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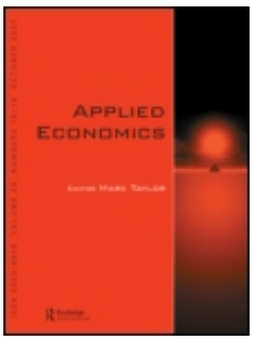
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The saving and investment nexus for China: evidence from cointegration tests

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The saving and investment nexus as postulated by Feldstein and Horioka (FH) (1980) is revisited. The saving investment correlation for China is estimated over the periods 1952–1998 and 1952–1994, the latter culminating in a period of fixed exchange rate regime. Amongst the key results, it is found that saving and investment are correlated for China for both the period of the fixed exchange rate and the entire sample period. With high saving-investment correlation, the results suggest that the Chinese economy is in conformity with the FH hypothesis. This is a valid outcome, for in China capital mobility was fairly restricted over the 1952–1994 period as indicated by the relatively low foreign direct investment.

I. Introduction

Feldstein and Horioka (1980) argued that in the presence of a high correlation between saving and investment (S–I) capital mobility should be low. This theory has generated voluminous literature over the last couple of decades. Several studies (see, *inter alia*, Sarno and Taylor, 1998; Abbott and Vita, 2003; Schmidt, 2003; Narayan, 2005) have tested this theory. At best, the empirical results are mixed. An important feature of the extant literature is that the bulk of the saving investment nexus is investigated for developed countries (see, *inter alia*, Abbott and Vita, 2003; Schmidt, 2003). Only a few studies (Sinha and Sinha, 1998; Sinha, 2002) investigate the issue for some developing Latin American and Asian countries within a time series cointegration and error correction framework.

This study differs from the extant literature in two novel ways. First, for the first time the saving investment nexus for a large developing economy, China, is investigated. China is a suitable case to study for, not only is it a large developing economy, it is also one of the high performing economies in the world. Its economy has grown at an exceptional rate of 9% per annum over the last couple of decades. China also has an interesting story with its exchange rate regime. In a broad sense, China followed a fixed exchange rate regime until 1994, and thereafter it has embraced a managed floating exchange rate regime (Jin, 2003). Second, the treatment of the data series is both comprehensive and unique. While Sinha (2002) has attempted to correct for structural breaks in the data exogenously, this is departed from by employing the Zivot and Andrews (ZA, 1992) and Lumsdaine and Papell (LP, 1997) tests employed to search for

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endogenous breaks. Given that Zivot and Andrews (1992) argue that the break points should be viewed as being correlated with the data, selecting the break exogenously could lead to an over rejection of the unit root hypothesis.

The aims of this paper are achieved in four steps. In the first step, a detailed unit root treatment of the data series is undertaken to establish their order of integration. The central idea behind this exercise is to ascertain whether, in the presence of structural breaks in the data, the series are integrated of order one or otherwise. To accomplish this the ZA (1992) and LP (1997) one break and two break tests for unit roots, respectively are used. In the second step, the bounds test and the residual based test for cointegration between China's savings and investment for two periods: 1952–1998 and 1952–1994 are applied, the latter being restricted to the period of the fixed exchange rate regime. An important contribution here is that critical values (CVs) for the bounds *F*-test for sample sizes are computed ranging from 30–80 observations. In the third step, the long run and short run elasticities are estimated. Here, the long run elasticities are derived using a range of estimators which are renowned for producing parsimonious results in small sample sizes. The autoregressive distributed lag (ARDL) approach, the fully modified ordinary least squares (FMOLS) estimator of Phillips and Hansen (1990) and the dynamic ordinary least squares (DOLS) estimator of Stock and Watson (1993) are used. It is believed that the use of more than one estimator is crucial if there is concern about the robustness of the results.

II. Model

To examine the S–I correlation for China, the generic long-run model is applied which has the following form:

$$I_t = \alpha_0 + \beta_1 S_t + \varepsilon_t \tag{1}$$

Here, I_t is gross national investment as a proportion of gross domestic product (GDP); S_t is gross national saving as a proportion of GDP; α is the constant; and ε_t is the disturbance term. The S–I correlation is determined by the size of beta.[1]

To examine the F–H hypothesis using time series econometric techniques, it is common to test Equation 1 under fixed and flexible exchange rates (see, for instance, Abbott and Vita, 2003). Following this group of researchers, Equation 1 is estimated over two subperiods – 1952 to 1994 and 1952 to 1999. The first subperiod signifies a period of relatively low degree of capital mobility and high trade and financial restrictions.[2] If the degree of capital mobility has important effects on the S–I correlation, then it is expected for β to be higher over 1952–1994 – the period of a fixed exchange rate regime – as compared to the period encompassed by the full sample.

III. Methodology

Unit roots

Two versions of the ZA (1992) sequential trend break model are used to investigate the unit root hypothesis for investment and saving. Model A allows for a change in intercept, while model C allows for a change in both the intercept and slope.[3] As an illustration, Model A has the following form:

$$\Delta y_t = \kappa + \alpha y_{t-1} + \beta t + \theta_1 DU_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{2}$$

Model C takes the following form:

$$\Delta y_t = \kappa + \alpha y_{t-1} + \beta t + \theta_1 DU_t + \gamma_1 DT_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{3}$$

Here, Δ is the first difference operator, ε_t is a white noise disturbance term with variance σ^2, and $t = 1, \ldots, T$ is an index of time. The Δy_{t-j} terms on the right-hand-side of Equations 2 and 3 allow for serial correlation and ensure that the disturbance term is white noise. Finally, DU_t is an indicator dummy variable for a mean shift occurring at time TB and DT_t is the corresponding trend shift

[1] Bayoumi (1990) has argued that the use of total investment may lead to spurious correlations with savings that reflect endogenous behaviour by private agents. In this light, it is useful to estimate the F–H equation using total business fixed investment. However, data on total business fixed investment is not available for China.

[2] China was admitted to the WTO in December 2001. China began opening its economy, albeit gradually, since 1979. See also Branstetter and Feenstra (2002, p. 336).

[3] Previous studies of the unit root hypothesis which have employed the Zivot and Andrews (1992) sequential trend break model have tended to use model C (e.g., Raj, 1992; Perron, 1994; Ben-David and Papell, 1995); however, there is no consensus on which model is superior.

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variable, where $DU_t = 1$ and $DT_t = t - TB$ if $t > TB$; 0 otherwise. As is conventional, 'trimming region' [0.15, 0.85] is chosen and the break point where the value of TB for which the ADF t-statistic is minimized selected. The 't-sig' approach suggested by Hall (1994) is used to select the optimal lag length. The null hypothesis here is that the series $[y_t]$ is an integrated process without a structural break, against the alternative hypothesis that $[y_t]$ is trend stationary with a structural break in the trend function which occurs at an unknown time. Whilst asymptotic critical values are available for this test, Zivot and Andrews (1992) warn that with small sample sizes the distribution of the test statistic can deviate substantially from this asymptotic distribution. To circumvent this distortion, 'exact' critical values for the test are calculated following the methodology recommended in Zivot and Andrews (1992, p. 262).

LP (1997) propose a model that tests endogenously for two structural breaks. In essence, they extend Zivot and Andrews (1992) models A and C and call these model AA and model CC respectively. The approach here with respect to lag length selection and estimation of critical values is as in the case of model A and model C (for further details, see Narayan and Narayan, 2005)

Cointegration

Bounds testing approach. To implement the bounds testing procedure, it is essential to model Equation 1 as a conditional autoregressive distributed lag model (ARDL) as follows:

$$\Delta I_t = \alpha_0 + \theta_1 I_{t-1} + \theta_2 S_{t-1} + \sum_{i=1}^{p} \varpi_i \Delta I_{t-i} + \sum_{j=0}^{p} \beta_j \Delta S_{t-j} + \varepsilon \quad (4)$$

Here, all the variables are as previously defined. The bounds test for examining evidence for a long run relationship can be conducted using the F-test. The F-test statistic tests the joint significance of the coefficients on the one period lagged levels of the variables in Equation 6, that is, $H_0: \theta_1 = \theta_2 = 0$. The asymptotic distribution of critical values is obtained for cases in which all regressors are purely $I(1)$ as well as when the regressors are purely $I(0)$ or mutually cointegrated.

These hypotheses can be examined using the standard Wald or F statistics. The F test has a non-standard distribution which depends upon: (a) whether variables included in the ARDL model are $I(0)$ or $I(1)$; (b) the number of regressors, (c) whether the ARDL model contains an intercept and/or a trend; and (c) the sample size. Two sets of critical values are reported in Pesaran and Pesaran (1997) as well as in Pesaran *et al*. (2001). The two sets of critical values provide critical value bounds for all classifications of the regressors into purely $I(1)$, purely $I(0)$ or mutually cointegrated. However, these CVs are generated for sample sizes of 500 and 1000 observations and 20 000 and 40 000 replications respectively. Narayan (2004a, 2004b) and Narayan (2005) argues that exiting CVs, because they are based on large sample sizes, cannot be used for small sample sizes. For instance, he compares the critical values generated with 31 observations and the critical values reported in Pesaran *et al*. (2001) and finds that the upper bound CV at the 5% significance level for 31 observations with 4 regressors is 4.13 while the corresponding CV for 1000 observations is 3.49, which is 18.3% lower than the CV for 31 observations.[4] Given the relatively small sample size in the present study (43 observations and 47 observations) critical values are calculated specific to the sample size. As an additional contribution to the literature, critical values for sample sizes ranging from 30–80 observations are calculated and reported in the Appendix. These CVs are calculated using the same GAUSS code used to generate the original set of CVs. Further details on the methodology can be found in Pesaran *et al*. (2001). If the computed F statistics is higher than the upper bound of the critical values then the null hypothesis of no cointegration is rejected.

Residual based test for cointegration with regime shifts. The Gregory and Hansen (1996) test is applicable for $I(1)$ processes. Gregory and Hansen (1996) propose three models of a structural change. In the terminology of Gregory and Hansen, model 2C represents a level shift which takes the following form:

$$y_t = \alpha_1 + \alpha_2 D_t^{\tau} + \beta x_t + \mu_t \qquad t = 1, \ldots, n \quad (5)$$

Here $D_t^{\tau} = 0$ for $t < \tau$ and $D_t^{\tau} = 1$ for $t \geq \tau$. α_1 is the intercept before the shift and α_2 is the change in intercept due to the shift.

Model 3 is one with a level shift and trend (C/T). This takes the following form:

$$y_t = \alpha_1 + \alpha_2 D_t^{\tau} + \beta_0 t + \beta_1^{\tau} x_{2t} + \mu_t \qquad t = 1, \ldots, n \quad (6)$$

[4] Similar line of argument was taken by Narayan and Narayan (2005).

Table 1. Zivot and Andrews test for unit roots with one structural break

	Investment				Saving			
	Period: 1952–1998		Period: 1952–1994		Period: 1952–1998		Period: 1952–1994	
	Model A	Model C	Model A	Model C	Model A	Model C	Model A	Model C
	1971	1959	1958	1959	1958	1959	1967	1959
α	−2.4441	−1.1718	−0.9615	−1.1568	−0.6340	−0.8434	−0.6997	−0.8424
	(−7.2667)	(−6.7275)	(−5.5723)	(−6.6638)	(−5.9429)	(−7.7977)	(−5.8632)	(−7.3532)
θ	0.1076***	−0.1572	−0.2376***	−0.4600	−0.0392**	−0.0978	0.0919	−0.3159
	(4.7040)	(−0.0278)	(−2.7665)	(−0.0635)	(−2.5473)	(−0.0167)	(1.4477)	(−0.0545)
γ	–	−3.7533	–	−3.7034	–	−4.1614	–	−3.7753
		(−2.4139)		(−1.8874)		(−3.0555)		(−2.7674)
k	7	1	1	1	0	0	0	0
Exact critical values								
1%	−7.8403	−8.4799	−8.1098	−8.5651	−7.8954	−8.4575	−7.9707	−7.3302
5%	−7.0256	−7.7180	−7.2162	−7.6808	−7.1123	−7.7629	−7.1971	−7.7181
10%	−6.6437	−7.3043	−6.7909	−7.3161	−6.6862	−7.3593	−6.7855	−8.4354

Note: **(***) denotes statistical significance at the 5% and 1% levels respectively.

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Model 4 is one with a regime shift (C/S). This takes the following form:

$$y_t = \alpha_1 + \alpha_2 D_t^\tau + \beta_0 t + \beta_1^\tau x_{2t} + \beta_2^\tau x_{2t} D_t^\tau + \mu_t$$
$$t = 1, \ldots, n \quad (7)$$

Here, α_1 and α_2 are as in models 2 and 3, β_1 denotes the cointegrating slope coefficients before the regime shift, and β_2 denotes the change in the slope coefficient. To test for cointegration between y_t and x_t with structural change, i.e. the stationarity of μ_t in Equations 5–7 Gregory and Hansen (1996) propose a suite of tests. These statistics are the commonly used ADF statistic and extensions of the Z_α and Z_t test statistics of Phillips (1987). These statistics are defined as:

$$ADF^* = \inf_{\tau \varepsilon T} ADF(\tau) \quad (8)$$

$$Z_\alpha^* = \inf_{\tau \varepsilon T} Z_\alpha(\tau) \quad (9)$$

$$Z_t^* = \inf_{\tau \varepsilon T} Z_t(\tau) \quad (10)$$

If the breakpoint is unknown *a priori*, the model is estimated recursively allowing the breakpoint τ to vary such that $|0.15T| \leq \tau \leq |0.85T|$, where T is the sample size. The null hypothesis of no cointegration is investigated by application of the three tests (Equations 8–10). Here interest is in the smallest values for $ADF(\tau)$, $Z_\alpha(\tau)$ and $Z_t(\tau)$ across all possible breakpoints required to reject the null hypothesis.

IV. Empirical Results

Data

The data used in this paper are obtained from the *Comprehensive Statistical Data and Materials on 50 Years of New China*. This publication has annual data for China from 1952 to 1998.

Unit root test

While the bounds test for cointegration does not depend on pre-testing the order of integration, all variables need to be integrated of order one in order to apply the Gregory and Hansen (1996) test. The integration property of the series are also important given that other long-run estimators are used – the Philips–Hansen fully modified OLS and the Dynamic OLS of Stock and Watson.

To ascertain the order of integration, the work begins through applying the Augmented Dickey–Fuller (ADF) and Phillips Perron (PP) unit root tests. The ADF and PP tests suggest that [I, S] are each integrated of order one or $I(1)$. These results are not reported here to conserve space. However, one of the main concerns in this paper is with the implications of structural breaks on unit roots. Given the inability of standard ADF and PP to capture the impact of structural breaks, to circumvent this it is reported in Tables 1 and 2 the ZA (1992) one-break test results and the LP (1997) two-break test results, respectively. The ZA test with one structural break finds no additional evidence against the unit root null hypothesis relative to the unit root tests without

Table 2. Lumsdaine and Papell test for unit roots with two breaks

	Investment				Saving			
	Period: 1952–1998		Period: 1952–1994		Period: 1952–1998		Period: 1952–1994	
	Model A	Model C	Model A	Model C	Model A	Model C	Model A	Model C
TB_1	1959	1959	1959	1959	1968	1959	1959	1959
TB_2	1968	1977	1963	1975	1979	1977	1970	1977
α	−1.1298	−1.3439	−0.9631	−1.1722	−1.2363	−1.1678	−1.8862	−1.1814
	(−7.7152)	(−9.8421)	(−7.5483)	(−7.1703)	(−7.7352)	(−10.1665)	(−7.4935)	(−9.6450)
θ	−0.3104	−0.7214	−0.4525	−0.6669	0.1946	−0.5999	−0.3640	−0.6037
	(0.2577)	(−0.1516)	(0.3096)	(−0.0130)	(−0.1592)	(−0.1743)	(0.2537)	(−0.1633)
ω	−4.1668***	−0.0536	−4.7733***	−0.0478	6.3070***	−0.0833	−3.9414***	−0.0841
	(3.6006)	(−0.0335)	(3.5250)	(−0.0449)	(−5.1683)	(−0.0194)	(4.7888)	(−0.0214)
γ	–	−6.6734**	–	−4.8176	–	−8.1754***	–	−7.8090***
		(−2.2975)		(0.1541)		(−4.1019)		(−3.4356)
ψ	–	−2.1048***	–	−1.4799***	–	−4.7533***	–	−4.5595***
		(−5.1139)		(−4.8121)		(−4.7929)		(−4.2282)
k	1	1	0	1	7	1	6	1
Exact critical values								
1%	−11.4133	−10.4325	−11.0534	−9.7866	−11.7936	−10.7899	−11.1734	−9.5513
5%	−10.3680	−9.7180	−10.0154	−8.8337	−10.3975	−9.7935	−10.2911	−8.8910
10%	−9.8446	−8.3158	−9.5048	−8.4414	−9.8047	−8.4209	−9.6966	−8.5159

Note: **(***) denotes statistical significance at the 5% and 1% levels respectively.

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a structural break. In other words, in models A and C the unit root null hypotheses are not rejected at the 1% level for saving and investment for both the periods: 1952–1998 and 1952–1994. This result is consistent with the standard ADF and PP test results.

While it is true that the ZA (1992) test, by virtue of accounting for one structural break, is an advance over standard ADF and PP tests, it is argued that the ZA test may lose power when confronted with two or more breaks (see Lee and Strazicich, 2003). To address this problem, the procedure devised by LP (1997), which was explained earlier, is a good remedy. The results are presented in Table 2. Neither model AA nor model CC could reject the null hypothesis of a unit root in investment and saving at the 1% level for both the sample periods.

Cointegration tests

The cointegration test under the bounds framework involves the comparison of the *F*-statistics against the critical values, which are generated for specific sample sizes. Using Equation 4, each variable in the model – Equation 1 – is taken as a dependent variable in the calculation of the *F*-statistics. The calculated *F*-statistics are reported in panel A of Table 3.

When investment is the dependent variable for China, the calculated *F*-statistic $F_I(I|S) = 6.885$ is higher than the upper bound critical value of 4.460 at the 5% level, for the 1952–1998 period. However, if China's saving rate is the dependent variable over the same period, the calculated *F*-statistic $F_S(S|I) = 2.928$ is lower that the lower bound critical value at the 5% level. The same conclusion can be drawn for the 1952–1994 period. This suggests that the null hypothesis of no cointegration cannot be accepted for China when investment is the dependent variable.

The Gregory and Hansen test for cointegration in models with regime shift for the two periods (1952–1998 and 1952–1994) are presented in panel B of Table 3. The test results corroborate those from the bounds testing approach, leading to the conclusion that there is compelling evidence for cointegration between investment and saving for China both with and without regime changes.[5]

[5] The Gregory and Hansen (1996) test only accounts for one structural break. However, this test is applied despite finding two breaks in the data series. This is done because there is no cointegration technique that accounts for two breaks. The break points given by the Zivot and Andrews (1992) and Lumsdaine and Papell (1997) unit root tests are somewhat different to those given by the Gregory and Hansen (1996) cointegration test though the majority of the breaks are either 1957, 1958 or 1959. The different break dates are due to the fact that the tests for unit roots search for breaks in a series while the cointegration test searches for a break in the residual of two series. For an analysis of structural breaks in China's GDP, see Narayan (2004c).

Table 3. Conintegration test results

Panel A: Bound test for cointegration						
Critical value bounds of the F statistic: intercept and no trend						
	90% level		95% level		99% level	
T	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
47	3.190	3.730	3.877	4.460	5.607	6.193
43	3.210	3.730	3.937	4.523	5.593	6.333
Calculated F statistic						
Period			$F_I(I\|S)$		$F_S(S\|I)$	
1952–1998 ($T=47$)			6.8850		2.9288	
1952–1994 ($T=43$)			6.9520		2.6821	
Panel B: Gregory and Hansen test for cointegration						
Dependent variable I_t						
Model (1952–1998)	ADF^*	T_b	Z_t^*	T_b	Z_α^*	T_b
2(C)	−5.0733 ($K=0$)	1991	−5.0979	1991	−34.4413	1958
3(C/T)	−5.1701 ($K=0$)	1972	−5.1897	1958	−33.7371	1958
4(C/S)	−5.1171 ($K=0$)	1985	−5.1394	1985	−33.6101	1960
Model (1952–1994)						
2(C)	−5.6565 ($K=0$)	1957	−5.9556	1958	−37.5615	1958
3(C/T)	−5.8495 ($K=0$)	1958	−5.9165	1958	−37.1227	1957
4(C/S)	−5.6853 ($K=0$)	1957	−5.7875	1960	−39.1776	1957
Critical values						
Model [significance level]			ADF^*, Z_t^*		Z_α^*	
2(C) [10%]			−4.34		−36.19	
3(C/T) [10%]			−4.72		−43.22	
4(C/S) [10%]			−4.68		−41.85	
2(C) [5%]			−4.61		−40.48	
3(C/T) [5%]			−4.99		−47.96	
4(C/S) [5%]			−4.95		−47.04	

Note: Critical values are extracted from Table in Gregory and Hansen (1996, p. 109).

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Long-run and short-run elasticities

Since investment and saving are cointegrated the long-run model for the two sample periods was estimated using the following ARDL specification:

$$I_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 I_{t-i} + \sum_{i=0}^{n} \alpha_2 S_{t-i} + \mu_t \qquad (11)$$

On the Schwarz Bayesian Criteria (SBC), maximum of 2 lags was used for the model, such that $i_{\max}=2$. The results are presented in Table 4 along with results from two other long-run estimators – the FMOLS and the DOLS – shown to provide robust results in small sample sizes. All the three approaches provide similar results on the long-run correlation, demonstrating the robustness of the results. The three techniques indicate a strong correlation between national saving and investment rates for both the sample periods. The correlation is stronger for the 1952–1994 period than the 1952–1999 period (see Panel A, Table 4).

The error correction model was also estimated within the ARDL framework. The results for the 1952–1994 period show that the error correction term – ECM_{t-1} – is negative, indicating that the feedback mechanism is very effective in China in stabilizing China's external imbalances (Panel B, Table 4). In other words, convergence to long-run equilibrium after a shock to saving is instantaneous for investment in China. The ECM_{t-1} is weaker over the 1952–1998 period, taking the value of −0.62, suggesting that a deviation from the long-run equilibrium level of investment in one year is corrected by about 62% in the next year.

As for the short-run correlations, it is stronger in the periods of relatively lower degree of capital mobility consistent with the long run. However, the short-run correlations reflect business cycle

Table 4. Long-run and short-run elasticities

Panel A: Long-run elasticities						
Dependent variable: I_t						
	ARDL		P–H		DOLS	
Period	Constant	S_t	Constant	S_t	Constant	S_t
1952–1994	0.0089	1.1669***	0.0469*	1.0511***	0.0179	1.1345***
	(0.3601)	(15.6021)	(1.8110)	(13.3229)	(0.5987)	(12.4386)
1952–1998	0.0574***	0.9951***	0.0839***	0.9251***	0.0612**	0.9896***
	(8.3622)	(8.3622)	(2.9190)	(10.8603)	(2.1088)	(11.4683)
Panel B: short-run elasticities						
Dependent variable: ΔI_t						
	Constant		ΔS_t		ECM_{t-1}	
1952–1994	0.0089		1.1669***		−1.000***	
	(0.3601)		(15.6021)		(−5.5519)	
1952–1998	0.0356		1.2531		−0.6200***	
	(1.3826)		(10.4614)		(−4.2773)	

Note: *** (**) * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The figures in parentheses are the *t*-statistics.

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influences – adjustment in demand and supply shocks rather than the degree of capital mobility.

V. Conclusion

Feldstein and Horioka (FH, 1980) argued that in a closed economy, because capital mobility is restricted or non-existent, the saving–investment correlation would be high. This idea has puzzled many investigators, for FH (1980) found a high saving investment correlation for OECD countries despite their more open and integrated markets. In this paper, the FH (1980) thesis is revisited and tested for China over the periods 1952–1994 and 1952–1998, the former culminating a period of a fixed exchange rate. In doing so, three novel contributions are made to the literature. First, a large developing economy is studied for the first time within a time series framework; extant literature concentrates mainly on developed countries in testing the FH hypothesis. It is believed that any hypothesis gains popularity, acceptability or criticism once it is tested for a range of economies with different economic structures. In this light China, an economy that has performed exceptionally over the last couple of decades, is a suitable candidate. Secondly, treatment of the data series is both comprehensive and unique. Exogenous treatment of breaks in data series is departed from by employing, for the first time in this literature, the Zivot and Andrews (1992) and Lumsdaine and Papell (1997) tests in search for endogenous breaks. This is a crucial exercise, for Zivot and Andrews (1992) argue that the break points should be viewed as being correlated with the data; hence, selecting the break exogenously could lead to an over rejection of the unit root hypothesis. A third contribution of this study is that critical values for the bounds *F*-test are calculated for sample sizes ranging from 30–80 observations. This information is likely to be useful for researchers using the bounds testing approach to cointegration among small sample sizes.

Amongst the key results, it is found that saving and investment are cointegrated for China for both the period of the fixed exchange rate, 1952–1994 and the entire sample 1952–1998. The S–I correlation is positive and statistically significant over the sample covering the fixed exchange rate period. This result suggests that the Chinese economy is in conformity with the FH hypothesis, which is not surprising given that over the 1952–1994 period capital mobility has been fairly restricted in China as indicated by the relatively low foreign direct investment.[6]

[6] Foreign direct investment in China has increased rapidly in the 1990s, with real investment consistently been around 30% of real gross domestic product. 'For the last 5 years – with the exception of 1999 – China has been the world's second largest recipient of foreign direct investment' (Wang and Yao, 2002, p. 14).

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Appendix

Critical values for the bounds test: Case II: restricted intercept and no trend

	$k=0$		$k=1$		$k=2$		$k=3$		$k=4$		$k=5$		$k=6$		$k=7$	
n	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
1 per cent																
30	7.595	7.595	6.027	6.760	5.155	6.265	4.614	5.966	4.280	5.840	4.134	5.761	3.976	5.691	3.864	5.694
35	7.350	7.350	5.763	6.480	4.948	6.028	4.428	5.816	4.093	5.532	3.900	5.419	3.713	5.326	3.599	5.230
40	7.220	7.220	5.593	6.333	4.770	5.855	4.310	5.544	3.967	5.455	3.657	5.256	3.505	5.121	3.402	5.031
45	7.265	7.265	5.607	6.193	4.800	5.725	4.270	5.412	3.892	5.173	3.674	5.019	3.540	4.931	3.383	4.832
50	7.065	7.065	5.503	6.240	4.695	5.758	4.188	5.328	3.845	5.150	3.593	4.981	3.424	4.880	3.282	4.730
55	6.965	6.965	5.377	6.047	4.610	5.563	4.118	5.200	3.738	4.947	3.543	4.839	3.330	4.708	3.194	4.562
60	6.960	6.960	5.383	6.033	4.558	5.590	4.068	5.250	3.710	4.965	3.451	4.764	3.293	4.615	3.129	4.507
65	6.825	6.825	5.350	6.017	4.538	5.475	4.056	5.158	3.725	4.940	3.430	4.721	3.225	4.571	3.092	4.478
70	6.740	6.740	5.157	5.957	4.398	5.463	3.916	5.088	3.608	4.860	3.373	4.717	3.180	4.596	3.034	4.426
75	6.915	6.915	5.260	5.957	4.458	5.410	4.048	5.092	3.687	4.842	3.427	4.620	3.219	4.526	3.057	4.413
80	6.695	6.695	5.157	5.917	4.358	5.393	3.908	5.004	3.602	4.787	3.351	4.587	3.173	4.485	3.021	4.350
5 per cent																
30	5.070	5.070	4.090	4.663	3.538	4.428	3.272	4.306	3.058	4.223	2.910	4.193	2.794	4.148	2.730	4.163
35	4.945	4.945	3.957	4.530	3.478	4.335	3.164	4.194	2.947	4.088	2.804	4.013	2.685	3.960	2.597	3.907
40	4.960	4.960	3.937	4.523	3.435	4.260	3.100	4.088	2.893	4.000	2.734	3.920	2.618	3.863	2.523	3.829
45	4.895	4.895	3.877	4.460	3.368	4.203	3.078	4.022	2.850	3.905	2.694	3.829	2.591	3.766	2.504	3.723
50	4.815	4.815	3.860	4.440	3.368	4.178	3.048	4.002	2.823	3.872	2.670	3.781	2.550	3.708	2.457	3.650
55	4.795	4.795	3.790	4.393	3.303	4.100	2.982	3.942	2.763	3.813	2.617	3.743	2.490	3.658	2.414	3.608
60	4.780	4.780	3.803	4.363	3.288	4.070	2.962	3.910	2.743	3.792	2.589	3.683	2.456	3.598	2.373	3.540
65	4.780	4.780	3.787	4.343	3.285	4.070	2.976	3.896	2.750	3.755	2.596	3.677	2.473	3.583	2.373	3.519
70	4.750	4.750	3.780	4.327	3.243	4.043	2.924	3.860	2.725	3.718	2.564	3.650	2.451	3.559	2.351	3.498
75	4.760	4.760	3.777	4.320	3.253	4.065	2.946	3.862	2.725	3.718	2.574	3.641	2.449	3.550	2.360	3.478
80	4.725	4.725	3.740	4.303	3.235	4.053	2.920	3.838	2.688	3.698	2.550	3.606	2.431	3.518	2.336	3.458
10 per cent																
30	4.025	4.025	3.303	3.797	2.915	3.695	2.676	3.586	2.525	3.560	2.407	3.517	2.334	3.515	2.277	3.498
35	3.980	3.980	3.223	3.757	2.845	3.623	2.618	3.532	2.460	3.460	2.331	3.417	2.254	3.388	2.196	3.370
40	3.955	3.955	3.210	3.730	2.835	3.585	2.592	3.454	2.427	3.395	2.306	3.353	2.218	3.314	2.152	3.296
45	3.950	3.950	3.190	3.730	2.788	3.540	2.560	3.428	2.402	3.345	2.276	3.297	2.188	3.254	2.131	3.223
50	3.935	3.935	3.177	3.653	2.788	3.513	2.538	3.398	2.372	3.320	2.259	3.264	2.170	3.220	2.099	3.181
55	3.900	3.900	3.143	3.670	2.748	3.495	2.508	3.356	2.345	3.280	2.226	3.241	2.139	3.204	2.069	3.148
60	3.880	3.880	3.127	3.650	2.738	3.465	2.496	3.346	2.323	3.273	2.204	3.210	2.114	3.153	2.044	3.104
65	3.880	3.880	3.143	3.623	2.740	3.455	2.492	3.350	2.335	3.252	2.209	3.201	2.120	3.145	2.043	3.094
70	3.875	3.875	3.120	3.623	2.730	3.445	2.482	3.310	2.320	3.232	2.193	3.161	2.100	3.121	2.024	3.079
75	3.895	3.895	3.133	3.597	2.725	3.455	2.482	3.334	2.313	3.228	2.196	3.166	2.103	3.111	2.023	3.068
80	3.870	3.870	3.113	3.610	2.713	3.453	2.474	3.312	2.303	3.220	2.303	3.154	2.088	3.103	2.017	3.052

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Critical values for the bounds test: case III: unrestricted intercept and no trend

	$k=0$		$k=1$		$k=2$		$k=3$		$k=4$		$k=5$		$k=6$		$k=7$	
n	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
1 per cent																
30	13.680	13.680	8.170	9.285	6.183	7.873	5.333	7.063	4.768	6.670	4.537	6.370	4.270	6.211	4.104	6.151
35	13.290	13.290	7.870	8.960	6.140	7.607	5.198	6.845	4.590	6.368	4.257	6.040	4.016	5.797	3.841	5.686
40	13.070	13.070	7.625	8.825	5.893	7.337	5.018	6.610	4.428	6.250	4.045	5.898	3.800	5.643	3.644	5.464
45	12.930	12.930	7.740	8.650	5.920	7.197	4.983	6.423	4.394	5.914	4.030	5.598	3.790	5.411	3.595	5.225
50	12.730	12.730	7.560	8.685	5.817	7.303	4.865	6.360	4.306	5.874	3.955	5.583	3.656	5.331	3.498	5.149
55	12.700	12.700	7.435	8.460	5.707	6.977	4.828	6.195	4.244	5.726	3.928	5.408	3.636	5.169	3.424	4.989
60	12.490	12.490	7.400	8.510	5.697	6.987	4.748	6.188	4.176	5.676	3.783	5.338	3.531	5.081	3.346	4.895
65	12.400	12.400	7.320	8.435	5.583	6.853	4.690	6.143	4.188	5.694	3.783	5.300	3.501	5.051	3.310	4.871
70	12.240	12.240	7.170	8.405	5.487	6.880	4.635	6.055	4.098	5.570	3.747	5.285	3.436	5.044	3.261	4.821
75	12.540	12.540	7.225	8.300	5.513	6.860	4.725	6.080	4.168	5.548	3.772	5.213	3.496	4.966	3.266	4.801
80	12.120	12.120	7.095	8.260	5.407	6.783	4.568	5.960	4.096	5.512	3.725	5.163	3.457	4.943	3.233	4.760
5 per cent																
30	8.770	8.770	5.395	6.350	4.267	5.473	3.710	5.018	3.354	4.774	3.125	4.608	2.970	4.499	2.875	4.445
35	8.640	8.640	5.290	6.175	4.183	5.333	3.615	4.913	3.276	4.630	3.037	4.443	2.864	4.324	2.753	4.209
40	8.570	8.570	5.260	6.160	4.133	5.260	3.548	4.803	3.202	4.544	2.962	4.338	2.797	4.211	2.676	4.130
45	8.590	8.590	5.235	6.135	4.083	5.207	3.535	4.733	3.178	4.450	2.922	4.268	2.764	4.123	2.643	4.004
50	8.510	8.510	5.220	6.070	4.070	5.190	3.500	4.700	3.136	4.416	2.900	4.218	2.726	4.057	2.593	3.941
55	8.390	8.390	5.125	6.045	3.987	5.090	3.408	4.623	3.068	4.334	2.848	4.160	2.676	3.999	2.556	3.904
60	8.460	8.460	5.125	6.000	4.000	5.057	3.415	4.615	3.062	4.314	2.817	4.097	2.643	3.939	2.513	3.823
65	8.490	8.490	5.130	5.980	4.010	5.080	3.435	4.583	3.068	4.274	2.835	4.090	2.647	3.921	2.525	3.808
70	8.370	8.370	5.055	5.915	3.947	5.020	3.370	4.545	3.022	4.256	2.788	4.073	2.629	3.906	2.494	3.786
75	8.420	8.420	5.140	5.920	3.983	5.060	3.408	4.550	3.042	4.244	2.802	4.065	2.637	3.900	2.503	3.768
80	8.400	8.400	5.060	5.930	3.940	5.043	3.363	4.515	3.010	4.216	2.787	4.015	2.627	3.864	2.476	3.746
10 per cent																
30	6.840	6.840	4.290	5.080	3.437	4.470	3.008	4.150	2.752	3.994	2.578	3.858	2.457	3.797	2.384	3.728
35	6.810	6.810	4.225	5.050	3.393	4.410	2.958	4.100	2.696	3.898	2.508	3.763	2.387	3.671	2.300	3.606
40	6.760	6.760	4.235	5.000	3.373	4.377	2.933	4.020	2.660	3.838	2.483	3.708	2.353	3.599	2.260	3.534
45	6.760	6.760	4.225	5.020	3.330	4.347	2.893	3.983	2.638	3.772	2.458	3.647	2.327	3.541	2.238	3.461
50	6.740	6.740	4.190	4.940	3.333	4.313	2.873	3.973	2.614	3.746	2.435	3.600	2.309	3.507	2.205	3.421
55	6.700	6.700	4.155	4.925	3.280	4.273	2.843	3.920	2.578	3.710	2.393	3.583	2.270	3.486	2.181	3.398
60	6.700	6.700	4.145	4.950	3.270	4.260	2.838	3.923	2.568	3.712	2.385	3.565	2.253	3.436	2.155	3.353
65	6.740	6.740	4.175	4.930	3.300	4.250	2.843	3.923	2.574	3.682	2.397	3.543	2.256	3.430	2.156	3.334
70	6.670	6.670	4.125	4.880	3.250	4.237	2.818	3.880	2.552	3.648	2.363	3.510	2.233	3.407	2.138	3.325
75	6.720	6.720	4.150	4.885	3.277	4.243	2.838	3.898	2.558	3.654	2.380	3.515	2.244	3.397	2.134	3.313
80	6.720	6.720	4.135	4.895	3.260	4.247	2.823	3.885	2.548	3.644	2.355	3.500	2.236	3.381	2.129	3.289

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Critical values for the bounds test: case IV: unrestricted intercept and restricted trend

	$k=0$		$k=1$		$k=2$		$k=3$		$k=4$		$k=5$		$k=6$		$k=7$	
n	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
1 per cent																
30	10.200	10.200	7.593	8.350	6.428	7.505	5.666	6.988	5.205	6.640	4.850	6.473	4.689	6.358	4.490	6.328
35	9.975	9.975	7.477	8.213	6.328	7.408	5.654	6.926	5.147	6.617	4.849	6.511	4.629	5.698	4.489	5.064
40	9.575	9.575	7.207	7.860	5.980	6.973	5.258	6.526	4.763	6.200	4.427	5.837	4.154	5.699	3.971	5.486
45	9.555	9.555	7.133	7.820	5.878	6.870	5.150	6.280	4.628	5.865	4.251	5.596	3.998	5.463	3.829	5.313
50	9.320	9.320	7.017	7.727	5.805	6.790	5.050	6.182	4.557	5.793	4.214	5.520	3.983	5.345	3.762	5.172
55	9.300	9.300	6.893	7.537	5.678	6.578	4.990	6.018	4.455	5.615	4.111	5.329	3.870	5.171	3.643	5.021
60	9.245	9.245	6.780	7.377	5.620	6.503	4.928	5.950	4.412	5.545	4.013	5.269	3.775	5.086	3.584	4.922
65	8.960	8.960	6.707	7.360	5.545	6.453	4.848	5.842	4.347	5.552	4.020	5.263	3.758	5.040	3.557	4.902
70	8.890	8.890	6.577	7.313	5.448	6.435	4.760	5.798	4.293	5.460	3.966	5.234	3.720	5.004	3.509	4.808
75	8.905	8.905	6.613	7.253	5.505	6.298	4.808	5.786	4.300	5.377	3.984	5.153	3.728	4.954	3.511	4.789
80	6.695	6.695	5.157	5.917	4.358	5.393	3.908	5.004	3.602	4.787	3.351	4.587	3.173	4.485	3.021	4.350
5 per cent																
30	7.040	7.040	5.377	5.963	4.535	5.415	4.048	5.090	3.715	4.878	3.504	4.743	3.326	4.653	3.194	4.604
35	6.900	6.900	5.233	5.777	4.433	5.245	3.936	4.918	3.578	4.668	3.353	4.500	3.174	4.383	3.057	4.319
40	6.870	6.870	5.180	5.733	4.360	5.138	3.850	4.782	3.512	4.587	3.257	4.431	3.070	4.309	2.933	4.224
45	6.750	6.750	5.130	5.680	4.335	5.078	3.822	4.714	3.470	4.470	3.211	4.309	3.025	4.198	2.899	4.087
50	6.685	6.685	5.043	5.607	4.225	5.030	3.730	4.666	3.383	4.432	3.149	4.293	2.975	4.143	2.832	4.012
55	6.660	6.660	5.013	5.547	4.183	4.955	3.692	4.582	3.358	4.365	3.131	4.206	2.946	4.065	2.791	3.950
60	6.630	6.630	4.980	5.527	4.180	4.938	3.684	4.584	3.323	4.333	3.086	4.154	2.900	3.999	2.756	3.892
65	6.550	6.550	4.950	5.467	4.123	4.903	3.626	4.538	3.300	4.280	3.063	4.123	2.880	3.978	2.730	3.879
70	6.530	6.530	4.930	5.457	4.100	4.900	3.600	4.512	3.272	4.272	3.043	4.100	2.860	3.951	2.711	3.842
75	6.580	6.580	4.937	5.443	4.120	4.855	3.624	4.488	3.298	4.260	3.054	4.079	2.874	3.914	2.718	3.807
80	4.725	4.725	3.740	4.303	3.235	4.053	2.920	3.838	2.688	3.698	2.550	3.606	2.431	3.518	2.336	3.458
10 per cent																
30	5.785	5.785	4.427	4.957	3.770	4.535	3.378	4.274	3.097	4.118	2.907	4.010	2.781	3.941	2.681	3.887
35	5.690	5.690	4.380	4.867	3.698	4.420	3.290	4.176	3.035	3.997	2.831	3.879	2.685	3.785	2.578	3.710
40	5.680	5.680	4.343	4.823	3.663	4.378	3.264	4.094	2.985	3.918	2.781	3.813	2.634	3.719	2.517	3.650
45	5.625	5.625	4.300	4.780	3.625	4.330	3.226	4.054	2.950	3.862	2.750	3.739	2.606	3.644	2.484	3.570
50	5.570	5.570	4.230	4.740	3.573	4.288	3.174	4.004	2.905	3.822	2.703	3.697	2.550	3.609	2.440	3.523
55	5.570	5.570	4.230	4.730	3.553	4.238	3.132	3.956	2.868	3.782	2.674	3.659	2.538	3.560	2.420	3.481
60	5.555	5.555	4.203	4.693	3.540	4.235	3.130	3.968	2.852	3.773	2.653	3.637	2.510	3.519	2.392	3.444
65	5.510	5.510	4.187	4.660	3.535	4.208	3.122	3.942	2.848	3.743	2.647	3.603	2.499	3.490	2.379	3.406
70	5.530	5.530	4.173	4.647	3.505	4.198	3.098	3.920	2.832	3.738	2.631	3.589	2.485	3.473	2.363	3.394
75	5.530	5.530	4.193	4.647	3.505	4.213	3.110	3.900	2.832	3.717	2.636	3.579	2.486	3.469	2.372	3.370
80	3.870	3.870	3.113	3.610	2.713	3.453	2.474	3.312	2.303	3.220	2.180	3.154	2.088	3.103	2.017	3.052

View publication stats

Critical values for the bounds test: case V: unrestricted intercept and unrestricted trend

	$k=0$		$k=1$		$k=2$		$k=3$		$k=4$		$k=5$		$k=6$		$k=7$	
n	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
1 per cent																
30	18.560	18.560	10.605	11.650	7.977	9.413	6.643	8.313	5.856	7.578	5.347	7.242	5.046	6.930	4.779	6.821
35	18.020	18.020	10.365	11.295	7.643	9.063	6.380	7.730	5.604	7.172	5.095	6.770	4.704	6.537	4.459	6.206
40	17.910	17.910	10.150	11.230	7.527	8.803	6.238	7.740	5.376	7.092	4.885	6.550	4.527	6.263	4.310	5.965
45	17.500	17.500	9.890	10.965	7.317	8.720	6.053	7.458	5.224	6.696	4.715	6.293	4.364	6.006	4.109	5.785
50	17.530	17.530	9.895	10.965	7.337	8.643	5.995	7.335	5.184	6.684	4.672	6.232	4.310	5.881	4.055	5.640
55	17.480	17.480	9.800	10.675	7.227	8.340	5.955	7.225	5.108	6.494	4.608	5.977	4.230	5.713	3.955	5.474
60	17.020	17.020	9.585	10.420	7.057	8.243	5.835	7.108	5.066	6.394	4.505	5.920	4.117	5.597	3.870	5.338
65	16.850	16.850	9.475	10.515	7.013	8.230	5.795	7.053	4.974	6.378	4.482	5.923	4.111	5.586	3.835	5.339
70	16.660	16.660	9.370	10.320	6.873	8.163	5.663	6.953	4.922	6.328	4.428	5.898	4.070	5.534	3.774	5.248
75	16.610	16.610	9.325	10.325	6.930	8.027	5.698	6.970	4.932	6.224	4.393	5.788	4.060	5.459	3.768	5.229
80	16.600	16.600	9.170	10.240	6.730	8.053	5.620	6.908	4.890	6.164	4.375	5.703	4.000	5.397	3.728	5.160
5 per cent																
30	12.740	12.740	7.360	8.265	5.550	6.747	4.683	5.980	4.154	5.540	3.818	5.253	3.576	5.065	3.394	4.939
35	12.580	12.580	7.210	8.055	5.457	6.570	4.568	5.795	4.036	5.304	3.673	5.002	3.426	4.790	3.251	4.640
40	12.510	12.510	7.135	7.980	5.387	6.437	4.510	5.643	3.958	5.226	3.577	4.923	3.327	4.700	3.121	4.564
45	12.400	12.400	7.080	7.910	5.360	6.373	4.450	5.560	3.890	5.104	3.532	4.800	3.267	4.584	3.091	4.413
50	12.170	12.170	6.985	7.860	5.247	6.303	4.368	5.545	3.834	5.064	3.480	4.782	3.229	4.536	3.039	4.339
55	12.170	12.170	6.930	7.785	5.190	6.223	4.313	5.425	3.794	4.986	3.442	4.690	3.197	4.460	2.989	4.271
60	12.200	12.200	6.905	7.735	5.190	6.200	4.298	5.445	3.772	4.956	3.407	4.632	3.137	4.393	2.956	4.230
65	11.960	11.960	6.890	7.660	5.137	6.173	4.268	5.415	3.732	4.920	3.372	4.613	3.137	4.363	2.924	4.206
70	12.000	12.000	6.860	7.645	5.110	6.190	4.235	5.363	3.720	4.904	3.368	4.590	3.107	4.343	2.913	4.168
75	12.080	12.080	6.880	7.675	5.140	6.153	4.253	5.333	3.724	4.880	3.382	4.567	3.111	4.310	2.915	4.143
80	12.060	12.060	6.820	7.670	5.067	6.103	4.203	5.320	3.678	4.840	3.335	4.535	3.077	4.284	2.885	4.111
10 per cent																
30	10.340	10.340	6.010	6.780	4.577	5.600	3.868	4.965	3.430	4.624	3.157	4.412	2.977	4.260	2.843	4.160
35	10.240	10.240	5.950	6.680	4.517	5.480	3.800	4.888	3.374	4.512	3.087	4.277	2.879	4.114	2.729	3.985
40	10.160	10.160	5.915	6.630	4.477	5.420	3.760	4.795	3.334	4.438	3.032	4.213	2.831	4.040	2.668	3.920
45	10.150	10.150	5.880	6.640	4.437	5.377	3.740	4.780	3.298	4.378	3.012	4.147	2.796	3.970	2.635	3.838
50	10.020	10.020	5.780	6.540	4.380	5.350	3.673	4.715	3.240	4.350	2.950	4.110	2.750	3.944	2.590	3.789
55	10.110	10.110	5.800	6.515	4.370	5.303	3.640	4.670	3.210	4.294	2.927	4.068	2.724	3.893	2.573	3.760
60	10.030	10.030	5.765	6.500	4.350	5.283	3.645	4.678	3.200	4.310	2.912	4.047	2.709	3.856	2.551	3.716
65	9.970	9.970	5.755	6.470	4.353	5.257	3.638	4.643	3.196	4.262	2.897	4.022	2.690	3.830	2.531	3.685
70	10.020	10.020	5.765	6.455	4.330	5.243	3.615	4.635	3.182	4.258	2.893	4.008	2.683	3.807	2.519	3.669
75	10.030	10.030	5.765	6.470	4.323	5.273	3.618	4.630	3.182	4.248	2.890	3.993	2.681	3.800	2.530	3.648
80	9.960	9.960	5.725	6.450	4.307	5.223	3.588	4.605	3.160	4.230	2.867	3.975	2.657	3.776	2.504	3.631

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