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Is there an S-curve relationship between U.S. trade balance and terms of trade? An analysis across industries and countries

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Abstract

A key relationship in international economics is that between trade flows and exchange rates. This paper examines the empirical evidence of S-curve relationship between U.S. trade balance and terms of trade both at the aggregated and disaggregated level from 1989Q1 to 2010Q4. I find evidence of an S-curve for U.S. total trade in all goods and services with the rest of the world, as well as that for overall manufacturing and non-manufacturing categories. I further examine the top 20 industries at the SITC 3-digit level, and find evidence of an S-curve in 15 industries. Finally, the relationship is explored with the major trading partners in each of these twenty industries, also yielding positive evidence for several nations.

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1. Introduction

A key relationship in international economics is that between trade balance and terms of trade. Understanding their dynamics is the key to a successful trade policy. Whether depreciation actually helps improve trade deficits remain a key question that has drawn much scholarly attention. There exists a voluminous body of literature that has looked at the effect of currency depreciation on net exports of nations. Most of these centers on the concept of a 'J-curve.'

However more recent literature has emerged from the mid-1990s that focuses on the 'S-curve' relationship of the correlation function between trade balance and terms of trade. This follows from the seminal work of Backus, Kehoe and Kydland (1994) (BKK, henceforth) who in a dynamic general equilibrium setting show that terms of trade is positively correlated to future movements of the trade balance but is negative correlated with past movements thus resulting in a shape that resembles an 'S-curve.' Given the importance of the U.S. in the world economy, this project contributes to this relatively new body of literature by examining the S-curve relationship for both aggregate and disaggregated U.S. trade data. Persistent trade deficits in the U.S. over the last one decade calls for a deeper scrutiny at the relationship between trade balance and movements in exchange rates.

The remainder of the paper proceeds as follows. Section 2 provides a brief survey of the literature on S-curves. Section 3, presents the data, variable(s) construction and the aggregate level results, specifically for U.S. total trade, and then manufacturing and non-manufacturing categories, respectively. Section 4, examines the S-curve relationship at the industry level, both with respect to the world as well as country-specific. Finally, section 5 concludes along with policy implications of the analysis.

2. Survey of the existing S-curve literature.

BKK (1994) consider two countries that produce imperfectly substitute goods using capital and labor, which are subject to persistent shocks. A favorable productivity shock increases domestic output, consumption and investment, while deteriorating the terms of trade. With persistent shocks the increase in the latter two typically exceed the former, causing a trade deficit during the period of rising output. Over time this boom in both consumption and investment wanes out and the trade deficit turns into a surplus. Thus this dynamic response results in a countercyclical movement in trade balance and an asymmetric cross-correlation function between terms of trade and trade balance giving rise to an 'S-curve.' In contrary, if an industry has no capital flows and is subject to government fiscal spending shocks the dynamic relationship between terms of trade and trade balance will depict an inverse 'U' or tent shape.

Existing studies on S-curve can be broadly classified under three categories – aggregate, disaggregate, and industry level analyses. The earliest work emanating in the S-curve literature focused on aggregate trade data for a country with the rest of the world. The first of such studies is the seminal work of BKK (1994). The authors examine the evidence for 11 OECD nations from mid-1950s to 1990 employing quarterly data and using the ratio of import and export price deflator as the measure of terms of trade, find the S-curve shape for 6 nations. Noticeable there is no evidence of an S-curve for the U.S. from 1972 to 1990. Senhadji (1998) using an international real business cycle model find productivity shocks as the key to generate an S-curve relationship. Empirically, the author examines the relationship for 30 less developed nations from 1960 to 1993 finding evidence for most. Parikh and Shibata (2004) analyze the relationship using annual data from 1970-1999 for 59 less developed nations, all with mixed results.

The next strand of literature focused on examining a nation's trade balance and exchange rate relationship with respect to specific partner nations rather than the rest of the world. This is driven by the concern of an 'aggregation bias.' In other words, aggregate data will not show if a country's trade balance is improving against some trading partner(s) while deteriorating against others (see *inter alia*, Bahmani-Oskooee and Ratha 2007a, 2007b). In the former paper, the authors examine U.S. trade balance from 1973-2000 using quarterly data. There is weak evidence of an S-curve for U.S. trade balance with the world but a stronger evidence for that with the industrial countries. When extending their analysis to 23 nations, the evidence is also supported for most of the cases. The second paper examines the S-curve phenomenon in the context of Japan's trade with its 12 major trading partners using quarterly data from 1980-2005, and finds evidence for most cases.[1]

The most recent line of literature has examined the S-curve effect for a nation's trade at the industry level. Such analyses include those by Bahmani-Oskooee and Ratha (2008), between the U.S.-U.K. in 52 industries with support for S-curve in 36; Bahmani-Oskooee and Ratha (2009a) for U.S.-Canada trade with positive evidence in 41 out of 60 industries; Bahmani-Oskooee and Ratha (2009b) for trade between the U.S. and China for 104 industries with evidence in 42; Bahmani-Oskooee and Ratha (2010) for U.S.-India trade find evidence of S-curve in 15 out of the 27 industries studied. The present study combines these three categories of existing work for the U.S. to glean deeper into the pattern of S-curve using an updated database.

3. Aggregate level analysis of S-curve.

3.1 Data and variable construction

Data for U.S. exports and imports both with the rest of the world and specific partner nations are sourced from the United States International Commission (USITC) database and spans from 1989Q1 to 2010Q4. In this regards this paper is an extension of BKK (1994) which conclude in 1990. In line with the existing literature I measure trade balance as the ratio of net exports divided by the real GDP of the U.S. The latter is taken from the U.S. Bureau of Economic Analysis (BEA).

$$TB_t = \frac{(X-M)_t^{US}}{GDP_t^{US}} \qquad (1)$$

where X denotes U.S. exports and M imports. While trade theorists use the ratio of export over import prices as a measure of terms of trade, real business cycle literature measures trade balance in the inverse manner – the ratio of import over export prices. I follow the latter convention in measuring trade balance, in keepings with the existing literature cited earlier. Export (import)

[1] Specifically, the authors find strong evidence for Japan's trade with Canada, France, Italy, Germany, Philippines and Switzerland, but a weak evidence for Australia, Indonesia, Korea, New Zealand, the U.K. and the U.S.

price indices that are both country and industry specific were unavailable. So following previous studies I employ the bilateral real exchange rate as a proxy for terms of trade.

$$TOT_t = \frac{CPI_t^{\,i}}{(CPI_t^{\,US} * E_t)} \tag{2}$$

where CPI^i and CPI^{US} denote the consumer price indices of country *i* and the U.S., respectively. E is defined as the bilateral nominal exchange rate of country *i* per unit of the U.S. dollar.[2] For analyses of U.S. trade balance with the rest of the world I use the inverse of the real effective exchange rate. Data on all exchange rates and price indices are sourced from the IMF's International Financial Statistics (IFS) database. All real exchange rate series are expressed in their natural logarithmic forms. Further, all data are detrended using the Hodrick-Prescott filter, using a smoothing parameter of 1600, similar to BKK (1994). This enables me to separate short-run fluctuations from long-run movements in the variables being studied.

Finally, the cross correlation function between trade balance (TB) and terms of trade (TOT) is computed as follows:

$$COR = \frac{\sum TOT_t - \bar{TOT})(TB_{t+k} - \bar{TB})}{\sqrt{\sum (TOT_t - \bar{TOT})^2 \, (TB_{t+k} - \bar{TB})^2}} \tag{3}$$

where $\bar{TOT}$ and $\bar{TB}$ are the means of all observations used in calculating COR. By placing correlation coefficient (COR) on the vertical axis of each figure, and the different lags and leads (k) on the horizontal axis, I arrive at the graphical plot.

3.1 S-curve for U.S. aggregate trade.

Figures 1 to 3 show the results. I find positive values for correlation coefficients between the current period's terms of trade and future or lead values of the trade balance and a negative correlation coefficient between the terms of trade with the past or lagged values of trade balance leading to a shape resembling an 'S-curve'. This finding is an improvement from the results of BKK (1994) for the U.S. Similar S-curve findings are mirrored in figures 2 and 3, respectively, when I dissect U.S. total trade into its two main constituent categories – manufacturing and non-manufacturing. Next I examine evidence for an S-curve relationship for disaggregated industry-level trade flows.

[2] For nations in the euro zone, I break the sample into pre and post-euro eras and examine separately the evidence for S-curve. For the post euro period I use the euro per unit of the USD adjusted by the respective nation's CPI and that of the U.S. as the bilateral terms of trade measure. For China, I use the nominal exchange rate per unit of USD as Chinese CPI data were unavailable at quarterly frequency.

4. Industry level analysis of S-curve.

U.S. trade data at the Standard International Trade Classification (SITC) 3-digit level of disaggregation is first examined for each year over the entire period of study. They are sorted in terms of their values to identify the major industries for each year. The industries that show up recurrently in every year are then included in the pool of top 20 industries. Next within each industry I again follow a similar procedure and sort out the major trading partners in terms of value, both for U.S. exports and imports. The countries that show up repeatedly from 1989-2010 are identified as the major trading partners within each industry. Table 1 provides the list of industries analyzed along with the respective nations within each industry. Appendix provides the commodity descriptions.

4.1 Results with the rest of the world.

Figure 4 shows the graphs for each of the twenty industries. An ocular view exhibits resemblance of an ‘S-curve’ in 15 out of the 20 industries considered. As seen the results are stronger in cases of petroleum oil (SITC code 334), measuring instruments (874), parts of motor vehicles (784), medical and surgical instruments (872), pumps and gas compressors (743), internal combustion engines (713), paper and paperboard (641), metal manufactures (699). These are in line with the theoretical prediction of BKK (1994) where an industry subject to positive productivity shocks undergoes an increase in domestic output and a decrease in its relative price (the inverse of the terms of trade). I do not find evidence of S-curve for motor vehicles (SITC 781), automatic data processing machines (752), integrated circuits (776), parts and accessories of office machines (759) and baby carriages, toys (894).

For some industries I find the contemporaneous correlations between terms of trade and trade balance to be close to zero (SITC 542, 874, 784, 778, 899, 699) while for some others I find them to be more negative (SITC 764, 772, 893). In keepings with the theoretical predictions of BKK (1994), the former would be industries where the elasticity of substitution between domestic and foreign goods is higher compared to the latter ones.

4.2 Industry level results with individual partner nations

To deal with the earlier discussed issues of ‘aggregation bias’ I further dissect the data for each of these 20 industries into the major trading partners of the U.S., and examine the S-curve relationship on an individual industry-country level. Table 2 sums up the results for industry-country specific examinations of the S-curve. The figures are not shown for space considerations but are available on request.

Summarizing cross-sectionally across nations I find both Canada and France (either before or after adoption of euro) to show evidence of S-curve in 7 industries, Germany, the U.K., Ireland, and Korea in 5 industries; Brazil in 4; and Italy in 3 industries. I further tested for the sensitivity of these results to the choice of price index in constructing the bilateral real exchange rate. The analysis was performed by replacing the CPI with the producer price index for each nation. The results remained largely similar. The right panel of table 2 summarizes the results for evidence of S-curve using the PPI-based real exchange rate.

5. Conclusion.

This paper makes a detailed analysis of the dynamic relationship between terms of trade and trade balance for the U.S. I adopt a 'general-to-specific' approach where I move from aggregate level analysis to a more detailed disaggregate, country specific examination using quarterly data from 1989 to 2010.

I find U.S. total trade balance for all goods and services with the rest of the world to reveal a shape resembling an S-curve. Next when I disaggregate the data into manufacturing and non-manufacturing categories similar findings are also mirrored. Then I move towards analyzing U.S. trade balance for the top 20 industries at the SITC 3-digit level of data categorization, and find S-curve to be present in 15 out of the 20 industries (75%). Finally, I disaggregate the data further and look for evidence of S-curve with the major trading partners in these 20 industries, and find evidence in several industry-country cases.

Policy implications of this analysis would be for industries exhibiting S-curve, changes in exchange rates would ultimately improve trade balance and international competitiveness. This would further increase investment inflows in these sectors, thereby creating more domestic employment and enhancing national income.

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Appendix: SITC 3-digit level Commodity Descriptions

776 – Thermionic, cold cathode or photocathode valves or tubes, integrated circuits etc.
334 – Petroleum oils and oils from bituminous minerals.
764 – Telecommunications equipment; and apparatus and parts falling within telecommunications, etc.
781 – Motor cars and motor vehicles principally designed for the transport of persons.
542 – Medicaments (including veterinary medicaments.
874 – Measuring, checking, analyzing and controlling instruments and apparatus.
784 – Parts and accessories for tractors, motor cars and other motor vehicles.
752 – Automatic data processing machines and units thereof; magnetic or optical readers; machines transcribing coded media and processing such data.
872 – Instruments and appliances for medical, surgical, dental or veterinary purposes.
759 – Parts and accessories suitable for use solely or principally with office machines and automatic data processing machines.
772 – Electrical apparatus for switching or protecting electrical circuits or for making connections to or in electrical circuits.
778 – Electrical machinery and apparatus.
743 – Pumps (not for liquids), air or gas compressors and fans; ventilating hoods incorporating a fan; centrifuges; filtering etc.
713 – Internal combustion piston engines and parts thereof.
899 – Miscellaneous manufactured articles.
641 – Paper and paperboard.
699 – Manufactures of base metal.
893 – Articles of plastics.
515 – Organo-inorganic compounds, heterocyclic compounds, nucleic acids and their salts.
894 – Baby carriages, toys, games and sporting goods.

Table 1: U.S. Trade Balance with industry-country pair studied

776	334	764	781	542	874	784	752	872
China	Netherlands	Mexico	Canada	Canada	Canada	Canada	Canada	Canada
Mexico	Canada	Canada	Mexico	Switzerland	China	Mexico	Mexico	Japan
Malaysia	France	Japan	UK	Belgium	Germany	Germany	China	Mexico
Korea	Brazil	China	Japan	Japan	Mexico	China	UK	Germany
Canada	UK	Hong Kong	China	France	Japan	Japan	Japan	UK
Singapore	Belgium	UK	Italy	Germany	UK	Brazil	Singapore	China
Germany	Mexico	Germany	Netherlands	Ireland	Singapore	France	Hong Kong	France
Japan	Argentina	Korea	Korea	Italy		Korea	Korea	Switzerland
Thailand	Korea	Singapore		Spain		UK	Ireland	Ireland
				Netherlands		Italy		

772	778	743	713	899	641	699	893	515	894
Mexico	Canada	Canada	Canada	Canada	Canada	Mexico	Canada	Belgium	Canada
Canada	Mexico	Mexico	Mexico	Ireland	Mexico	China	Mexico	France	Mexico
China	China	China	UK	Switzerland	Japan	UK	Japan	Germany	Japan
UK	UK	Brazil	Germany	Germany	China	Japan	UK	Singapore	Hong Kong
Korea	Japan	France	Brazil	Mexico	Germany	Germany	China	Japan	Korea
Japan	Korea	Japan	Japan	UK	Korea	Korea	Germany	Ireland	Germany
Malaysia	France	UK	India	China	UK	France	France	UK	UK
Singapore	Malaysia	Korea	Korea	France	Brazil	Brazil	Korea	Canada	Spain
Dominican Republic		Singapore	China	Japan	Italy	Italy	Hong Kong		
				Sweden		India	Dominican Republic		

Table 2: Industry and country specific results

	Results using CPI-based real exchange rate	Results using PPI- based real exchange rate
SITC	Countries with evidence of S-curve	Countries with evidence of S-curve
776	China.	No evidence for the sample of countries.
334	Canada, France (pre euro), Belgium (pre euro), Netherlands (post euro).	France (pre euro), Belgium (pre euro), Netherlands (post euro).
764	Canada, Germany (pre euro), Singapore.	Canada, Singapore.
781	UK, Korea, Italy (pre euro).	Italy (pre euro), Netherlands (post euro).
542	France (pre euro), Ireland (pre euro), Spain (pre euro), Spain (post euro).	France (pre euro), Ireland (pre euro), Spain (pre euro), Spain (post euro).
874	No evidence for our sample of countries.	No evidence for the sample of countries.
784	Canada, Brazil, France (pre euro), France (post euro), Korea.	Germany (pre euro), Brazil, France (pre euro), France (post euro), UK.
752	Hong Kong.	Hong Kong.
872	Germany (pre euro), UK, China, France (pre euro), Ireland (pre euro), Ireland (post euro).	Germany (pre euro), Ireland (pre euro), France (post euro).
759	Mexico, Ireland (pre euro).	Mexico, Ireland (pre euro).
772	No evidence for the sample of countries.	No evidence for the sample of countries.
778	Canada, UK, Korea, France (pre euro).	Canada, France (pre euro).
743	Canada, Japan, Korea.	Canada, Japan, Korea.
713	Germany (pre euro), Germany (post euro), Brazil, India.	Germany (pre euro), Germany (post euro), Brazil, India.
899	Canada, Ireland (pre euro), Switzerland, Germany (post euro).	Ireland (pre euro), Switzerland, Germany (pre euro), Germany (post euro).
641	Korea, Brazil, Italy (pre euro), Italy (pre euro).	Italy (pre euro), Italy (pre euro).
699	UK, Brazil, France (pre euro), France (post euro), Germany (post euro), France (post euro), Italy (post euro), India.	Brazil, France (post euro), Italy (post euro), India.
893	Canada, Korea, Hong Kong, Dominican Republic.	Canada, Germany (pre euro), Korea,
515	France (post euro), Germany (post euro), Ireland (post euro).	France (post euro), Germany (post euro),
894	Mexico, UK, Spain (pre euro), Spain (post euro).	Mexico, UK, Spain (pre euro), Spain (post euro).

Figure 1: U.S. total trade balance

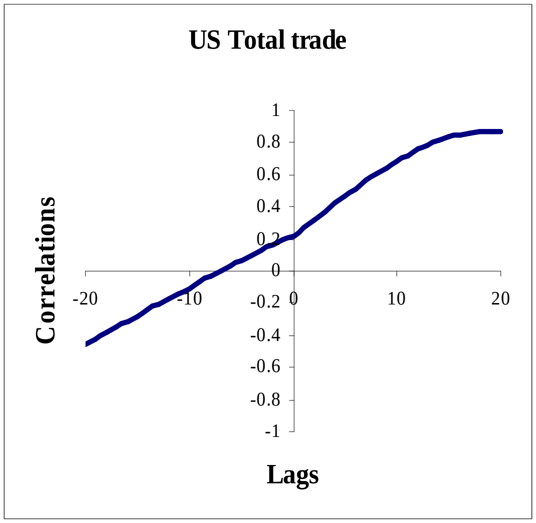


Figure 2: U.S. Manufacturing trade balance

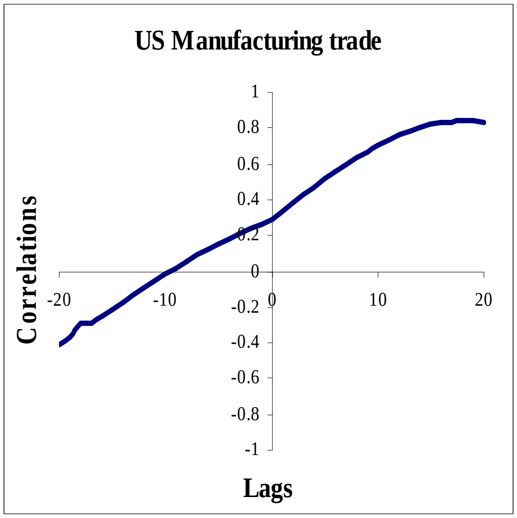


Figure 3: U.S. Non-manufacturing trade balance

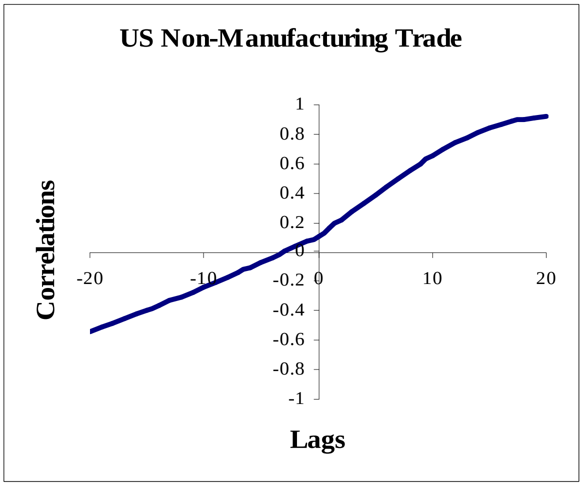
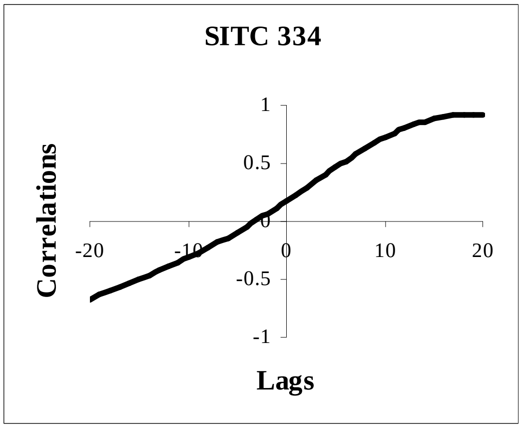
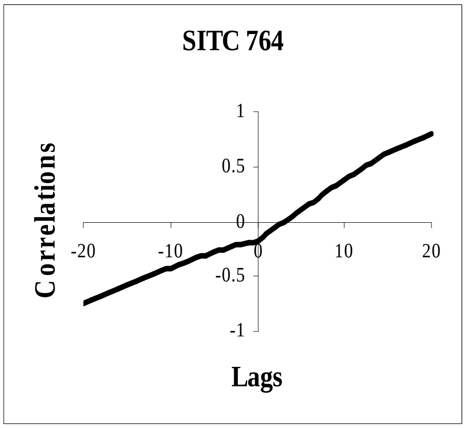
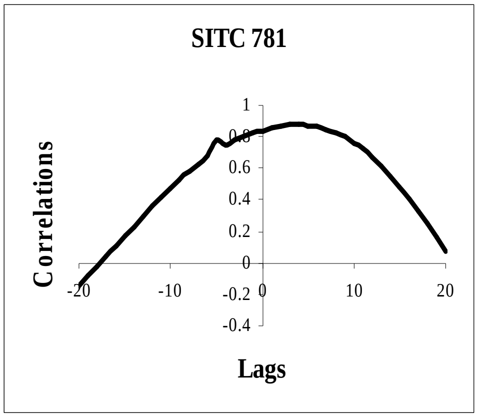


Figure 4: US trade with the rest of the world at the SITC 3-digit industry level



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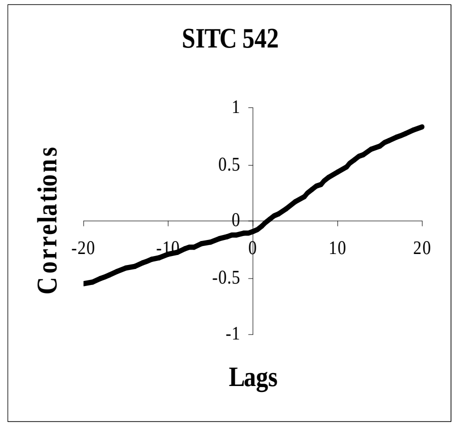
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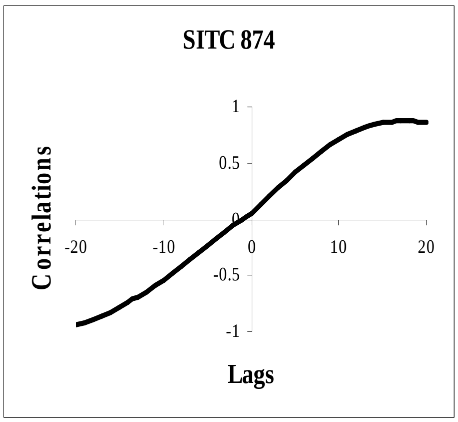
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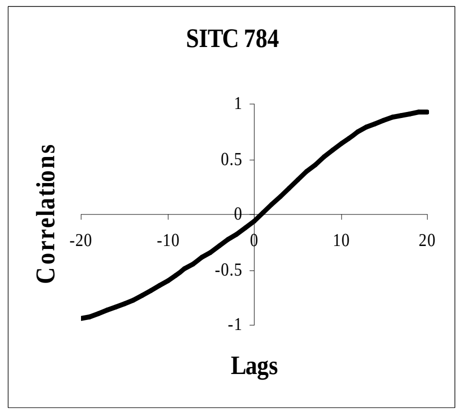
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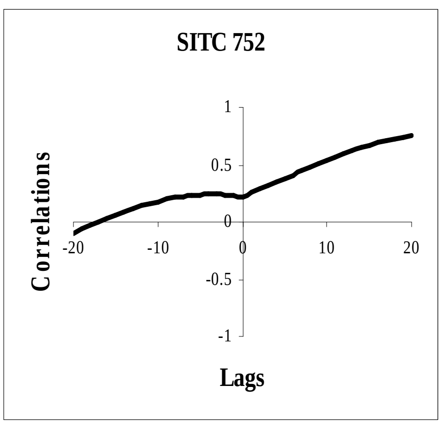
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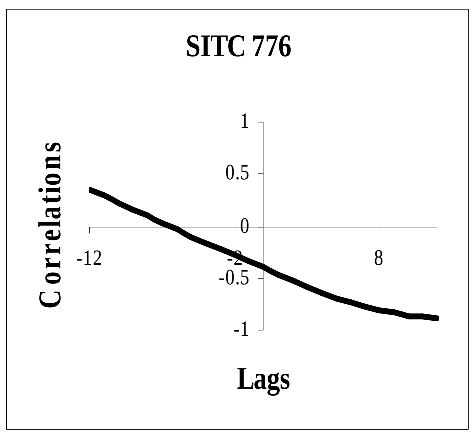
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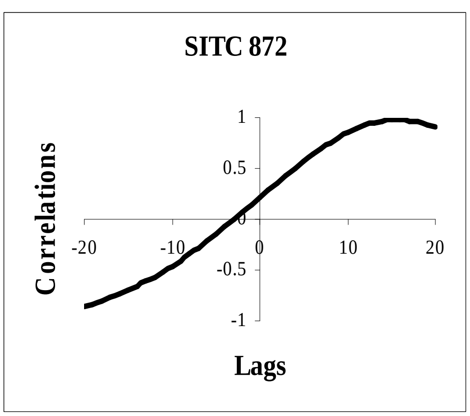
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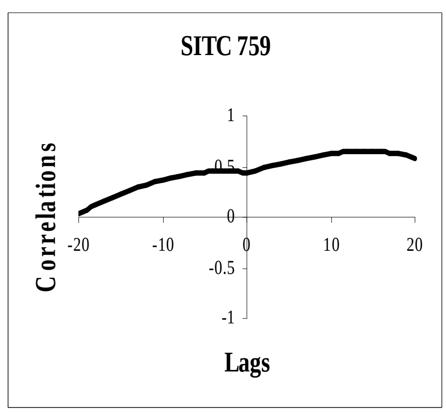
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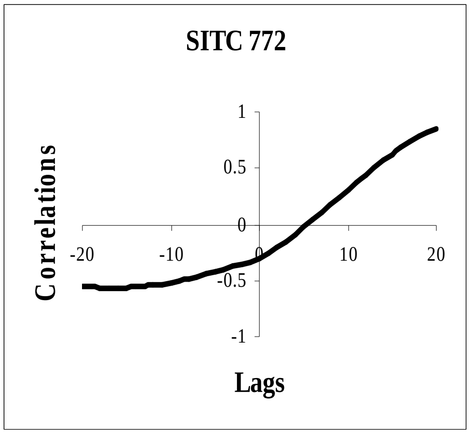
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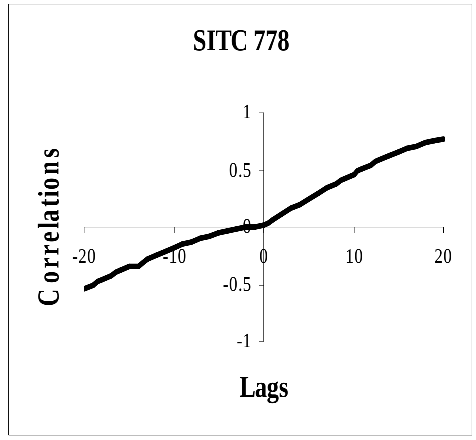
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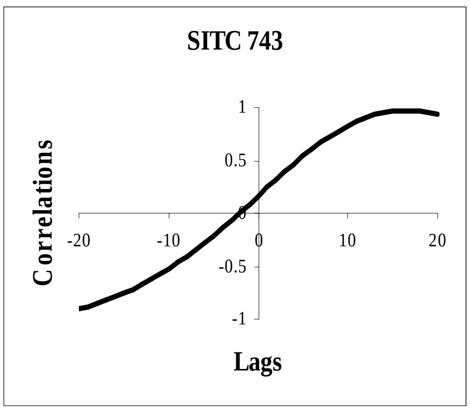
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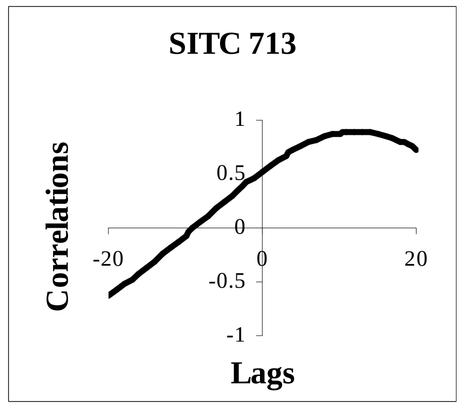
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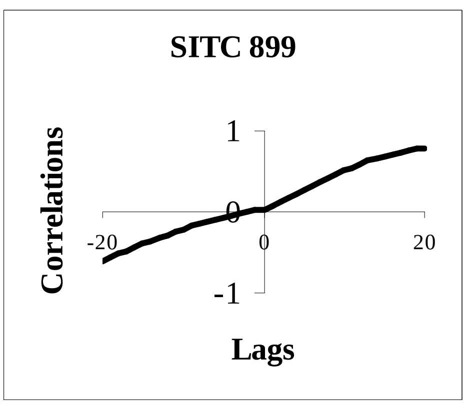
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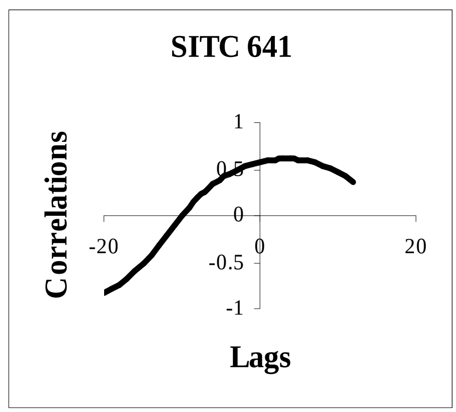
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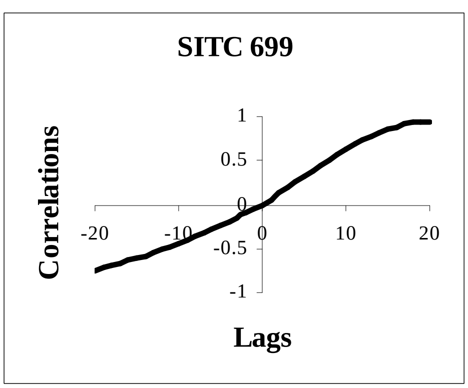
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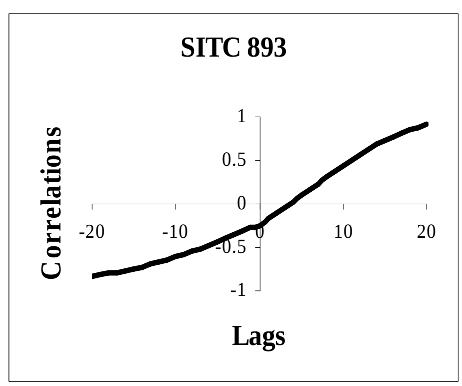
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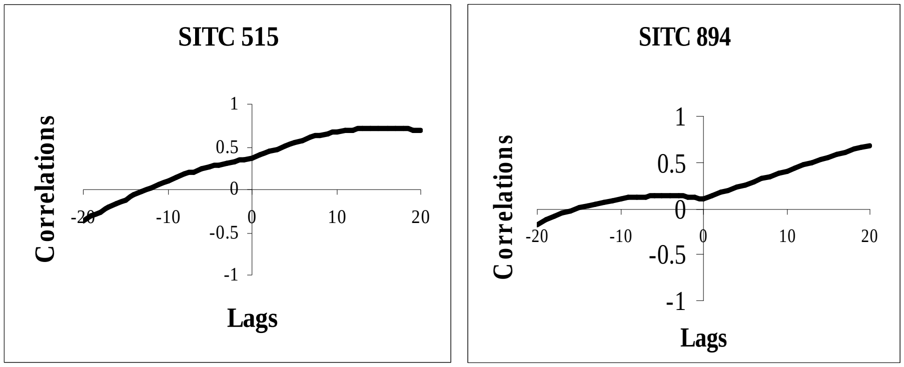
Correlations
Lags


SITC 515
Correlations
Lags
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SITC 894
Correlations
Lags
1
0.5
0
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-1
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0
10
20