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Transition Probability Matrices and Revealed Comparative Advantage Persistence in a Small Hydrocarbon-based Economy

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Abstract: *Over the past 10 years, Trinidad and Tobago has seen a shift in its trade structure due to increased energy exports and foreign investment in the energy sector. This paper proposes to explore the changing pattern of exports by evaluating the dynamics and persistence of comparative advantage as measured by an RCA (Revealed Comparative Advantage) index using 3-digit export data for the period 1991-2008. The paper calculates and examines Balassa's RCA Index for the Trinidad and Tobago economy to determine how its comparative advantage has changed over the time period 1991-2008 using tools such as Galtonian Regressions, Markov Chains, Transition Probability Matrices, Mobility Indices and Granger Causality tests. The results indicated that the pattern of trade in Trinidad and Tobago has become more specialised as the country focused on the exports of petroleum products and has not placed as much emphasis on the development of non-energy exports.*

Keywords: *Revealed Comparative Advantage (RCA), Balassa Index, Galtonian Regression, Markov Chains, Transition Probability Matrix, Mobility Indices*

1. Introduction

Whereas absolute advantage refers to the ability of a party (an individual, or firm, or country) to produce more of a good or service than its competitors using the same amount of resources, comparative advantage refers to the ability of a party to produce a good, product or service at a lower opportunity or marginal cost. Ricardo (1817) outlined the theory of comparative advantage and cited costs and technological differences as the source of comparative advantage among nations. Other theories such as the widely accepted Heckscher-Ohlin theory considered factor endowments (land, labour and capital) as the source of a nation's comparative advantage. Vernon (1966, 1979) developed a model that attributes comparative advantage in the production of new products to sources that may change over the life cycle of the products. A further theory developed by Schultz (1961) and Becker (1975) placed emphasis on the concept of human capital as the source of comparative advantage. Regardless of its source, comparative advantage is a key concept in explaining sources of trade as well as in determining economic welfare, and directing an economy's trade and investment strategy.

Over the past 15 years, the Trinidad and Tobago economy has undergone significant structural changes particularly in its export basket. The country had long been a primary exporter of oil as well as sugar which had traditionally been its primary source of comparative advantage. Recently, the country enjoyed a period of economic growth which was primarily driven by increased production and exports of natural gas combined with favourable global oil and gas prices. Natural gas has now become the primary driver of economic growth and export revenues in Trinidad and Tobago.

This paper proposes to conduct a rigorous analysis on the pattern of merchandise exports from Trinidad and Tobago over the period 1991-2008. This analysis will give a clear picture of the industries that possess a revealed comparative advantage as measured by the widely accepted Balassa Index. Furthermore, this study will also seek to identify whether the pattern of exports has changed significantly over the period due to the structural changes that the economy experienced, using numerous tools outlined in the literature. Finally associated policy recommendations will be made based on results of the investigation.

2. Revealed Comparative Advantage and the Trinidad case

In his seminal paper "Trade Liberalisation and Revealed Comparative Advantage", Balassa (1965) introduced the

concept of revealed comparative advantage. Comparative advantage could be "revealed" by observed trade patterns that reflect differences in factor endowments across nations. Since then, the theory of revealed comparative advantage has been widely used and applied in many studies as a measure of international trade specialisation and comparative advantage. This paper proposes to utilise the concept of revealed comparative advantage to analyse changes in the pattern of trade in Trinidad and Tobago.

Structural changes in economic policies impact a country's revealed comparative advantage. By employing a more open trade policy stance, many countries can increase their comparative advantage in products and sectors. This is possible due to new efficiencies in production, adoption of new technologies and knowledge transfers that developing countries could gain from trading with developed countries. Several studies have outlined the impact of structural changes on revealed comparative advantage. In their study of revealed comparative advantage in Asian and Latin American markets, Bender and Li (2002) noted that a number of economies in Latin America underwent economic structural changes that were linked to trade liberalisation and new outward looking trade policies. They argued that more efficient trade policies reduced distortions in factor allocations.

The Lawrence Index measures structural change in trade and is calculated as Lawrence Index = $(1/2)\sum_{i=1}^{n} |s_{i,t} - s_{i,t-1}|$ where $s_{i,t}$ is the share of sector i's exports in total exports of the country at year t (Sapir, 1996). Using the Lawrence index to measure structural changes in both markets, they concluded that Latin America experienced positive structural change since the 1990s and that economic structural changes increased the share of export products (sectors) that were dynamic in the world markets (Bender and Li, 2002, p.9). It was concluded that the improvement in revealed comparative advantage in Latin America reflected changes in government's strategy towards trade liberalisation (which countries such as Mexico, Argentina, Chile and Peru experienced during the 80s and 90s) rather than changes in factor endowments.

Hinloopen and van Marrewijk (2004) undertook a comprehensive analysis of structural changes and revealed comparative advantage in Chinese economies (China, Hong Kong and Taiwan). They utilised tools such as Galtonian Regressions, pp plots and harmonic mass indices to analyse how the structure of comparative advantage evolved over a 20-year period in response to more open trade strategies. They found that all three regions underwent significant structural changes in trade patterns over the time period which had a considerable effect on revealed comparative advantage. The authors argued that Taiwan benefitted greatly from more open trade policies adopted by China as this helped to ease the transition from unskilled-labour intensive exports, towards more technologically intensive exports. Thus Taiwan was able to specialise in these technologically intensive products instead of labour-intensive products which had been its traditional source of comparative advantage. Hong Kong's comparative advantage which was heavily concentrated in unskilled-labour intensive products, also made a shift towards technology intensive products over time due to changes in Chinese trade policies. Moreover, Hinloopen and Van Marrewijk (2004, p.43) stated that "China's stronghold in primary products gradually reduced and its high grip on unskilled-labor intensive products increased, as did its grip on natural resource intensive products and human-capital intensive products."

Lutz (1987) argued that the emergence of newly industrialised countries (NICs) onto the international arena of manufacturing exports was a direct consequence of shifts in comparative advantage in the world economy. This development was as a result of production facilities moving from industrialised countries to newly industrialised countries to take advantage in the last stage of the product life cycle of lower wages. The factories will produce for both the export and domestic markets eventually replacing imports within the local market. In the long term these facilities will export to industrialised states. Thus by changing their economic structure, newly industrialised countries experienced a shift in their comparative advantage.

Studies on the Asian economies (Kojima, 1985; Lo and Salih., 1987; Rana, 1990; Yamazawa, 1990; Fukasaku, 1992; Hobday, 1995) have stated that emphasis on trade and foreign direct investment gave these economies great capacity for structural change and allowed them to gain comparative advantage in many product categories allowing for rapid development of their economies. Kilduff and Chi (2006) stated that in the early stages of development, countries tend to focus on labour intensive sectors. However, over the course of industrialisation and through the transfer of technologies and techniques, specialisation in more capital-intensive products and processes will emerge. As time progresses, industrialised nations may experience a decline in overall comparative advantage as newly industrialised markets enter the fold. Chow (1990) in his analysis of the NICs of South East Asia observed that in order for these economies to survive they needed to shift their focus and specialisation towards skill intensive, technology intensive markets.

Based on these findings this paper examines how changes in trade structure of Trinidad and Tobago economy have impacted upon its revealed comparative advantage. During the period 1999-2008 Trinidad and Tobago went through a sustained period of economic growth and development. This economic development was due in large measure to the production and export of natural gas which superseded crude oil as the primary export product of Trinidad and Tobago. According to

2009 data from the Ministry of Energy, Exports of Natural Gas (tcf) is 5.61(Exports of barrels of Oil). This shows that natural gas is far and away the most important export commodity in the Trinidad and Tobago. In 2007, the country produced 1.4 trillion cubic feet (tcf) of natural gas, up 7% year-on-year and over three times the level seen in 1997. Table 1 shows the trend data in production of crude oil and natural gas in Trinidad and Tobago, whereas Figure 1 illustrates the trend graphically.

Table 1. Crude Oil and Natural Gas Production in Trinidad and Tobago (1970-2009)

Year	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**
Crude Oil (BPD)	140,000	129,000	141,000	166,000	187,000	216,000	212,000	229,000	230,000	214,000
Natural Gas (BOEPD)	32,210	31,393	32,359	31,162	28,470	25,876	29,045	34,234	40,870	44,612
Year	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Crude Oil (BPD)	212,000	189,000	177,000	160,000	170,000	176,000	169,000	155,000	151,000	149,000
Natural Gas (BOEPD)	48,515	51,018	62,441	69,690	72,489	72,609	76,606	79,388	89,116	90,203
Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Crude Oil (BPD)	150,000	149,000	144,000	134,000	141,000	142,000	141,000	135,000	134,000	141,000
Natural Gas (BOEPD)	92,946	100,508	96,717	108,796	124,666	133,835	150,702	163,987	163,987	206,836
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Crude Oil (BPD)	138,000	135,000	155,000	164,000	152,000	171,000	173,578	154,129	149,033	150,734
Natural Gas (BOEPD)	255,684	272,430	317,747	464,454	480,067	546,272	642,548	687,865	691,085	715,901

Keys: BOEPD – Barrel of oil equivalent per day; BPD – Barrel per day

Source: Based on BP (2010)

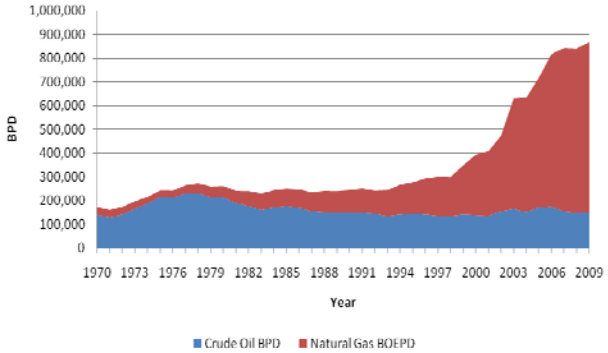

Figure 1. Trinidad and Tobago Oil and Gas Production (1970-2009)

The country has also benefited from a large amount of foreign investment into the energy sector which according to the UNCTAD world investment report 2011 was up from US$633 million in 1999 to over US$2,937 million in 2010. Trinidad and Tobago's gas production has also fuelled a web of downstream production facilities in the past ten years including plants producing methanol, ammonia, urea, and natural gas liquids and collectively these all account for a large proportion of total exports. T&T is the world's largest exporter of both ammonia and methanol and the world's sixth largest exporter of LNG, constituting approximately 52% of US LNG imports in 2010. One methanol plant owned by Methanol Holdings Trinidad Limited is currently the largest in the world at 1.89 million tonnes output per year, and the fourth LNG train owned by Atlantic LNG is one of the world's largest LNG trains, at 5.2 million tonnes, Along with the increase in natural gas exports, global crude oil and energy prices increased during the period under study allowing the Trinidad and Tobago economy to earn additional export revenues. However, this increase in exports and growth within the energy sector was not matched by growth in the non-energy sector. Non-energy exports including manufactures and agriculture products have been steadily declining over the period in question. In addition, Trinidad and Tobago effectively shut down its 300-year old sugar industry in 2007 following the closure of its largest sugar production factory, Caroni 1975 Limited.

Adding to the urgency with which shifting patterns of comparative advantage has to be understood is the fact that proven reserves of oil and gas are dwindling as evidenced by falling reserve to production ratios. The historical reserves to production ratios for natural gas are

shown in Figure 2. Proven reserves of natural gas are currently estimated at 13.46 trillion cubic feet in 2010 compared to 14.2 trillion cubic feet in 2009 according to the latest Ryder Scott report. Proven reserves of crude oil are estimated at 0.8 thousand million barrels with a reserve to production ratio of 15.1.

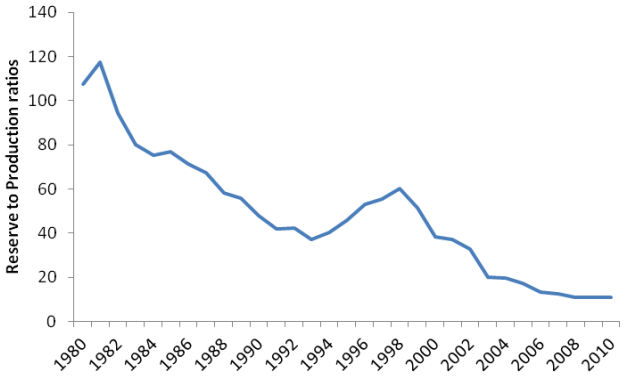

Figure 2. Reserve to Production Ratios for Natural Gas in Trinidad and Tobago (1980- 2010)
Source: Abstracted from BP (2010)

Many policy makers have opined that unless there is a major new discovery of natural gas and/or crude oil, focus on the production of these commodities or goods will eventually stall, leaving Trinidad and Tobago in a vulnerable state.

3. Measuring Revealed Comparative Advantage

Because comparative advantage is defined in terms of autarkic price relationships that cannot be readily observed, measuring reveal comparative advantage has proven to be historically problematic (Hoen and Oosterhaven, 2006). de Benedictis and Tamberi (2001, p.324) stated that relative autarkic prices are unobservable variables and this hampers the identification of true or shadow comparative advantage. Balassa (1965, p.100) states that "Comparative advantage appears to be the outcome of a number of factors, some measurable, others not, some easily pinned down, others less so."

Liesner (1958) was the first to use post trade data in order to measure comparative advantage. His research effort focused on developing a methodology to assess the effects of Britain's entry into the EU which required an analysis of comparative advantage. He developed an index (hereafter referred to the Liesner index) shown in Equation 1:

$$LI_a^i = X_a^i / X_d^i \qquad \ldots\ldots \textit{Eq.1}$$

Where: LI_a^i is the comparative advantage in country a in product i,

X_a^i is country a's exports in product i, and

X_d^i is exports of i in an identified market d.

However, Liesner's (1958) proposed index was characterised by a variety of problems. One such problem identified was the unrealistic assumption that inflationary pressures are the same as far as both countries' exports are concerned (Liesner, 1958). In addition, the results regarding the precise order of product comparative advantage cannot be taken as definite. Thus Liesner was not able to make any firm conclusions with regard to broad sectors of industries.

Balassa (1965) argued that the true pattern of comparative advantage could be observed from post-trade data. Specifically he noted that "One wonders, therefore, whether more could not be gained if, instead of enunciating general principles and trying to apply these to explain actual trade flows, one took the observed pattern of trade as a point of departure" (Balassa, 1965, p.101).

To measure comparative advantage Balassa derived an index (hereafter referred to as the RCA index) that measures a country's comparative advantage. The RCA index has since become the most widely used measure of revealed comparative advantage in the literature (Bojnec 2001; Havrila and Gunawardana, 2003). The RCA index seeks to identify whether a country has a "revealed" comparative advantage rather than to determine the underlying sources of comparative advantage. The basic logic behind the RCA index is to evaluate comparative advantage on the basis of a country's specialisation in exports relative to some reference group (in most cases total world exports). Balassa's approach, essentially says that the pattern of trade that emerges in free trade will reflect a country's underlying comparative advantage. Thus the RCA index is used for calculating the relative advantage or disadvantage of a certain country in a certain class of goods or services as evidenced by trade flows. The RCA index is shown in Equation 2:

$$RCA_{ij} = (X_{ij}/X_{it}) / (X_{nj}/X_{nt}) \qquad \ldots\ldots \textit{Eq.2}$$

Where:

X = exports
i = country index
j = commodity index
n = set of countries
t = set of commodities.

The RCA index can be interpreted as follows:

- $RCA_{ij} > 1$ - Country i has comparative advantage in product j;
- RCAij < 1 - Country i has comparative disadvantage in commodity j;
- $RCA_{ij} = 1$ - Country i has "neutral" comparative advantage in commodity j.

Balance et al. (1987) added the following further comments regarding the RCA index. Firstly, each index provides a demarcation between countries that reveals a comparative advantage in a particular sector and those countries that does not. This is done by observing that value of the index and using the criteria stated above.

Secondly, it quantifies the sector specific degree of comparative advantage enjoyed by one country or set of countries. Thirdly, it allows for possible cross-country and cross-sector rankings according to their specific values.

de Benedictis and Tamberi (2004, p.328) took the analysis further, stating that "while a cardinal interpretation of the RCA index values should be considered informative for comparative analysis across countries and across time, a general ordinal analysis, both in space and in time, of the entire RCA index sectoral distribution can provide many interesting insights of the comparative advantage of the considered areas." Therefore one can use the RCA index and the distribution of comparative advantage in a given country to conduct a greater analysis of the patterns of trade.

While the RCA index is useful in assessing whether or not a country has comparative advantage in a commodity, its utility in comparative advantage studies has proven to be limited and problematic (Hillman, 1980; Bowen, 1983; Balance et al., 1987; Deardorff, 1994; Hoen and Oosterhaven, 2006). The major shortcoming of the RCA index is its asymmetric property. The RCA index has a fixed lower bound of 0 with 1 being the comparative advantage neutral point, while its upper bound in general is not delimited, as shown in Figure 3.

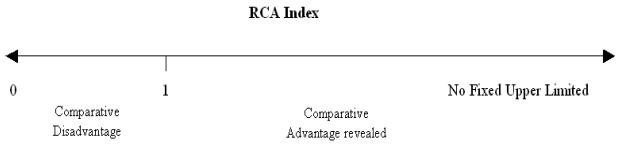

Figure 3. The Range of the RCA Index

In order to give additional interpretational substance to the distribution of the RCA index, Hinloopen and van Marrewijk (2001) have gone further to divide the theoretical range of the RCA index into four additional classes shown in Table 2. These four classes outline the strength of a country's comparative advantage.

Table 2. The States of Comparative Advantage

Class	Value of RCA Index	Result
Class A	0 – 1	Industries with comparative disadvantage
Class B	1 – 2	Industries with weak comparative advantage
Class C	2 – 4	Industries with medium comparative advantage
Class D	Greater than 4	Industries with strong comparative advantage

Source: Based on Hinloopen and Marrewijk (2001)

A second theoretical disadvantage of the RCA index is that it can only signify whether or not a country has comparative advantage in a commodity, as its magnitude has neither the ordinal property nor the cardinal property (Hillman, 1980). Yeats (1985) observed that using the RCA index to measure a countries' comparative advantage tends to give inconsistent and misleading results, as it would signify stronger comparative advantage for countries with a small market share in the world export markets. Furthermore, Hoen and Oosterhaven (2006, p.683) concluded that "to theoretically derive the distribution of the standard Balassa Index appears to be impossible, because it depends on the number of countries and sectors, while its mean is unstable and larger than the theoretically expected value of 1."

Despite its identified shortcomings, the RCA index continues to be the most widely accepted and widely used measure of international specialisation and comparative advantage. Many additional measures of revealed comparative advantage have been put forward, some of which address specific shortcomings of Balassa's measure. Examples of these alternative indices include the logarithmic Balassa (1965) index put forward by Soete and Verspagen (1994), the weighted revealed comparative advantage index suggested by Proudman and Redding (1998), the additive revealed comparative advantage index outlined in Hoen and Oosterhaven (2006) and the normalised revealed comparative advantage index by Yu et al. (2008). Each of these indices has their specific advantages; however, they all present their own unique shortcomings and in some cases present even greater problems that those identified with the RCA index.

The RCA index continues to be the most popular measure of revealed comparative advantage as it persists as the best solution in identifying revealed comparative advantage. Many recent studies such as Georgiou (2009) who looked at entrepreneurship and its effect on revealed comparative advantage identified the RCA index as the preferred measure of comparative advantage. Bernatonyte (2009) in her study on Intra-Industry Trade in Lithuania identifies the RCA index as a dominating measure of export specialisation and Grigorovici (2009) in analysing specialisation in Romania's services sector, noted that the RCA index "is the most widely used for estimating the comparative advantage in the commercial relations between countries." In this context, this paper utilises the RCA index as the preferred choice for assessing revealed comparative advantage in Trinidad and Tobago.

4. Empirical Analysis of Trinidad and Tobago's Revealed Comparative Advantage

4.1 Data and Methodology

In order to observe the pattern of trade and the persistence of revealed comparative advantage over the period 1991-2008, this study will compare the average

RCA index results for the period 1991-1993 to the period 2006-2008 using various statistical techniques. These two times periods represent the period just before and the end of the strong period of economic growth.

Firstly the RCA index is calculated using standard international trade classification (sitc) data stated in dollar value of trade at the 3-digit level, and the source is based on the online database of the United Nations Comtrade (2010). The paper analyses the patterns of revealed comparative advantage visually using plots and cumulative distribution functions (this will give a general overview about how the pattern of comparative advantage has changed from one time period to the next). A review of the statistical properties of both distributions is also conducted. This paper then moves on to utilise more sophisticated tools (such as Galtonian regressions, transition probability matrices and mobility indices) to explore the evolution and persistence of revealed comparative advantage over the two time periods.

4.2 RCA Index in Trinidad and Tobago

The paper calculates the average RCA index for the time periods 1991-1993 and 2006-2008. Table 3 shows all the industries that have a revealed comparative advantage (i.e. RCA > 1) in each time period. Hillman (1980) derives conditions under which the RCA Index replicates a comparative advantage in an industry. Essentially, as long as an economy does not specialise only in the export of that product or is not a monopolist in world markets, then RCA in an industry signifies comparative advantage. This is known in the literature as the Hillman condition. The Hillman condition (as illustrated in Equation 3) was applied to this study. Whenever the Hillman condition was satisfied, the RCA index could be used as a sufficient measure of comparative advantage.

Hillman Condition:

$$1 - X^{j}_{i,t}/X^{j}_{t} > X^{j}_{i,t}/X_{i,t}\,(1 - X_{i,t}/X_{t}) \qquad \ldots\ldots \textit{Eq.3}$$

Where,

- $X^{j}_{i,t}/X^{j}_{t}$ = market share i.e. the country's share of exports in a particular sector relative to the total exports in that sector of the group of reference countries.
- $X^{j}_{i,t}/X_{i,t}$ = degree of export specialisation i.e. the share of a country's exports in a particular sector relative to total exports.
- $X_{i,t}/X_{t}$ = country size i.e. the share of a country's exports relative to total exports of the group of reference countries.

In looking at Table 3 it can be seen that for the time period 1991-1993, Trinidad and Tobago had a revealed comparative advantage in 27 industry categories. However, in the corresponding time period 2006-2008, the number of industries with revealed comparative advantage fell to 20. The fact that fewer industries possessed a revealed comparative advantage in the second period suggests a certain degree of polarisation of the pattern of comparative advantage in the Trinidad and Tobago economy. Furthermore, if one was to observe the exports of oil and gas products as well as downstream energy products (sitc 3 and 5), one would notice that most of these industries have strengthened their comparative advantage position as evidenced by larger RCA values from one time period to the next.

Figures 4 and 5 show this trend while giving a clearer picture as to the evolution and persistence of RCA over the two time periods, 1991-1993 and 2006-2008, respectively. The trend suggests a change in pattern of RCA over the two time periods as there is a greater concentration of RCA in the energy and petrochemical sectors which have increased their RCA values while areas of weaker comparative advantage have become furthered weakened or have disappeared altogether, for example food and beverage and non-resource manufacturing products (sitc 0 and 1 represents food and beverage and sitc 7 and 8 represents non-resource manufacturing). Therefore it would seem to suggest that from the first time period to the second, Trinidad and Tobago has become more specialised in its export patterns, especially in the energy sector and downstream energy products.

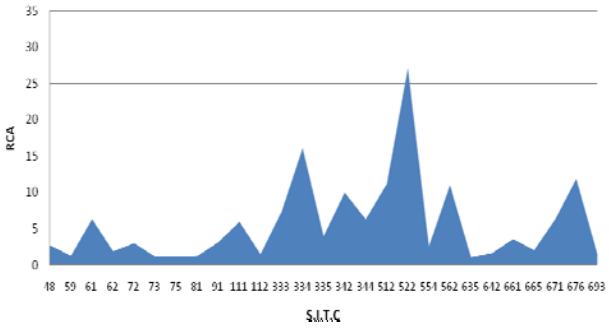

Figure 4. Average RCA, 1991-1993

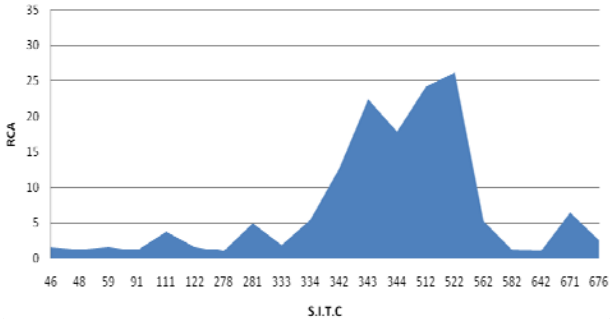

Figure 5. Average RCA, 2006-2008

4.3 Cumulative Distribution Function (CDF) of both distributions

The Cumulative Distribution Function (CDF)

Table 3. Industries in Trinidad and Tobago (with RCA > 1), 1991-1993 and 2006-1008

Industry	1991-1993 Average	2006-2008 Average
046 - MEAL AND FLOUR OF WHEAT AND FLOUR OF MESLIN		1.57
048 - CEREAL PREPARATIONS AND PREPARATIONS OF FLOUR OR STARCH OF FRUITS OR VEGETABLES	2.68	1.34
059 - FRUIT JUICES (INCL. GRAPE MUST) AND VEGETABLE JUICES, UNFERMENTED AND NOT CONTAINING ADDED SPIRIT, WHETHER OR NOT CONTAINING ADDED SWEETENING MATTER	1.25	1.59
061 SUGARS, MOLASSES, AND HONEY	6.30	
062 SUGAR CONFECTIONERY	1.86	
072 COCOA	2.98	
073 CHOCOLATE AND OTHER FOOD PREPARATIONS CONTAINING COCOA	1.11	
75 SPICES	1.11	
081 FEEDING STUFF FOR ANIMALS	1.21	
091 MARGARINE AND SHORTENING	3.13	1.19
111 NONALCOHOLIC BEVERAGES	5.93	3.78
112 ALCOHOLIC BEVERAGES	1.46	
122 TOBACCO, MANUFACTURED		1.59
278 CRUDE MINERALS		1.08
281 IRON ORE AND CONCENTRATES		4.98
333 PETROLEUM OILS AND OILS FROM BITUMINOUS MINERALS	7.33	1.90
334 PETROLEUM OILS AND OILS FROM BITUMINOUS MINERALS (OTHER THAN CRUDE), AND PRODUCTS THEREFROM CONTAINING 70% (BY WT) OR MORE OF THESE OILS, N.E.S.	16.10	5.49
335 RESIDUAL PETROLEUM PRODUCTS, N.E.S. AND RELATED MATERIALS	3.93	
342 LIQUEFIED PROPANE AND BUTANE	9.97	12.71
343 NATURAL GAS, WHETHER OR NOT LIQUEFIED		22.38
344 PETROLEUM GASES AND OTHER GASEOUS HYDROCARBONS	6.28	17.85
512 ALCOHOLS, PHENOLS, PHENOL-ALCOHOLS AND THEIR HALOGENATED, SULFONATED, NITRATED OR NITROSATED DERIVATIVES	11.17	24.14
522 INORGANIC CHEMICAL ELEMENTS, OXIDES AND HALOGEN SALTS	27.14	26.13
554 SOAP, CLEANSING AND POLISHING PREPARATIONS	2.56	
562 FERTILISERS	10.99	5.28
582 PLATES, SHEETS, FILM, FOIL AND STRIP OF PLASTICS		1.17
635 WOOD MANUFACTURES	1.02	
642 PAPER AND PAPERBOARD, CUT TO SIZE OR SHAPE, AND ARTICLES OF PAPER OR PAPERBOARD	1.61	1.12
661 LIME, CEMENT, AND FABRICATED CONSTRUCTION MATERIALS, EXCEPT GLASS AND CLAY MATERIALS	3.54	
665 GLASSWARE	2.02	
671 PIG IRON AND SPIEGELEISEN, SPONGE IRON, IRON OR STEEL GRANULES AND POWDERS AND FERROALLOYS	6.28	6.47
676 IRON AND STEEL BARS, RODS, ANGLES, SHAPES AND SECTIONS, INCLUDING SHEET PILING	11.88	2.59
693 WIRE PRODUCTS (EXCLUDING INSULATED ELECTRICAL WIRING) AND FENCING GRILLS	1.50	
Total Number of Industries with revealed comparative advantage:	**27**	**20**

completely describes the probability distribution of a real-valued random variable, in this case RCA. It plots the probability of not observing a value from the data which does not exceed a specific value.

For every real number x, the CDF of a real-valued random variable X is given by:

$$x \rightarrow F_X(x) = P(X \leq x),$$

Here, the right-hand side of the equation represents the probability that the random variable X takes on a value less than or equal to x. The probability that X lies in the interval [a, b] is therefore FX(b) − FX(a) if a < b. For the case of RCA, the CDF analyses the probability that a distribution will have a value greater than one thus indicating that the country has a revealed comparative advantage in a product category. It has been observed in each period, only a small number of product categories possess RCA values of one or greater (less than 10% in both periods). Both CDF plots in Figures 6 and 7 reflect these observations.

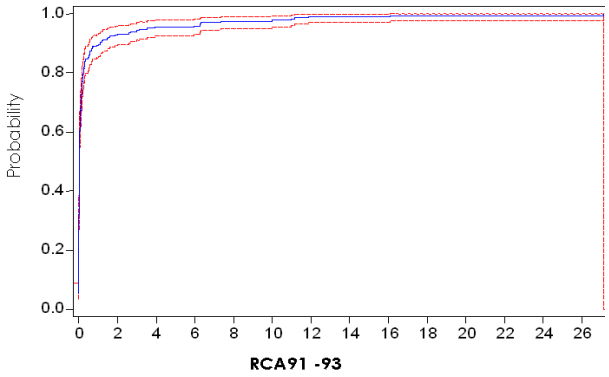

Figure 6. Cumulative Distribution Functions for 1991-1993

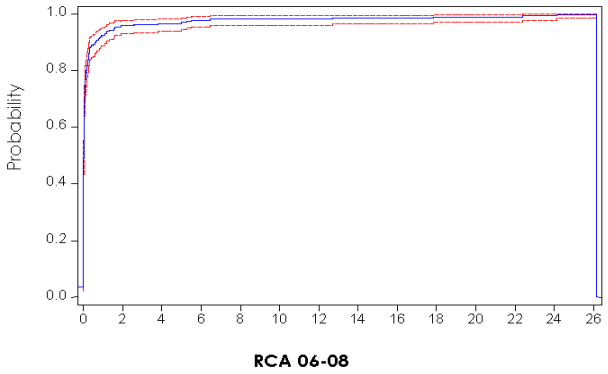

Figure 7. Cumulative Distribution Functions for 2006-2008

Careful examination of the two cumulative distribution functions reveals that the majority of product categories have a very high probability of having an RCA value equal or closer to zero. Based on the results shown in Table 2 over 80% of product categories in the agriculture sector for the period 1991-1993 and over 90% of agriculture exports in the period 2006-2008 have a comparative disadvantage i.e. RCA <1. Furthermore, the CDF indicates that the distributions are asymmetrical, thus the mean of the distributions are not an appropriate measure of its statistical properties.

4.4 Statistical Attributes of both Distributions

The results of the statistical properties for both distributions are shown in Table 4. The first property to highlight regarding each distribution is the relatively higher mean (0.665 in 1991-1993 and 0.628 in 2006-2008). At first glance this would indicate that the industry categories in Trinidad and Tobago have relatively high RCA values. Chew (1990) as well De Benedictis and Tamberi argued that the mean is not a strong indicator of the distribution of an index when the distribution is characterised by a high degree of skewness (in this case 6.55 and 6.79 for 1991-1993 and 1006-1008, respectively). This is consistent with the empirical observations from the CDF plots. This high degree of skewness gives the arithmetic mean little meaning. Chew (1990, p.125) argues that "the arithmetic mean is a very poor synthetic indicator in cases where the underlying distribution is characterised by a pronounced skewness". Hosein (2008, p.141) stated that "some sectors having a RCA above unity means that at least one other sector would have a RCA score below unity, so that there is no statistical sense in saying that the mean of the RCA index is greater than or less than one."

Table 4. The Statistical Properties of both distributions

	Average RCA 1991-1993	**Average RCA 2006-2008**
Mean	0.665	0.628
Median	0.028	0.015
Maximum	27.135	26.125
Minimum	0.000	0.000
Std. Dev.	2.549	3.007
Skewness	6.552	6.795
Kurtosis	55.787	51.008
Jarque-Bera	31678.491	26658.752
Probability	0.000	0.000
Sum	170.916	161.446
Sum Sq. Dev.	1663.432	2315.350
Observations	257	257

Chew (1990) stated in such cases the median values would function as a stronger indicator of distribution as it is not influenced by extreme values. de Benedictis and Tamberi (2004, p.334) stated "in contrast the median values have an immediate interpretation in that a high median value implies that an economy has a large

number of its industries with comparative advantage whilst an economy with a low median value is one which has a high degree of comparative disadvantage." Hinloopen and van Marrewijk (2004, p.15) also noted that "the mean is a poor indicator for the statistical properties of the distribution and it is better to focus on the distribution of the percentiles."

Following these assertions, an examination of the median values for the two time periods indicates that both are very close to zero (0.028 in 1991-1993 and 0.015 in 2006-2008). The conclusion being that half of the 257 industry categories have a score less than 0.028 in 1991-1993 and 0.015 in 2006-2008, thus supporting the results that a vast majority of sectors in Trinidad and Tobago have a comparative disadvantage in both time periods. This also reaffirms the conclusions derived from observing the CDF plots, in that both distributions are asymmetrical.

The Jarque-Bera (JB) test can be used as an indicator of normality in each distribution (Jarque and Bera, 1987). The test measures the difference between skewness and kurtosis of a distribution from the normal distribution. The observed JB statistics indicate that both distributions are not normally distributed. Based on an analysis of the statistical attributes of both periods, it can be concluded that both distributions are abnormally distributed and skewed to the right. The statistical attributes also support the assertion that there has been a greater degree of polarisation in export specialisation in Trinidad and Tobago.

Having concluded that both distributions are abnormally distributed and skewed to the right, as well as getting preliminary results to support a case for increased polarisation in specialisation of exports, the paper will now employ tools such as Galtonian regressions, transition probability matrices and mobility indices to further explore how the pattern of revealed comparative advantage has evolved.

4.5 Galtonian Regression

The Galtonian regression technique was originated by Galton (1889) and further utilised by Hart and Praise (1956) to analyse business concentration. Subsequent to this, the Galtonian regression has been used in a variety of areas such as Cantwell (1989), Hart (1976, 1995). More relevant works by researchers (such as Frantzen (2008), Laursen (1998), Sharma and Dietrich (2007), Worz (2005), Hinloopen and van Marrewijk (2004) and Hosein (2008)) have utilised it in analysing the changes in trade specialisation patterns using RCA indices. In the same vein, this study employs Galtonian regressions to determine whether the T&T economy has become more or less specialised in each of the three-digit industry categories. This simple ordinary least squares (OLS) method allows for the comparison of two cross-sections at two different points of time to determine how much change in the structure of trade specialisation in a given country is made between both periods of interest (Hosein, 2008).

Equation 4 shows the simple form of a Galtonian regression.

$$RCA_{t2} = \alpha_o + \beta_1 RCA_{t1} + e_1 \qquad \text{….. Eq.4}$$

With RCA_{t2} being the average RCA values for time period 2006-2008 and RCA_{t1} being the average RCA values for time period 2991-2993.

The value of the β coefficient can be interpreted as follows:

- $\beta = 1$: there is no change in the degree of specialisation between the two time periods.
- $\beta > 1$: the economy has become more specialised in its area of comparative advantage and less specialised in product categories in which it carried a low level of specialisation.
- $0 < \beta < 1$: product categories with initially high values of RCA experience a decline between the listed time periods whilst those with initially low scores experience growth over time and so overall a β score in this range indicates that the economy has become more diversified.
- If $\beta < 0$, it means that there is a sharp reversal in comparative advantage.

Let $\lambda = 1 - \beta$. The size of variable λ measures the regression effect. For a low value of λ (i.e. for high values of β), there is a concentration of the pattern of specialisation. A high value of λ indicates a significant change in the pattern of revealed comparative advantage. The results of the Galtonian regression with average RCA 2006-2008 as the dependent variables and average RCA 1991-1993 as the independent variable are shown in Table 5.

The estimated value of β is 1.238, indicating that the pattern of Trinidad and Tobago exports has become more specialised i.e. the pattern of specialisation has widened. The magnitude of the regression (which is calculated to be 0.238) supports the conclusion of a concentration in the pattern of specialisation. These results are consistent with the fact that for the period 1991-1993 the Trinidad and Tobago economy had a comparative advantage in twenty-seven (27) industry categories. For the second period 2006-2008, this fell to twenty (20).

This paper raises and answers the question of whether the regression coefficient (1.23) is significantly different from unity and this is investigated using the Wald test in Table 6. The results reject the null hypothesis and conclude that $\beta \neq 1$.

4.6 Markov Chains and Transition Probability Matrix

In closely examining how the pattern of comparative advantage has evolved over time, Markov chains and transition probability matrices are two valuable interrelated tools. A Markov chain may be simply defined as a sequence of random values whose

Table 5. Galtonian Regression Results - Dependent Variable RCA 2006-2008

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Average RCA91-93	1.238186	0.051994	16.12086	0.0000
C	0.070763	0.136723	0.517567	0.6052
R-squared	0.504741	Mean dependent var		0.628195
Adjusted R-squared	0.502799	S.D. dependent var		3.007380
S.E. of regression	2.120578	Akaike info criterion		4.349007
Sum squared resid	1146.697	Schwarz criterion		4.376626
Log likelihood	-556.8473	Hannan-Quinn criter.		4.360114
F-statistic	259.8823	Durbin-Watson stat		1.232204
Prob(F-statistic)	0.000000			

Table 6. Wald Test (Null Hypothesis: $\beta = 1$)

Test Statistic	Value	df	Probability
F-statistic	212.0116	(1, 61)	0.0000
Chi-square	212.0116	1	0.0000

probability values at time period t hinges on the value of the number in the time interval, t-1. The overall controlling factor in a Markov chain is the transition probability matrix (TPM). A TPM is defined as a square array of non-negative numbers such that the rows tally to unity and represent a discrete Markov chain.

Many researchers (e.g., Proudman and Redding (2000), Brasili et al. (2000) and Hinloopen and van Marrewijk (2001)) employed TPMs to identify the persistence and mobility of revealed comparative advantage as measured by the RCA index. For the Trinidad and Tobago case, a TPM was constructed using Hinloopen and van Marrewijk (2001) classes of RCA seen in Table 7 to chart the probability of the evolution of RCA from the first time period to the second.

Table 7. Transition Probability Matrix, 1991-1993 to 2006-2008

		To			
		a	**b**	**c**	**d**
From	**a**	0.974	0.017	0.000	0.009
	b	0.778	0.222	0.000	0.000
	c	0.714	0.286	0.000	0.000
	d	0.091	0.091	0.182	0.636

The first diagonal element of 0.974 signifies a high degree of persistence amongst the comparative disadvantage class. In other words, a commodity with a comparative disadvantage (Class A) in one time period is likely not to change in the second period. This result is not surprising as a majority (90% +) of all industry categories having a comparative disadvantage in the first time period persisted into the second time period. The other diagonal elements are 0.222, 0.000 and 0.636, respectively. The relatively high values of the elements are along the leading diagonal point to some degree of persistence. The matrix suggests that the areas of no comparative advantage and strong comparative advantage experience a high degree of persistence as the probability that they change is very low. However, the areas of weak (class A) and moderate comparative advantage (class B) have a very high probability of moving towards no comparative advantage. This lends further evidence to the case for increased specialisation of exports as industries with strong comparative advantage persist to the second period while areas of weak and moderate comparative advantage decline.

A further enquiry into the changing pattern of specialisation and the revealed comparative advantage structure of the Trinidad and Tobago economy is now undertaken using mobility indices.

4.7 Indices of Mobility

Proudman and Redding (1998, p.24) proposed to utilise mobility indices to observe the changing specialisation patterns in a country's exports. These mobility indices attempt to reduce information about mobility from the transition probability matrices into one single statistic. The paper will outline four such indices, with each placing emphasis on different properties of the transition probability matrices.

4.7.1 Shorrocks Index (M_1)

Shorrocks (1978) proposed an index of mobility that evaluates the trace (tr) of the transition probability matrix. This index captures the relative magnitude of both diagonal and off-diagonal elements of the transition probability matrix and can also be shown to equal the amount of the harmonic mean of the expected duration of remaining in a given cell. The Shorrock's Index (M_1) is calculated using the formula set out in Equation 5.

$$M_1 = K\text{-}tr(P)/K\text{-}1 \qquad \ldots\ldots \textit{Eq.5}$$

Where K is number of classes, and tr(P) is the trace of the transition probability matrix (the sum of the diagonal elements). The higher value of the SH indicates greater mobility, with a value of zero designating perfect immobility.

4.7.2 Bartholomew Index (M_2)

Bartholomew (1973) introduced an index that presented information on the average number of class boundaries crossed by an individual originally in state k weighted by the corresponding proportions π_k of the ergodic distribution. Hinloopen and van Marrewijk (2001) went on to state that M_2 uses these as weights to calculate an extended version of M_1 while simultaneously "penalising" large movements.

$$M_2 = \Sigma_k \pi_k \Sigma_l p_{kl} \circledcirc k\text{-}1 \circledcirc \qquad \ldots\ldots \textit{Eq.6}$$

Where p is the transition probability matrix and π_k is its ergodic distribution.

4.7.3 Shorrocks Index (M_3)

Shorrocks (1978) also proposed a second mobility index referred to as M_3. This index analyses the determinant of the matrix. The product of the eigenvalues of the transition probability matrix is equal to the determinant. M_3 is calculated as:

$$M_3 = 1 - \det(P) \qquad \ldots\ldots \textit{Eq.7}$$

4.7.4 Sommers and Conlisk Index (M_4)

Sommers and Conlisk (1979) proposed their own index (M_4) which is based on the eigenvalues of the TPM. Hinloopen van Marrewijk (2001, p.16) stated that "Since P is a transition probability matrix there is always one eigenvalue equal to 1 and the modulus of the other eigenvalues is bounded from above by 1. Convergence to the ergodic distribution occurs at a geometric rate given by powers of the eigenvalues. The smaller the modulus of an eigenvalue, the faster its corresponding component converges. Moreover, the dominant that is the slowest, convergence term is given by the second largest eigenvalue." M_4 is shown in Equation 8.

$$M_4 = 1 - \lambda_2 \qquad \ldots\ldots \textit{Eq.8}$$

Where λ_2 is the second largest eigenvalue of *P*. According to Fields and Ok (1999), there has been no consensus view in the literature that indicates which is the best index to use as each focuses on different properties of the TPM. This paper will utilise both M_1 and M_4 index as they both give a wider view of mobility. Researchers (such as Buchinsky and Fields (2003) and Shahar (2008)) utilised mobility indices in analysing trade patterns. The mobility indices were calculated from 1991 to all subsequent years to see how the pattern of trade has evolved over the entire period from 1991-2008.

It is shown in Figure 8 that both mobility indices demonstrate an upward pattern during the later years of the time period. This indicates that the pattern of trade demonstrated significant mobility from 1991, and on this basis one can conclude that the pattern of revealed comparative advantage has changed from 1991 to 2008. It should be noted that both mobility indices increased during the identified period of economic boom brought about by significant exports of petroleum products (2002-2008). These conclusions are consistent with the findings of the paper thus far.

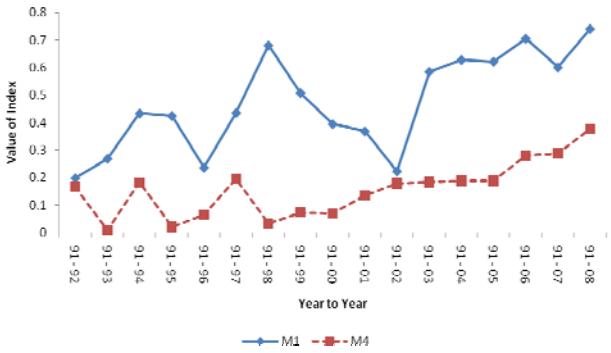

Figure 8. Mobility Indices from 1991-2008

5. Conclusion

This paper outlined a methodology to examine the changes in the patterns of trade, specialisation and revealed comparative advantage from the time period 1991 – 1993 to 2006 – 2008. Based on the calculations of the RCA index and the subsequent analysis performed on the patterns of revealed comparative advantage, the paper found that over 92% of industry categories in both time periods are at a comparative disadvantage. In addition, evidence derived from the number of industries with revealed comparative advantage as well as Galtonian regressions suggests a shift in the pattern of export towards a more specialised export base. The elements of the transition probability matrix reflected that there is a high probability of persistence in industries with an initial very strong comparative advantage (RCA>4) and those with a comparative disadvantage (RCA<1).

However, industries with weak and moderate comparative advantage have a high probability of moving towards being in a position of a comparative

disadvantage or weaker comparative advantage. This shows that there was mobility in the pattern of trade; and this conclusion is supported by reference to both mobility indices. Trinidad and Tobago currently exports a concentrated basked of goods and it appears to be getting even more concentrated. On this basis, the paper concludes that there has been a shift in the pattern of specialisation and revealed comparative advantage towards a greater degree of specialisation from the period 1991-1993 to 2006-2008. The structural changes that the economy underwent during the period 1991-2008 had a significant impact on its pattern of comparative advantage.

From a policy standpoint, it appears that Trinidad and Tobago is heavily reliant on the energy sector for export revenue and subsequently economic growth and development. One can make a compelling argument for the presence of the so-called resource curse or Dutch Disease in Trinidad and Tobago. This can be challenging for the Trinidad and Tobago economy due to the fact that proven oil and gas reserves are on the decline as evidenced by the 2010 Ryder Scott Report (Ryderscott, 2010)

The government of Trinidad and Tobago would therefore need to enact further policies to promote diversification of the export base so as to ensure that there is greater persistence in comparative advantage across all sectors and not just the energy sector. In this regard, special attention could be placed on areas that have shown a comparative advantage in the past which have disappeared due to focus on the energy sector or have RCA values of close to unity. Examples include focus on agro-processing and niche manufacturing. Furthermore, the export base needs be expanded further so that the Trinidad and Tobago economy is not just focused on areas that are dependent on the oil and gas industry. This would ensure that the country is earning export revenue from a wider base should there be any adverse shocks in the production or prices of energy sector products.

The Government must continue to enact policies that promote competitiveness in manufacturing and the services sectors so as to increase the value added within these sectors. Seven priority sectors in the non-energy sector were identified for development as part of the strategy for diversification. However, these sectors need to be revisited as they may not be as relevant in terms of growth and comparative advantage. For example sectors such as film and music and entertainment were selected, however the growth and export earning potential may not be enough to sustain the economy. Fish and fish processing was also one of the identified sectors. However, the latest data shows that the fish stocks in Trinidad and Tobago waters are on the decline. Should the decline in oil and gas reserves persist, the country would need to tap into sectors that are less dependent on petroleum and this points to the need for more wide ranging policies should be explored.

It can be argued that the technical and knowledge capacity outside of the energy needs to be expanded. The country has already introduced policies to promote the development of technical skills in its population by the establishment of new universities. For instance, the establishment of the University of Trinidad and Tobago is to impart technical and industrial skills to its students. This must be complemented with programmes to improve the capacity for innovation in Trinidad and Tobago.

One of the major constraints to increasing non-energy exports is the enabling environment. Manufacturing firms have cited that Government has little incentives in place to promote non-energy exports. In addition port facilities, the level of bureaucracy as well as complicated export procedures have prevented them from exploring the export market. These issues would need to be addressed with a sustained drive towards promoting local non-energy exports, particularly in the areas that have a comparative advantage.

Scope for future work based on this analysis would be attempting to link the strategy of export diversification to economic development in Trinidad and Tobago. There is a wide literature on the link between diversification of exports and economic development. However, empirical evidence has not been firmly established. In addition, a more comprehensive analysis on the distributions of revealed comparative advantage can be undertaken including comparing the distributions between time periods and comparing across countries.

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■