the model include a constant, a deterministic trend, or lagged differences of the dependent variable? I started with a general model–with both constant and trend–and moved to a more specific model only if one variable was insignificant and the null hypothesis could not be rejected. The lag length should be set to remove serial correlation, rather than improve explanatory power, so lags were added until serial correlation (of first order and fourth order, as assessed by the Breusch-Godfrey test) was absent from the model. In fact, none of the models from which the conclusions in table A2.1 come included any lags.

Table A2.1
ADF test results

Series	Test statistic	Crit value (5%)	Model	Conclusion
TWI5NZ	-0.6953	-1.9455	N	Can't reject H_0
TWI5AU	-2.2890	-2.9069	C	Can't reject H_0
TWI5US	-2.9483	-3.4801	C, t	Can't reject H_0
TWI14NZ	-0.5846	-1.9458	N	Can't reject H_0
TWI14AU	-3.1131	-2.9092	C	Reject H_0
TWI14US	-1.5878	-3.4836	C, t	Can't reject H_0
HWI5NZ	-0.7112	-1.9455	N	Can't reject H_0
HWI5AU	-1.4008	-1.9455	N	Can't reject H_0
HWIUS	-2.6448	-3.4801	C, t	Can't reject H_0

Critical values are from MacKinnon (1991). In the model column, n means neither a constant, nor a trend was included. C means a constant was included, and t a time trend.

The PP test deals with serial correlation differently from the ADF test. Instead of appending lags to the right-hand side variables, a heteroscedasticity and autocorrelation consistent (HAC) residual variance is used to compute standard errors for parameter estimates. EViews uses the Newey-West HAC residual variance. In most cases, we would not expect the PP test to contradict the ADF test above. In fact, table A2.2 below shows that the conclusions reached are the same regardless of which test is used.

Table A2.2
PP test results

Series	Test statistic	Crit value (5%)	Model	Conclusion
TWI5NZ	-0.6104	-1.9455	N	Can't reject H_0
TWI5AU	-2.3827	-2.9069	C	Can't reject H_0
TWI5US	-2.8813	-3.4801	C, t	Can't reject H_0
TWI14NZ	-0.6013	-1.9458	N	Can't reject H_0
TWI14AU	-3.1607	-2.9092	C	Reject H_0
TWI14US	-1.5486	-3.4836	C, t	Can't reject H_0
HWI5NZ	-0.6624	-1.9455	N	Can't reject H_0
HWI5AU	-1.3580	-1.9455	N	Can't reject H_0
HWI5US	-2.6018	-3.4801	C, t	Can't reject H_0

Critical values are from MacKinnon (1991). The symbols in the Model column are explained in the footnote to table A2.1. Truncation lag used is three for each regression.

Our conclusions regarding the stationarity or nonstationarity of the series are that the fourteen country trade-weighted index for a currency union with Australia does not have a unit root. However, for each other series examined, we cannot reject the unit root null hypothesis. Thus many standard statistical analysis techniques may be invalid when applied to these series.

Each series has also been tested for the presence of a second unit root. In every case, we can reject the possibility of a second unit root at the 5 per cent level of significance.

Appendix 3
The sample generalised variance

Given two samples we may want to know whether the variability of the two series are the same. The standard approach to this problem is to use an F-test. This presumes the samples are taken at random from normally distributed populations. If the samples are not independent, as is likely in this study, then the F-test is not the most appropriate test. A more appropriate test, taken from Anderson (1957), is the sample generalised variance test.

The null hypothesis is $H_0 : \sigma_1^2 = \sigma_2^2$, where σ^2 is the population variance. The test statistic is

$$2(N-1)\left[\frac{S_1^2 S_2^2 - S_{12}^2}{\sigma_1^2\sigma_2^2 - \sigma_{12}^2}\right]^{\frac{1}{2}} \qquad \text{(A3.1)}$$

and is distributed as $\chi^2_{(2N-4)}$ under the null hypothesis. N is the sample size, S_i^2 is the sample variance for sample i, and S_{12}^2 is the sample covariance. In practice the population variances and covariance are unknown and need to be approximated. We do this using the following approximation. First, divide the sample into m subsamples, indexed by k, with size n_k. Approximate the population variances and covariance by A3.2 and A3.3.

$$\sigma_i^2 \approx \bar{S}_i^2 = \frac{1}{N-m}\sum_{k=1}^{m}(n_k - 1)S_{i,k}^2 \qquad \text{(A3.2)}$$

$$\sigma_{12}^2 \approx \bar{S}_{12}^2 = \frac{1}{N-m}\sum_{k=1}^{m}(n_k - 1)S_{12,k}^2 \qquad \text{(A3.3)}$$

The distribution of the test statistic remains $\chi^2_{(2N-4)}$ under the null hypothesis.

In this paper m is chosen to be eight when N is 65 and m is four when N is 27. Each subsample is of approximately equal length.