Current Accounts and Exchange Rates: A New Look at the Evidence

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1. Introduction

Financial and economic news reporters frequently include interviews with or quotations from economists that proclaim a connection between exchange rates and current accounts. Most economists assert that a J-Curve phenomena characterizes the data: that currency depreciation. Actual empirical studies on this issue, however,have shown a very mixed set of results.

Krugman and Baldwin (1987) find evidence of a J-Curve with an initial phase of current account deficits (following depreciation) that lasts about four quarters. Similarly, Foray and McMillan (1999) present evidence of a J-Curve. Their VAR results for the U.S. and a European aggregate, building on work by Eichenbaum and Evans, 1995, indicate that a negative monetary shock reduces real GDP for about 1-1/2 years, generates currency appreciation for about half a year, and creates a trade balance surplus for about 1 1/2 years, followed by trade deficits after that. This gives a typical J-Curve.

On the other hand**,** Moffett (1989) finds *no* evidence for the J-Curve for the United States. Similarly, Rose and Yellin (1989) find no reliable evidence of a J-Curve in 25 years of American data; in fact they "robustly" reject the J-Curve hypothesis with U.S. data, finding "no convincing evidence that a currency depreciation causes a trade deficit in the short run either in bilateral or aggregate U.S. data," and "little evidence of a reliable long run relationship between the exchange rates and a trade balance."

A standard theoretical explanation has emerged for the (alleged) J-Curve in the data. A currency depreciation, in the presence of little or no offsetting changes in nominal price levels, raises the relative price of imports to home buyers and reduces the relative price of home exports to foreign buyers. In the short run, the quantity of goods imported and exported may be largely predetermined by previously-signed trade contracts, so the fall in the *value* of a given quantity of home exports creates a trade deficit (or smaller surplus). Once new trade contracts are signed, the fall in the relative price of home goods raises the quantity of home goods demanded, creating a tendency for a trade surplus. Domestic goods are cheaper, so foreigners buy more of them and, with sufficiently high elasticities of demand, spend more on them. With these elasticity conditions satisfied, changes in quantities traded overwhelm the changes in valuations. Consequently, the currency depreciation leads to an eventual trade surplus. This *fall* in the trade surplus, followed by a *rise*, naturally led to the J-Curve nomenclature.

Backus, Kehoe, and Kydland (1994) take an a more general-equilibrium view of the problem, pointing out that the relation depends critically on the *source* of fluctuations. Their empirical results show that the trade balance is counter-cyclical and is generally *negatively* correlated with *current* and *future* changes in the terms of trade, but *positively* correlated with *past* changes in the terms of trade. Our statistical approach and results complement theirs, and add to the theoretical challenge of finding a model (including sources of distrubances) that can quantitatively reproduce the relations in the data.

The standard approach focuses on a single source of exogenous disturbance – an exogenous change in the exchange rate, given sluggish nominal prices, and leading to changes in quantities demanded and (with demand-determined quantities), trade flows and GDP. The standard model also makes questionable assumptions about prices: it relies on an *absence* of pricing-to-market (international price discrimination with nominal prices set in buyers' currencies). Recent evidence has emphasized the importance of pricing to market in the data, and a large set of recent theoretical work on exchange rates embodies that assumption. In addition, the standard J-Curve model has implications for other variables, such as GDP. In that model, a currency depreciation reduces the relative price of home products, leading to an (eventual) increase in aggregate demand (by foreigners) for domestic products, eventually raising exports *and* raising real GDP. Little empirical work has focused on this additional set of predictions of the standard model.

A small literature has developed exploring nonlinearities in exchange-rate data.[1] Our earlier paper, Leonard and Stockman (2000), tests the predictions of a wide class of theoretical models by examining nonlinearities in the bivariate relationships between exchange rates and cross-country ratios of GDP. That paper shows that when a country's real GDP rises (relative to another country) for a sustained period (at least 5 consecutive quarters), that country's currency initially *depreciates* in real terms, then *appreciates* significantly *above* its original level while GDP remains temporarily high. While the *initial* response is consistent with the main theoretical models, the subsequent response of the exchange rate contradicts those models.

Our current paper employs a similar approach to study bivariate statistical relationships between current accounts, exchange rates, and cross-country ratios of GDP. The paper differs from previous empirical work on these issues because we use nonparametric methods to allow for nonlinearities, employ a minimum of statistical assumptions, and focus on a fundamental characterization of the data. We present new evidence on the connections between exchange rates, the current account, and GDP. While the evidence we present loosely supports some common beliefs about the data, it conflicts with some common theoretical models. Consequently, our results pose new

[1] This work inlucdes Taylor (2000), who discusses related problems with linear specifications in univariate analyses of exchange-rate mean reversion, and O'Connell and Wei (1997), Obstfeld sand Taylor (1997), and Michael, Nobay, and Peel (1997).

challenges for theory.

Specifically, our evidence shows evidence of a J-Curve. When a country experience real depreciation against another country for a sustained period (at least 5 consecutive quarters), that country may initially experience a larger current account deficit than in "normal" times, but, after a lag, tends to experience a current account surplus. The evidence of the subsequent surplus is stronger than the evidence of an initial deficit.

In addition, we find evidence *inconsistent* with the standard theoretical model of the J-Curve. Specifically, an increase in the relative current account tends to be associated with a *fall* in relative GDP, even after a lag – contradicting the implication of the standard theoretical model that an increase in the current account surplus results from a rise in foreign demand (due to home currency depreciation), which raises home GDP. Consequently, our evidence supports the J-Curve in the data but *not* its common explanation.

2. Data and Normality Tests

We examine quarterly data on current accounts, nominal exchange rates, consumer price indexes, and real GDP over the time period 1974:1 to 1997:4, for 18 countries. All data are taken from the International Financial Statistics CD-ROM and are seasonally adjusted.

For each pair of countries, we calculate the real exchange rate $\tilde{q} \equiv \ln(ep^*/p)$, the difference in the ratios of current accounts to GDP, $\tilde{c} \equiv \frac{CA}{y} - \frac{CA^*}{y^*}$, and the GDP ratio $\tilde{x} \equiv \ln(y/y^*)$. Then we remove means and linear trends in each series, resulting in series for the detrended real exchange rate, q, the detrended relative current account,

ca, and detrended relative (real) GDP, x.

Nearly all previous empirical work involving the connections between these series relies upon statistical techniques that assume these series are normally distributed (Gaussian). Seldom, however, have researchers reported evidence on the appropriateness of that assumption. We begin by examining the results of three standard statistical tests.

First, the Shapiro-Wilk test for normality has good power and arguably provides the best omnibus test for normality. Suppose $y = (y_1, y_2, ..., y_n)$ ordered such that $y_1 < y_2 < ... < y_n$. Define $m' = (m_1, m_2, ..., m_n)$ to be the vector of expected values of the standard normal order statistics. Finally use an ordered random sample from a standard normal distribution $x_1 < x_2 < ... < x_n$ to calculate $V = (v_{ij})$ where $v_{ij} = \text{cov}(x_i, x_j)$. The Shapiro-Wilk test statistic is then:

$$W = \frac{\left[\sum_{i=1}^{n} a_i y_i\right]^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2}$$

where

$$a' = (a_1, a_2, ..., a_n) = m'V^{-1}\left[(m'V^{-1})(V^{-1}m)\right]^{-1/2}.$$

Tables of values for a' are readily available[2].

Second, we employ the Shapiro-Francia test, which is similar to the Shapiro-Wilk test and has the same asymptotic distribution. Third, we perform tests based on skewness and kurtosis, testing for normality based on the third and fourth moments of the empirical distribution function.[3]

Table 1 presents the results of the normality tests; the results cast strong doubt on the assumption of normality. The skewness-kurtosis tests reject normality at the 5% level

[2] See Royston (1982) for additional information on the Shapiro-Wilk test.
[3] Royston (1993) discusses these two tests in more detail.

more than 40% of the time for the real exchange rate, more than half the time for relative real GDP, and more than 20% of the time for the relative current account. The Shapiro-Wilk tests reject normality at the 5% level in more than half of the cases for the real exchange rate, almost two-thirds of the cases for relative real GDP, and more than one-fourth of the time for the relative current account. The Shapiro-Fancia tests reject normality at the 5% level in almost half of the cases for the real exchange rate, more than half of the cases for relative real GDP, and 30% of the time for the relative current account. Because this evidence casts considerable doubt on the normality assumptions that underlie most analyses of exchange-rate data, the remainder of the statistical tests in this paper will be distribution-free.

TABLE 1

NORMALITY TESTS:

Number of series ***rejected*** as Gaussian:

Test	**Variable**	**Total Number of Series**	**Rejected as Gaussian at Significance Levels:**		
			1%	**5%**	**10%**
Skewness/Kurtosis	Real exchange rate	306	70	126	170
	Relative GDP	306	90	160	186
	Relative Current Account	272	14	58	78
Shapiro-Wilk	Real exchange rate	306	108	172	196
	Relative GDP	306	150	194	212
	Relative Current Account	272	32	74	118
Shapiro-Francia	Real exchange rate	306	88	146	178
	Relative GDP	306	110	178	196
	Relative Current Account	272	36	82	122

To focus our attention on large and persistent changes – long enough periods of time to show J-Curves, business-cycle phenomena, etc., and to avoid results based on small, transitory changes in the data. we define a ***run*** in some bilateral variable involving two countries as a sequence of at least five consecutive quarterly observations in which that (detrended) variable exceeds its unconditional mean, i.e. quarters $\{t_1, t_2, \ldots, t_T\}$ for which $x_{AB,s} > 0 \ \forall \ s \in \{t_1, t_2, \ldots, t_T\}$ -- or the same condition for one of the other variables -- and $T \geq 6$. The Appendix shows the distributions of runs in our sample data.

We examine pairs of countries and pairs of time series. In each case, we seek evidence on whether the probability distribution of *one* variable (e.g. the relative current-account) differs in periods of (1) runs in the *second* variable (e.g. the real exchange rate), and (2) other periods, without such runs. In addition, we present evidence on how the behavior of that first variable changes over the course of runs in the second variable. To do that, we define quarter $\tilde{t}$ as belonging to the ***beginning*** of a run if (i) the run started at $\tilde{t}-2, \tilde{t}-1, or\ \tilde{t}$, *and* (ii) $\tilde{t}+4$ is in the same run. Similarly, define quarter $\tilde{t}$ as belonging to the ***middle*** of a run if $\tilde{t}-2$ and $\tilde{t}+2$ are in the same run. Finally, define quarter $\tilde{t}$ as belonging to the ***end*** of a run if (i) the last quarter of the run is $\tilde{t}, \tilde{t}+1, or\ \tilde{t}+2$, *and* (ii) $\tilde{t}-4$ is in the same run.[4]

To assess the significance of these results, we turn next to nonparametric test statistics to determine whether the behavior of exchange rates during runs differs from their behavior outside runs.

[4] When T=7, for example, the first two quarters of the run are in its *beginning*, the final two quarters are in its *end*, and the middle three quarters are in its *middle*.

3. Wilcoxon Rank-Sum Tests

Method

One method of evaluating whether two samples X and Y are drawn from the same distribution is the Wilcoxon Rank-Sum test. The test is based on the idea that if the distribution from which the samples are drawn differs in terms of a location parameter, then combining and ordering the samples should yield ranks of one sample larger than the ranks of the other. Formally, suppose the two populations have the same form, but the X sample may be drawn from a distribution with a different central tendency or location than the distribution producing the Y sample. Thus, we wish to test:

$$H_0 : F_Y(x) = F_X(x) \qquad \text{for all x}$$
$$H_A : F_Y(x) = F_X(x-\theta) \qquad \text{for all x and some } \theta$$

Using the Wilcoxon rank-sum test, we will accept the one-sided location alternative H_A: $\theta<0$ if the sum of the ranks of the X's is larger than some critical value. Thus, for an X sample of size *m* and a Y sample of size *n*, the test statistic is:

$$W_N = \sum_{i=1}^{N} iD_i$$

where $m+n=N$ and $D_i=1$ if the i^{th} variable in the combined ordered arrangement is an X and $D_i=0$ if the i^{th} variable is a Y.

If the distribution is continuous so that there are no ties among the values in X and Y, then under H_0 the mean and variance and variance of W_N are

$$E[W_N] = \frac{m(N+1)}{2} \qquad \mathrm{var}(W_N) = \frac{mn(N+1)}{12}$$

For samples larger than 12, a normal approximation has been shown to be a practical alternative to generating the exact small sample probability distribution of W_N.

One advantage of our bilateral approach over the standard VAR approach is that we take account of changes in *both* countries in every bilateral pair. One disadvantage, perhaps, is that our approach does not identify sources of shocks, or condition on such shocks as an impulse-response function does. However, one can also regard this as an *advantage* of our approach. We do not employ assumptions required for identication of shocks. Given the questionable identifying assumptions often employed in time-series analysis of data that presumably must be described by a general-equilibrium model, our approach provides evidence on *unconditional* moments that pose challenges for theoretical models to explain.[5]

Results

Tables 2A-D show the results of the Wilcoxan rank-sum test for differences in medians of (a) exchange rates during runs in relative current accounts; (b) relative current accounts during runs in exchange rates; (c) relative GDP during runs in relative current accounts; and (d) relative current accounts during runs in relative GDP.

Table 2A shows that when a ("home") country experiences a current account *surplus* that exceeds that of another country for at least 5 consecutive quarters, it initially tends to have a *depreciated* currency (compared to "normal" times without runs in the relative current account surplus). That tendency for a depreciated currency continues through the middle of the run in the relative current-account; however, by the *end* of such a run in the current account, the home country tends to have an *appreciated* currency.

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[5] For example, results that condition on monetary shocks are highly questionable, given the difficulty of identifying such shocks. Much VAR evidence, as in Sims (1995), suggests that monetary shocks do *not* play a major role in explaining movements in real GDP. Consequently, there is room for suspicion that they are a major force explaining changes in exchange rates and the current account. However, using different identifying assumptions, other work such as Gali (1998) finds considerably larger roles for monetary shocks.

TABLE 2A
WILCOXAN RANK-SUM TESTS
FOR DIFFERENCES IN MEDIANS IN EXCHANGE RATES
DURING RUNS IN RELATIVE CURRENT ACCOUNTS

During Runs in Relative Current Account Surplus, Number of Times that Home Currency is:	**Number of Cases**	**Number of Statistically Significant Cases (5% level)**
	Beginning of Run in Relative Current Account (539 cases)	
Appreciated	90	16
Depreciated	169	54
	Middle of Run in Relative Current Account (539 cases)	
Appreciated	105	34
Depreciated	148	79
	End of Run in Relative Current Account (539 cases)	
Appreciated	149	36
Depreciated	108	14

Table 2B reverses the roles of the current account and the exchange rate in the analysis, to provide evidence on the J-Curve. The table shows that when a ("home") country experiences a real currency depreciation relative to another country for at least 5 consecutive quarters, it initially has a very *slight* tendency to have a current account deficit (compared to "normal" times without runs in the real exchange rate). However, by the middle of the run in real exchange-rate depreciation, the country (with a depreciated currency) has a strong tendency to have a current account *surplus*; that strong tendency continues through the end of the run in the real exchange rate. In other words, this table shows reasonably strong evidence of a J-Curve.

TABLE 2B
WILCOXAN RANK-SUM TESTS
FOR DIFFERENCES IN MEDIANS IN CURRENT ACCOUNTS
DURING RUNS IN REAL EXCHANGE RATES

During Runs of Real Exchange-Rate Depreciation, Number of Times that the Relative Current Account shows a:	**Number of Cases**	**Number of Statistically Significant Cases (5% level)**
	Beginning of Run in Real Exchange-Rate Depreciation ($$$ cases)	
Deficit	148	16
Surplus	117	12
	Middle of Run in Real Exchange-Rate Depreciation ($$$ cases)	
Deficit	97	39
Surplus	174	94
	End of Run in Real Exchange-Rate Depreciation ($$$ cases)	
Deficit	78	8
Surplus	182	44

Table 2C examines the relative current account and relative GDP. The table shows that when a (“home”) country experiences a current account surplus that exceeds that of another country for at least 5 consecutive quarters, it initially tends to have a low relative GDP (compared to “normal” times without runs in the current account surplus). That tendency for a low relative GDP continues through the middle of the run in the relative current-account; however, by vanishes by the end of such a run.

TABLE 2C
WILCOXAN RANK-SUM TESTS
FOR DIFFERENCES IN MEDIANS IN RELATIVE GDP
DURING RUNS IN RELATIVE CURRENT ACCOUNTS

During Runs in Relative Current Account Surplus, Number of Times with:	Number of Cases	Number of Statistically Significant Cases (5% level)
	Beginning of Run in Relative Current Account (539 cases)	
Low Relative GDP	201	60
High Relative GDP	59	8
	Middle of Run in Relative Current Account (589 cases)	
Low Relative GDP	190	99
High Relative GDP	72	26
	End of Run in Relative Current Account (522 cases)	
Low Relative GDP	135	24
High Relative GDP	124	37

Note: Relative Current Account is [(CA/GDP)-(CA*/GDP*)]; runs are sequences of at least 5 consecutive quarters in which a (detrended) variable exceeds its unconditional mean.

Notice that the evidence in Table 2C appears to be *inconsistent* with the usual theoretical explanation of the J-Curve. The table shows that an increase in the relative current account tends to be associated with a *fall* in relative GDP, even after a lag (i.e. during the middles of runs in current account surpluses). In contrast, the standard theoretical model of a J-Curve explains that an increase in the current account surplus results from a rise in the quantity of home products demanded by foreigners -- because real currency depreciation makes home products relatively cheaper -- which also implies a *rise* in GDP. Consequently, while our evidence supports the usual pattern of the J-Curve in the data for the current account and the exchange rate, it does *not* support the usual theoretical explanation of that J-Curve pattern.

Table 2D reverses the roles of the variables in Table 2C. It shows that when a ("home") country experiences a period of at least 5 consecutive quarters in which its (detrended) real GDP is high relative to another country's GDP, the home country *initially* tends to experience a current account surplus (compared to "normal" times without runs in the real GDP ratio). However, by the middle of the run, the relatively high-GDP country shows a strong tendency for a current account *deficit* (compared to normal times, without a run in relative GDP). That strong tendency continues (and further strengthens) by the end of the run in relative GDP. This evidence, like that in Table 2C, is *inconsistent* with the standard theoretical model of the J-Curve, as well as with the common claim that the current account is countercyclical. The evidence in Table 2D shows that a rise in relative real GDP tends to be associated initially with a current-account surplus, and then, *later,* with a current-account deficit. In contrast, standard models predict that an exogenous increase in home aggregate demand raises GDP while creating a current account deficit, particularly in the early stages of the boom before increased investment raises domestic capacity. The initial tendency toward a current account surplus could be consistent with a model driven by productivity shocks; however, calibrated models along those lines, such as Backus, Kehoe, and Kydland, predict that productivity shocks initially generate a current account deficit (as imports of capital increase to raise home investment in response to a persistent productivity shock).

TABLE 2D
WILCOXAN RANK-SUM TESTS
FOR DIFFERENCES IN MEDIANS IN CURRENT ACCOUNTS
DURING RUNS IN RELATIVE GDP

During Runs in Relative GDP, Number of Times that the Relative Current Account shows a:	**Number of Cases**	**Number of Statistically Significant Cases (5% level)**
	Beginning of Run in Relative GDP (473 cases)	
Deficit	112	11
Surplus	152	33
	Middle of Run in Relative GDP (570 cases)	
Deficit	193	114
Surplus	78	22
	End of Run in Relative GDP (464 cases)	
Deficit	203	50
Surplus	63	4

Tables 3A-3D repeat the experiments of Tables 2, but provide evidence on the *beginnings of the middles* of runs, and the *ends of the middles* of runs. The conclusions mirror those from Tables 2.

TABLE 3A
WILCOXAN RANK-SUM TESTS
FOR DIFFERENCES IN MEDIANS IN EXCHANGE RATES
DURING RUNS IN RELATIVE CURRENT ACCOUNTS

During Runs in Relative Current Account Surplus, Number of Times that Home Currency is:	Number of Cases	Number of Statistically Significant Cases (5% level)
	Beginning of Run in Relative Current Account (539 cases)	
Appreciated	90	16
Depreciated	169	54
	Beginning of Middle of Run in Relative Current Account 539 cases)	
Appreciated	97	10
Depreciated	162	36
	End of Middle of Run in Relative Current Account (522 cases)	
Appreciated	137	29
Depreciated	121	13
	End of Run in Relative Current Account (522 cases)	
Appreciated	149	36
Depreciated	108	14

Note: Relative Current Account is [(CA/GDP)-(CA*/GDP*)]; runs are sequences of at least 5 consecutive quarters in which a (detrended) variable exceeds its unconditional mean.

TABLE 3B
WILCOXAN RANK-SUM TESTS
FOR DIFFERENCES IN MEDIANS IN CURRENT ACCOUNTS
DURING RUNS IN REAL EXCHANGE RATES

During Runs of Real Exchange-Rate Depreciation, **Number of Times that the Relative Current Account shows a:**	**Number of Cases**	**Number of Statistically Significant Cases (5% level)**
	Beginning of Run in Real Exchange-Rate Depreciation (810 cases)	
Deficit	148	16
Surplus	117	12
	Beginning of Middle of Run in Real Exchange-Rate Depreciation (810 cases)	
Deficit	121	8
Surplus	145	15
	End of Middle of Run in Real Exchange-Rate Depreciation (803 cases)	
Deficit	90	6
Surplus	170	35
	End of Run in Real Exchange-Rate Depreciation (803 cases)	
Deficit	78	8
Surplus	182	44

TABLE 3C
WILCOXAN RANK-SUM TESTS
FOR DIFFERENCES IN MEDIANS IN RELATIVE GDP
DURING RUNS IN RELATIVE CURRENT ACCOUNTS

During Runs in Relative Current Account Surplus, Number of Times with:	Number of Cases	Number of Statistically Significant Cases (5% level)
	Beginning of Run in Relative Current Account (539 cases)	
Low Relative GDP	201	60
High Relative GDP	59	8
	Beginning of Middle of Run in Relative Current Account (539 cases)	
Low Relative GDP	205	46
High Relative GDP	53	2
	End of Middle of Run in Relative Current Account (522 cases)	
Low Relative GDP	157	17
High Relative GDP	99	16
	End of Run in Relative Current Account (522 cases)	
Low Relative GDP	135	24
High Relative GDP	124	37

TABLE 3D
WILCOXAN RANK-SUM TESTS
FOR DIFFERENCES IN MEDIANS IN CURRENT ACCOUNTS
DURING RUNS IN RELATIVE GDP

During Runs in Relative GDP, Number of Times that the Relative Current Account shows a:	Number of Cases	Number of Statistically Significant Cases (5% level)
	Beginning of Run in Relative GDP (473 cases)	
Deficit	112	11
Surplus	152	33
	Beginning of Middle of Run in Relative GDP (473 cases)	
Deficit	131	13
Surplus	132	14
	End of Middle of Run in Relative GDP (464 cases)	
Deficit	196	44
Surplus	72	1
	End of Run in Relative GDP (464 cases)	
Deficit	203	50
Surplus	63	4

4. Komolgorov-Smirnov Tests

Method

While the Wilcoxon rank-sum test evaluates differences in the *location* of probability distributions from which the two samples are drawn, other techniques can investigate whether the *forms* of the probability distributions also differ. The Komoglorov-Smirnov two-sample test determines whether two distribution functions associated with two samples are identical. Specifically, we wish to test:

$$H_0 : F_Y(x) = F_X(x) \qquad \text{for all x}$$
$$H_A : F_Y(x) \neq F_X(x) \qquad \text{for some x}$$

To calculate the test statistic for two samples X and Y of sizes m and n drawn from distributions $F_X(x)$ and $F_Y(x)$, order the variables in each sample as

$$X_1, X_2, ..., X_m \text{ and } Y_1, Y_2, ..., Y_n$$

and define the empirical analogs of the distribution functions as:

$$S_X(x) = \begin{cases} 0 & \text{if } x < X_1 \\ \frac{k}{m} & \text{if } X_k \leq x \leq X_{k+1} \qquad \text{for } k = 1,2,...m-1 \\ 1 & \text{if } x \geq X_m \end{cases}$$

$$S_Y(x) = \begin{cases} 0 & \text{if x} < Y_1 \\ \frac{k}{m} & \text{if } Y_k \leq x \leq Y_{k+1} \qquad \text{for } k = 1,2,...n-1 \\ 1 & \text{if } x \geq Y_m \end{cases}$$

The test statistic then becomes

$$T_{m,n} = \sup_x \left| S_x(x) - S_Y(x) \right|$$

The small sample distribution of $T_{m,n}$ can be looked up in available tables. For larger samples, the asymptotic distribution of $\left(\sqrt{mn/(m+n)}\right)T_{m,n}$ is given by

$$L(t) = 1 - 2\sum_{i=2}^{\infty} (-1)^{i-1} e^{-2i^2t^2}$$

The Komolgorov-Smirnov can also be utilized to test the null hypothesis against the one one-sided alternative:

$$H_A : F_Y(x) \leq F_X(x) \qquad \text{for all x}$$
$$H_A : F_Y(x) < F_X(x) \qquad \text{for some x}$$

The asymptotic distribution of the test statistic $T_{m,n}$ now becomes

$$L(t) = 1 - e^{-2t^2}$$

Results

Tables 4A-4D show that the results of the Komolgorov-Smirnov tests are similar to the results from the Wilcoxon rank-sum tests. Table 4A shows that when a country experiences a run in its relative current account surplus, it tends intitially to have a *depreciated* currency (compared to “normal” times without such a run). Somewhere in the middle of the run, that tendency *reverses* itself: bu the end of the middle of the run in the relative current-account, and at end of the run, the home country tends to have an *appreciated* currency.

Table 4B, like Tables 2B and 3B, shows some evidence of a J-Curve. The table shows that real currency depreciation has little effect on the current account in the short run, but is associated with current account *surplus* after a lag.

TABLE 4A
KOMOLGOROV-SMIRNOV TESTS
FOR DIFFERENCES IN DISTRIBUTIONS OF EXCHANGE RATES
DURING RUNS IN RELATIVE CURRENT ACCOUNTS

During Runs in Relative Current Account Surpluses, Number of Cases in which Home Currency is:	**Number of Cases**
	Beginning of Run in Relative Current Account
Appreciated	35
Depreciated	84
Number of Statistically Significant Cases (two-sided test; 10% level)	84 out of 260
	Beginning of Middle of Run in Relative Current Account
Appreciated	24
Depreciated	62
Number of Statistically Significant Cases (two-sided test; 10% level)	52 out of 260
	End of Middle of Run in Relative Current Account
Appreciated	42
Depreciated	31
Number of Statistically Significant Cases (two-sided test; 10% level)	39 out of 259
	End of Run in Relative Current Account
Appreciated	66
Depreciated	34
Number of Statistically Significant Cases (two-sided test; 10% level)	63 out of 259

TABLE 4B

KOMOLGOROV-SMIRNOV TESTS

FOR DIFFERENCES IN DISTRIBUTIONS OF CURRENT ACCOUNTS

DURING RUNS IN REAL EXCHANGE RATES

During Runs in Real Exchange Rates, Number of Cases in which Home Currency has a Current Account:	**Number of Cases**
	Beginning of Run in Real Exchange Rate
Deficit	29
Surplus	26
Number of Statistically Significant Cases (two-sided test; 10% level)	34 out of 267
	Beginning of Middle of Run in Real Exchange Rate
Deficit	35
Surplus	32
Number of Statistically Significant Cases (two-sided test; 10% level)	28 out of 268
	End of Middle of Run in Real Exchange Rate
Deficit	21
Surplus	47
Number of Statistically Significant Cases (two-sided test; 10% level)	37 out of 262
	End of Run in Real Exchange Rate
Deficit	19
Surplus	63
Number of Statistically Significant Cases (two-sided test; 10% level)	61 out of 262

Table 4C, like Tables 2C and 3C, shows that when a country has a run in its relative current account, it initially tends to have a low relative GDP (compared to “normal” times without runs in the current account surplus). The tendency for low GDP vanishes somewhere in the middle of the run. This table provides further evidence against the usual theoretical explanation of the J-Curve. According to the standard model, an increase in the current account surplus results from an increase in foreign demand for home products, which should raise the current account surplus *and raise* GDP.

Similarly, Table 4D, like Tables 2D and 3D, shows a run in relative real GDP is *initially* accompanied by a current account surplus. However, the table shows strong evidence that this increase in GDP is accompanied, with a lag, by a current account *deficit*. This table provides additional evidence against the standard theoretical model of the J-Curve.

TABLE 4C
KOMOLGOROV-SMIRNOV TESTS
FOR DIFFERENCES IN DISTRIBUTIONS OF RELATIVE GDP
DURING RUNS IN RELATIVE CURRENT ACCOUNTS

During Runs in Relative Current Account Surpluses, Number of Cases in which Home GDP, relative to Foriegn GDP, is:	**Number of Cases**
	Beginning of Run in Relative Current Account
High GDP	22
Low GDP	93
Number of Statistically Significant Cases (two-sided test; 10% level)	78 out of 260
	Beginning of Middle of Run in Relative Current Account
High GDP	3
Low GDP	74
Number of Statistically Significant Cases (two-sided test; 10% level)	53 out of 260
	End of Middle of Run in Relative Current Account
High GDP	30
Low GDP	43
Number of Statistically Significant Cases (two-sided test; 10% level)	37 out of 259
	End of Run in Relative Current Account
High GDP	51
Low GDP	48
Number of Statistically Significant Cases (two-sided test; 10% level)	71 out of 259

TABLE 4D
KOMOLGOROV-SMIRNOV TESTS
FOR DIFFERENCES IN DISTRIBUTIONS OF CURRENT ACCOUNTS
DURING RUNS IN RELATIVE GDP

During Runs in Relative GDP, Number of Cases in which Home Currency has a Current Account:	**Number of Cases**
	Beginning of Run in Relative GDP
Deficit	23
Surplus	49
Number of Statistically Significant Cases (two-sided test; 10% level)	45 out of 266
	Beginning of Middle of Run in Relative GDP
Deficit	31
Surplus	33
Number of Statistically Significant Cases (two-sided test; 10% level)	31 out of 266
	End of Middle of Run in Relative GDP
Deficit	65
Surplus	7
Number of Statistically Significant Cases (two-sided test; 10% level)	39 out of 268
	End of Run in Relative GDP
Deficit	82
Surplus	19
Number of Statistically Significant Cases (two-sided test; 10% level)	61 out of 268

5. Magnitudes

Tables 5-8 provide evidence on the magnitudes of the changes in variables documented in previous sections.

EXCHANGE RATES DURING RUNS IN CURRENT ACCOUNTS

Table 5a

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF EXCHANGE RATES DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = .030	First Quarter of Run in Relative Current Account (539 cases)
standard deviation = .112	
Skewness = .000	
Kurtosis = 3.43	
Percentiles:	Log exchange rate (unconditional mean = 0)
1%	-.249
5%	-.153
10%	-.105
25%	-.046
50% (median)	.028
75%	.105
90%	.174
95%	.217
99%	.313

This table shows: (1) At the beginning of a run in the Relative Current Account, the median exchange rate is 2.8% above (i.e. depreciated relative to) its unconditional mean. The $$$

Table 5b

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF EXCHANGE RATES DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = -.012	Middle of Run in Relative Current Account (539 cases)
standard deviation = .104	
Skewness = -.337	
Kurtosis = 3.42	
Percentiles:	Mean Log exchange rate (unconditional mean = 0)
1%	-.262
5%	-.163
10%	-.117
25%	-.052
50% (median)	.015
75%	.083
90%	.146
95%	.176
99%	.237

Table 5c
SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF EXCHANGE RATES DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = -.025 standard deviation = .115 Skewness = -.129 Kurtosis = 3.35	Beginnings of Middles of Runs in Relative Current Accounts (539 cases)
Percentiles:	Log exchange rate (unconditional mean = 0)
1%	-.255
5%	-.162
10%	-.115
25%	-.049
50% (median)	-.022
75%	.099
90%	.174
95%	.204
99%	.298

Table 5d
SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF EXCHANGE RATES DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = -.017 standard deviation = .115 Skewness = -.210 Kurtosis = 3.27	Ends of Middles of Runs in Relative Current Accounts (539 cases)
Percentiles:	Log exchange rate (unconditional mean = 0)
1%	-.313
5%	-.209
10%	-.149
25%	-.085
50% (median)	-.009
75%	.067
90%	.131
95%	.162
99%	.249

Table 5e
SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF EXCHANGE RATES DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = -.025 standard deviation = .114 Skewness = -.283 Kurtosis = 3.04	Ends of Runs in Relative Current Accounts (522 cases)
Percentiles:	Log exchange rate (unconditional mean = 0)
1%	-.326
5%	-.225
10%	-.169
25%	-.101
50% (median)	-.022
75%	.057
90%	.115
95%	.152
99%	.224

CURRENT ACCOUNTS DURING RUNS IN EXCHANGE RATES

Table 6a
SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF RELATIVE CURRENT ACCOUNTS DURING RUNS IN REAL EXCHANGE RATES

mean = -.000 standard deviation = .005 Skewness = 1.03 Kurtosis = 8.20	First Quarter of Run in Real Exchange Rate (650 cases)
Percentiles:	Relative Current Account Surplus
1%	-.0121
5%	-.0071
10%	-.0052
25%	-.0026
50% (median)	.0002
75%	.0017
90%	.0043
95%	.0071
99%	.0168

Table 6b
SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF RELATIVE CURRENT ACCOUNTS DURING RUNS IN REAL EXCHANGE RATES

mean = -.0005	Middle of Run in Real Exchange Rate (622 cases)
standard deviation = .0035	
Skewness = .03	
Kurtosis = 5.98	
Percentiles:	Relative Current Account Surplus
1%	-.0090
5%	-.0049
10%	-.0034
25%	-.0013
50% (median)	.0004
75%	.0022
90%	.0044
95%	.0061
99%	.0110

Table 6c
SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF RELATIVE CURRENT ACCOUNTS DURING RUNS IN REAL EXCHANGE RATES

mean = .0003	Beginnings of Middles of Runs in Real Exchange Rates (539 cases)
standard deviation = .004	
Skewness = .123	
Kurtosis = 4.97	
Percentiles:	Relative Current Account Surplus
1%	-.0120
5%	-.0062
10%	-.0043
25%	-.0020
50% (median)	-.0000
75%	.0022
90%	.0054
95%	.0080
99%	.0128

Table 6d
SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF EXCHANGE RATES DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = .0007	Ends of Middles of Runs in Real Exchange Rates (539 cases)
standard deviation = .0047	
Skewness = -.245	
Kurtosis = 4.71	
Percentiles:	Relative Current Account Surplus
1%	-.0128
5%	-.0069
10%	-.0048
25%	-.0018
50% (median)	.0002
75%	.0032
90%	.0064
95%	.0084
99%	.0157

Table 6e
SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF EXCHANGE RATES DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = .001	Ends of Runs in Real Exchange Rates (803 cases)
standard deviation = .005	
Skewness = .013	
Kurtosis = 6.37	
Percentiles:	Relative Current Account Surplus
1%	-.0120
5%	-.0060
10%	-.0037
25%	-.0016
50% (median)	.0005
75%	.0034
90%	.0060
95%	.0083
99%	.0145

RELATIVE GDP DURING RUNS IN CURRENT ACCOUNTS

Table 7a

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF RELATIVE GDP DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = =.017	First Quarter of Run in Relative Current Account (539 cases)
standard deviation = .086	
Skewness = -2.28	
Kurtosis = 78.58	
Percentiles:	Relative GDP (unconditional mean = 0)
1%	-.136
5%	-.091
10%	-.070
25%	-.041
50% (median)	-.013
75%	.014
90%	.037
95%	.053
99%	.089

Table 7b

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF RELATIVE GDP DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = -.015	Middle of Run in Relative Current Account (589 cases)
standard deviation = .088	
Skewness = -2.78	
Kurtosis = 89.07	
Percentiles:	Relative GDP (unconditional mean = 0)
1%	-.113
5%	-.074
10%	-.062
25%	-.039
50% (median)	-.014
75%	.013
90%	.038
95%	.049
99%	.084

Table 7c

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF RELATIVE GDP DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = -.022	Beginnings of Middles of Runs in Relative Current Accounts (539 cases)
standard deviation = .090	
Skewness = -.270	
Kurtosis = 80.34	
Percentiles:	Relative GDP (unconditional mean = 0)
1%	-.145
5%	-.089
10%	-.076
25%	-.048
50% (median)	-.021
75%	.011
90%	.033
95%	.049
99%	.083

Table 7d

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF RELATIVE GDP DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = -.0058	Ends of Middles of Runs in Relative Current Accounts (522S cases)
standard deviation = .077	
Skewness = -4.34	
Kurtosis = 70.28	
Percentiles:	Relative GDP (unconditional mean = 0)
1%	-.102
5%	-.073
10%	-.058
25%	-.032
50% (median)	-.006
75%	.025
90%	.052
95%	.070
99%	.106

Table 7e

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF RELATIVE GDP DURING RUNS IN RELATIVE CURRENT ACCOUNTS

mean = .004	Ends of Runs in Relative Current Accounts (522 cases)
standard deviation = .080	
Skewness = -4.13	
Kurtosis = 73.26	
Percentiles:	Relative GDP (unconditional mean = 0)
1%	-.1319
5%	-.0583
10%	-.0437
25%	-.0274
50% (median)	.0037
75%	.0331
90%	.0608
95%	.0816
99%	.1176

RELATIVE CURRENT ACCOUNTS DURING RUNS IN RELATIVE GDP

Table 8a

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF CURRENT ACCOUNTS DURING RUNS IN RELATIVE GDP

mean = =.0012	First Quarter of Run in Relative GDP (473 cases)
standard deviation = .0043	
Skewness = .780	
Kurtosis = 4.90	
Percentiles:	Relative Current Account (unconditional mean = 0)
1%	-.0090
5%	-.0049
10%	-.0032
25%	-.0012
50% (median)	.0004
75%	.0032
90%	.0066
95%	.0096
99%	.0156

Table 8b

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF CURRENT ACCOUNTS DURING RUNS IN RELATIVE GDP

mean = =-.0013	Middle of Run in Relative GDP (531 cases)
standard deviation = .0030	
Skewness = .264	
Kurtosis = 6.69	
Percentiles:	Relative Current Account (unconditional mean = 0)
1%	-.0097
5%	-.0059
10%	-.0048
25%	-.0028
50% (median)	-.0011
75%	.0011
90%	.0018
95%	.0035
99%	.0070

Table 8c

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF CURRENT ACCOUNTS DURING RUNS IN RELATIVE GDP

mean = .0001	Beginnings of Middles of Runs in Relative GDPs (473 cases)
standard deviation = .004	
Skewness = .050	
Kurtosis = 4.38	
Percentiles:	Relative Current Account (unconditional mean = 0)
1%	-.0120
5%	-.0064
10%	-.0051
25%	-.0022
50% (median)	.0000
75%	.0023
90%	.0054
95%	.0073
99%	.0111

Table 8d

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF CURRENT ACCOUNTS DURING RUNS IN RELATIVE GDP

mean = -.0020	Ends of Middles of Runs in Relative GDPs (473 cases)
standard deviation = .0046	
Skewness = -1.00	
Kurtosis = 5.73	
Percentiles:	Relative Current Account (unconditional mean = 0)
1%	-.0174
5%	-.0103
10%	-.0082
25%	-.0038
50% (median)	-.0011
75%	.0006
90%	.0022
95%	.0042
99%	.0085

Table 8e

SUMMARY STATISTICS: CONDITIONAL DISTRIBUTION OF CURRENT ACCOUNTS DURING RUNS IN RELATIVE GDP

mean = -.0016	Ends of Runs in Relative GDP (522 cases)
standard deviation = -.899	
Skewness = 4.51	
Kurtosis = 73.26	
Percentiles:	Relative Current Account (unconditional mean = 0)
1%	-.0156
5%	-.0097
10%	-.0071
25%	-.0034
50% (median)	-.0008
75%	.0008
90%	.0029
95%	.0042
99%	.0071

6. Conclusions

This paper “goes back to basics” in empirical analysis of the J-Curve. After documenting strong violations in the distributional assumptions that underlie nearly all previous work on this issue, it employs distribution-free, non-parametric statistical tests to characterize the data. While this approach would provide weaker evidence than a parametric approach utilizing the “true” distributions underlying the data-generating process, and does not provide direct evidence on sources of shocks or causality, it does provide summaries of the main relations in the data between real exchange rates, the current account, and real GDP. Our results find some evidence of a J-Curve in the data, but appear to be inconsistent with the usual theoretical explanation of the J-Curve. In that sense, our results pose a strong challenge to theorists.

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Appendix 1

Distributions of Run Lengths

Runs in Relative Current Account Surpluses (CA/y - CA*/y*)			
Number of Quarters in Run	Number of Runs	Percent of Total	Cumulative Percent
5	87	14.77	14.77
6	74	12.56	27.33
7	100	16.98	44.31
8	46	7.81	52.12
9	35	5.94	58.06
10	49	8.32	66.38
11	44	7.47	73.85
12	16	2.72	76.57
13	9	1.53	78.10
14	16	2.72	80.81
15	15	2.55	83.36
16	11	1.87	85.23
17	15	2.55	87.78
18	21	3.57	91.34
19	11	1.87	93.21
20	1	0.17	93.38
21	8	1.36	94.74
22	6	1.02	95.76
23	5	0.85	96.60
24	3	0.51	97.11
25	5	0.85	97.96
26	1	0.17	98.13
27	3	0.51	98.64
28	6	1.02	99.66
29	1	0.17	99.83
30	1	0.17	100.00
Total	589		100.00

Runs in Real Exchange Rates			
Number of Quarters in Run	Number of Runs	Percent of Total	Cumulative Percent
5	95	10.69	10.69
6	99	11.14	21.82
7	75	8.44	30.26
8	49	5.51	35.77
9	60	6.75	42.52
10	55	6.19	48.71
11	38	4.27	52.98
12	43	4.84	57.82
13	42	4.72	62.54
14	43	4.84	67.38
15	32	3.60	70.98
16	27	3.04	74.02
17	19	2.14	76.15
18	36	4.05	80.20
19	33	3.71	83.91
20	17	1.91	85.83
21	25	2.81	88.64
22	14	1.57	90.21
23	10	1.12	91.34
24	13	1.46	92.80
25	6	0.67	93.48
26	11	1.24	94.71
27	6	0.67	95.39
28	8	0.90	96.29
29	5	0.56	96.85
30	2	0.22	97.08
31	1	0.11	97.19
33	2	0.22	97.41
34	3	0.34	97.75
36	2	0.22	97.98
37	4	0.45	98.43
38	3	0.34	98.76
40	4	0.45	99.21
41	2	0.22	99.44
42	1	0.11	99.55
46	1	0.11	99.66
47	1	0.11	99.78
48	1	0.11	99.89
50	1	0.11	100.00
Total	889		100.00

Runs in Relative GDP			
Number of Quarters in Run	Number of Runs	Percent of Total	Cumulative Percent
5	35	6.14	6.14
6	27	4.74	10.88
7	34	5.96	16.84
8	40	7.02	23.86
9	24	4.21	28.07
10	18	3.16	31.23
11	26	4.56	35.79
12	27	4.74	40.53
13	22	3.86	44.39
14	34	5.96	50.35
15	22	3.86	54.21
16	21	3.68	57.89
17	26	4.56	62.46
18	21	3.68	66.14
19	37	6.49	72.63
20	24	4.21	76.84
21	17	2.98	79.82
22	13	2.28	82.11
23	12	2.11	84.21
24	10	1.75	85.96
25	7	1.23	87.19
26	6	1.05	88.25
27	8	1.40	89.65
28	8	1.40	91.05
29	9	1.58	92.63
30	4	0.70	93.33
31	6	1.05	94.39
32	4	0.70	95.09
33	1	0.18	95.26
34	4	0.70	95.96
35	7	1.23	97.19
36	3	0.53	97.72
37	1	0.18	97.89
38	1	0.18	98.07
39	1	0.18	98.25
40	2	0.35	98.60
41	1	0.18	98.77
43	2	0.35	99.12
45	1	0.18	99.30
46	1	0.18	99.47
48	1	0.18	99.65
54	1	0.18	99.82
57	1	0.18	100.00
Total	570		100.00

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