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Estimating Quarterly, Expenditure-Based GDP for Jamaica: A General Kalman Filter Approach

Prudence Serju[1]
Research Services Department
Research and Economic Programming Division
Bank of Jamaica

Abstract

This paper represents a tentative attempt at developing a quarterly real GDP series, *from the expenditure side,* for Jamaica between 1991 and 2002. The paper evaluates a set of indicators that are consistent, both methodologically and empirically, with annual data available from the Statistical Institute of Jamaica. A state space model is used to interpolate the annual benchmarks and the output from this framework is compared against estimates from the traditional Denton's Least Square method. While the estimates from the Denton's Least Square method more closely tracked the changes in the indicator, and suffers from the step problem to a lesser degree, the aggregated quarterly GDP estimates from the state space model has better in sample forecasting properties. The paper has provided a preliminary base for more advanced modelling work on aggregate demand, but an evaluation of the stylised facts suggests that real interest may have had an impact, albeit marginal, on some of the categories of spending.

Keywords: Interpolation, Kalman filter, National Accounting
JEL Classification: E32, E37

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1.0 Introduction

Estimates of Jamaica's Gross Domestic Product (GDP) based on the expenditure approach are currently available at an annual frequency, and only in current prices. Research on models of monetary transmission to aggregate demand is therefore constrained by this shortcoming, because modern econometric techniques, such as vector autoregression, consume many degrees of freedom in the estimation process.

In this context, the primary objective of this study is to interpolate the available annual estimates and to identify appropriate deflators to convert these estimates to constant prices. The most appropriate indicator or set of indicators for each category of spending, along with the reported annual GDP value, is incorporated into a state space framework to produce the quarterly real estimates. The estimates derived from the State Space model (SSM) are also compared to estimates calculated from the more traditional Denton Least Square method (DLSM).

The main findings of the paper are that the estimates from the DSLM more closely tracked the changes in the indicator, relative to the estimates from the SSM. The SSM also appeared to be less consistent compared with the DLSM, in terms of the ratios of the benchmarks to the indicators (BI ratios). Notwithstanding the apparent shortcomings of the SSMs, the aggregated quarterly GDP generated from this method has better in sample forecasting properties. The Theil U statistics are relatively smaller for the SSM estimates, compared with those for the DLSM, because of volatility in the latter estimates.

The paper starts with an overview of the Jamaican accounting process under the expenditure method, followed by a review of related literature and the methodological issues relating to the DLSM and SSM. A discussion on the identification of appropriate indicators and deflators for each category of spending follows thereafter. The penultimate section of the paper presents the results and evaluates the estimates of the competing models. A brief overview of stylised facts is also outlined in this section. The conclusion is presented in the final section.

2.0 Current Approach to Estimating GDP by The Expenditure Method

Consistent with the System of National Accounts (1968, 1993), the Statistical Institute of Jamaica (STATIN) takes into account four groups of expenditure in determining GDP; consumption expenditure, gross capital formation, exports and imports of goods and services[2]. Consumption is further divided into private and government spending, while gross capital formation is separated into gross fixed capital formation and changes in stocks. The annual data series are only available in current prices at purchaser's value.

Two broad approaches exist for the production of estimates of each component of expenditure. Firstly, estimates of expenditure can be built up from a "*commodity-flow*" method in which the total supply of goods and services from domestic production and imports is allocated to intermediate and final uses for a particular category of spending. The full power of the commodity-flow method is attained when independent estimates could be made for each of the use items, i.e., when specific information establishes the basis of the distribution of the supply of products to the various kinds of uses. The commodity-flow method is necessarily less sophisticated when one of the uses (e.g., changes in inventories, gross fixed capital formation or even final consumption) has to be derived residually, or the distribution to users -- fully or partly -- has to be made in fixed proportions without enough direct information on, or from users.

The second approach, the direct expenditure method, is more straightforward than the commodity flow approach expenditure in that spending by institutional units, which can be observed directly, is measured. This type of measurement is usually applicable to large units such as the Government where a consolidated source of data exists.

The commodity flow approach is used by STATIN in preparing estimates of private final consumption expenditure. For this category, items of spending are classified according to their end use or economic function. Special allowances are made for items that have multiple end-uses. The estimate of consumption is calculated as the sum of the retail value of local production and the f.o.b. value of imports. Data on local production are

[2] Definitions and explanations for these terms are available in 1993 System of National Accounts

obtained from estimates of value added from the agriculture, manufacturing, electricity & water and transport, storage & communication sectors. Other data are gathered from balance of payments and household expenditure and living conditions surveys[3].

The direct expenditure approach is used to estimate government final consumption expenditure and the imports and exports of goods and services. Government final consumption expenditure is compiled from fiscal reports from the Ministry of Finance and published estimates of Government's revenues and expenditure. Data on local government are gathered from published estimates of revenues and expenditure of parish councils. Data relating to statutory bodies are obtained directly from these institutions.

There is substantial diversity in the different types of gross fixed capital formation that may take place and, consequently, the methodological challenges that may face the Statistician. The System of National Account (SNA) (1993) lists the following main types of capital formation: (a) Acquisitions, less disposals of new or existing tangible fixed assets, subdivided by type of asset into: (i) Dwellings; (ii) Other buildings and structures; (iii) Machinery and equipment; (iv) Cultivated assets -- trees and livestock -- that are used repeatedly or continuously to produce products such as fruit, rubber, milk, etc.; (b) Acquisitions, less disposals, of new and existing intangible fixed assets, sub-divided by type of asset into: (i) Mineral exploration; (ii) Computer software; (iii) Entertainment, literary or artistic originals; (iv) Other intangible fixed assets; (c) Major improvements to tangible non-produced assets, including land; and (d) Costs associated with the transfers of ownership of non-produced assets.

Locally, the commodity-flow approach is employed to estimate gross fixed capital formation, while changes in stock are estimated by both the commodity-flow method and from data on sectoral production. For the former category, estimates for dwellings and machinery and equipment are made from the sum of the value of retained paid-duty imports, local production minus estimated value of goods used for repair & maintenance and for personal purposes, plus estimated dealers margin and transport and installation

[3] Statistics on retail sales are also used in some countries to estimate individual consumption expenditure.

costs. The value of capital goods produced locally is obtained from data from the production accounts. Durable goods purchased by households are derived from household surveys and for motorcars are obtained from information on motor vehicle registration from the registrar's office. The estimates of dealer's margin, transportation and installation costs are derived from periodic sample surveys of business establishments. Annual surveys and tax records are the primary sources of data on inventories. STATIN is in the process of updating its database on category (b).

Estimates of the value of imports and exports of goods are produced from external trade statistics. Of note exports are valued at freight on board (f.o.b.) and imports at cost insurance and freight (c.i.f.) Services data are obtained from the Central Bank.

Table 1 shows the average contribution of the four expenditure groups to GDP, in nominal terms, between 1991 and 2002. Expenditure on consumption and gross capital formation were the largest groups over this period, contributing on average 82.0 per cent and 27.8 per cent of GDP, respectively, over the period. For consumption expenditure, private and public spending contributed 68.3 per cent and 13.7 per cent of GDP, respectively. Gross exports and imports of goods & services were relatively large, on average. However, net export on average made a negative contribution of 9.8 per cent to GDP, over the period.

Table 1: Contribution to Gross Domestic Product - Income Rank

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Contrib'n Mean (%)	Std Dev
1. Final Consumption Expenditure	77.3	72.9	79.7	79.1	81.5	82.3	83.5	84.1	83.8	84.6	87.1	87.9	82.0	4.2
Private	66.0	64.2	68.1	68.9	70.3	68.9	68.2	67.4	68.2	68.6	71.1	69.6	68.3	1.8
Government	11.3	8.8	11.5	10.2	11.1	13.4	15.3	16.7	15.6	15.9	16.0	18.3	13.7	3.0
2. Gross Capital Formation	23.8	27.9	28.7	27.2	28.8	29.2	29.3	25.9	24.5	26.8	29.2	32.2	27.8	2.3
Gross Fixed Capital Formation	23.2	27.6	28.0	27.0	28.5	29.0	29.1	25.7	24.4	26.7	29.1	32.0	27.5	2.4
Increase in Stock	0.6	0.3	0.7	0.2	0.3	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.3	0.2
Net Exports	-1.2	-0.9	-8.3	-6.3	-10.3	-11.5	-12.9	-10.0	-8.3	-11.4	-16.4	-20.1	-9.8	5.5
3. Exports of Goods & Services	49.0	58.3	48.0	52.0	50.8	43.9	39.4	40.4	41.5	43.2	38.9	36.3	45.1	6.5
4. Less Imports of Goods & Services	50.2	59.2	56.3	58.3	61.1	55.5	52.2	50.4	49.8	54.6	55.2	56.4	54.9	3.7

3.0 Literature Review

Attempts to solve the problem of low frequency or missing GDP (and other) data have a long history. Researchers have, for good reasons, opted to generate quarterly observations (more formally referred to as temporal disaggregation) through a process called "Benchmarking" – combining a series of high frequency data with a series of less frequent data. The main problem in benchmarking arises when the two series show inconsistent movements, and the less frequent data is considered the more reliable. Benchmarking is generally done retrospectively as annual benchmark data are available some time after quarterly data. This procedure also has a forward-looking element in that the relationship between benchmark and indicator data (benchmark: indicator ratio) can be extrapolated forward to improve quarterly estimates for the most recent periods for which benchmark data are not yet available.

There are two main approaches to benchmarking time series data, namely a purely numerical approach and a statistical approach. The numerical approach differs from the statistical approach in that simulated data are not assumed to follow a specified a statistical time series model. The numerical approach encompasses the family of least squares minimization methods proposed by Denton (1971), Helfsand et al (1977), Bassie (1958) and the method proposed by Ginsburgh (1973). Lisman and Sandee (1964) also proposed a set of weights that could be used to generate quarterly GDP estimates from annual data. The statistical modelling approach encompasses ARIMA model based methods proposed by Hillmer and Trabelis (1987) and State space models proposed by Durbin and Quenneville (1997) and implemented by Bernanke, Gertler and Watson (1997) to interpolate real GDP in the United States of America. In addition, Chow and Lin (1971) proposed a multivariate general least squares regression approach for interpolation, distribution, and extrapolation of time series. While not being a benchmarking method in a strict sense, the Chow-Lin method is related to the statistical approach.

Lanning (1986) also conceptualised a third approach in which missing data is estimated simultaneously with model parameters. He then sought to compare the model results with

the traditional benchmarking approach in which the missing data is first interpolated and then used to estimate the model. He however found that the estimates of the model parameters from the simultaneous approach have a larger variance and are less reliable than the model parameters estimated with complete data in the second stage.

There has been some interest in the Caribbean in producing quarterly GDP estimates in the absence of official statistics. Allen (2002), generated supply side based estimates of quarterly GDP by employing the Denton Least Squares estimates, supported by other numerical measures such as the Lisman & Sandee (1986) method. A statistical approach was employed, on a somewhat more aggregated model, to produce a longer time series but this was fairly rudimentary in nature. Nicholls, Coker and Forde (1995) also attempted to generate quarterly GDP for Trinidad and Tobago in the framework of the now outdated Lisman Sandee (1986) method. They found that these estimates were not robust when compared with the official statistics, and proposed to advance the investigation by reviewing the relative merit of the Chow & Lin (1971) method.

This paper goes beyond these two attempts to evaluate the most robust statistical method available to date against the most widely used numerical method. In the remainder of this section, we set out the broad framework the Denton Least Squares methods and the State Space Approach – the best representatives of the two broad classes of benchmarking techniques.

3.1. Denton Least Squares Estimates

The Denton (1971) Least Squares formulation was designed to eliminate the "step problem" that arises when related series, with imperfect coverage, are used to interpolate low frequency GDP data. The step problem occurs when the Benchmark to Indicator (BI) ratio changes dramatically from year, given that the indicator or related series that is used in the distribution process grows at different rate from the benchmark. Step problems are most evident in simple *pro-rata distribution* techniques which is implemented as follows:

$$X_{q,\beta} = I_{q,\beta} \cdot \left(\frac{A_\beta}{\sum_q I_{q,\beta}} \right)$$

$X_{q,ß}$ is the level of the quarterly national accounts estimate for quarter q of year ß. $I_{q,\ ß}$ is the level of the indicator in quarter q of year ß, and $A_ß$ is the level of the annual data for year ß. The expression $\left(\frac{A_\beta}{\sum_q I_{q,\beta}}\right)$ is the annual BI ratio. With pro rata distribution, there will be a distinct jump in adjacent $X_{q,ß}$'s when $I_{q,\ ß}$ and $A_ß$ grows at different rates, such that the compensating adjustment in quarterly estimates from one distinct year to the next will be put into the first quarter of each year, while other quarterly growth rates are left unchanged. The significance of the step problem depends on the size of the variation in the annual BI ratio.

To maintain simplicity, we outline only the basic version of the Denton Least square method (the Proportional Denton Technique or PDT). This method involves solving the following optimisation problems:

$$\left(X_1.....\overset{\min}{X_{4\beta}}....X_T\right)\sum_{t=2}^{T}\left[\frac{X_t}{I_t}-\frac{X_{t-1}}{I_{t-1}}\right]^2$$

under the restriction that, for the flow series,

$$\sum_{t=2}^{T} X_t = A_y, \quad y \in \{1.....\beta\}^4$$

where t is time[5]. Intuitively, the PDT implicitly constructs from the annual observed BI ratios a time series of quarterly BI ratios that is as smooth as possible. Enhancements to the PDT improve the ability of the technique to extrapolate based on available indicators when there are no available annual benchmarks.

3.2 State Space Models and the Kalman Filter

State space models (SSMs) have been applied in the econometric literature to model unobserved variables, such as expectations, measurement errors, missing observation and

[4] The sum of the quarters should be equal to the independent annual estimate for each benchmark year.
[5] (t=4y-3) is equal to the first quarter of year y, and t=4y the fourth quarter of year y. Similarly, t=1 is equal to the first quarter of year 1

unobserved components (cycles and trends). A thorough survey of the application of SSMs in econometrics can be found in Hamilton (1994) and Harvey (1989).

The idea behind a state-space representation is to capture the dynamics of an observed (nx1) vector "*y"*, in terms of a possibly unobserved (rx1) "state" vector ξ_t, known as the *observation equation* for the system:

$$y_t = A'x_t + H'\xi_t + w_t$$

Here y_t is an (*n* x 1) vector of variables that is observed at date *t*, *H'* is an (*n* x *r)* matrix of coefficients, and w_t is an (*n* x 1) vector that could be described as measurement error; w_t is assumed to be i.i.d *N*(0,R) and independent of ξ_1 and v_t for (τ = 1,2,...). Equation (1.6) also includes x_t, a (*k* x 1) vector of observed variables that are exogenous or predetermined and which enter the expression through the *(n x k)* matrix of coefficients *A'*.

The dynamics of ξ_t are assumed to follow the following autoregressive process (typically called the *state equation*):

$$\xi_{t+1} = F\xi_t + v_{t+1}$$

The state and observation equations constitute a linear state-space representation for the dynamic behaviour of *y*. The framework can be further generalized to allow for time-varying coefficient matrices, non-normal disturbances and non-linear dynamics.

There are two advantages in representing a dynamic system in state space form. Firstly, the state space model allows unobserved variables (state variables) to be incorporated into and estimated along with the observable model. Secondly, these models can be analysed using a Kalman (1960) filter[6].

[6] The Kalman filter algorithm has also been utilised to compute exact, finite sample forecasts for Gaussian ARMA models, multivariate ARMA models, multiple indicators & multiple causes (MIMIC), Markov Switching models and time varying coefficient models.

The multivariate Kalman filter is an algorithm for calculating the sequence $\left\{\hat{\xi}_{t+1}\big|_t\right\}_{t=1}^{T}$ and $\left\{P_{t+1}\big|_t\right\}_{t=1}^{T}$, where $\hat{\xi}_{t+1}\big|_t$ denotes the optimal forecast of ξ_{t+1}, based on observations of $\left(y_0, y_1 y_2, ..., y_{t-1}, y_t, x_0, x_1, x_2, ..., x_{t-1}, x_t\right)$, and $P_{t+1}\big|_t$ denotes the mean squared error (MSE) of this forecast. The filter is implemented by iterating expressions[7] determining $\hat{\xi}_{t+1}\big|_t$ and $P_{t+1}\big|_t$ for t=1,2,……T.

3.3 Methodology

In this particular application, y_t in (2) is an expenditure category, while x_t is the indicator series related to that particular component. The equations for this system are as follows:

$$\xi_{t+1} = F\xi_t + C'x_{t+1} + Rv_{t+1} \qquad (1)$$

$$y_t = a_t'x_t + h_t' \cdot \xi_t \qquad (2)$$

Following Cuche and Hess (1999), y_t is given in each quarter as follows: $y_1 = 0$, $y_2 = 0$, $y_3 = 0$, y_4 = annual figure. When these annual observations are stored in one column, the 'zero' observations are not included, resulting in a reduced vector of size $\left[\frac{T}{4} \times 1\right]$. Time-invariant coefficients are assumed for the matrices, F, C′ and R.

The observation equation embodies the constraint that the sum of four quarterly observations within a year equals the annual observed GDP. In this regard, no error term is specified for the observation equation, so that the Kalman filter generates exact values of the coefficients vector a'_t and h'_t to ensure the summation condition holds.

4.0 Identification of Related Series

To facilitate the interpolation of the components of quarterly GDP by expenditure, sets of quarterly indicators were identified and assessed for their accuracy and timeliness. The

[7] See Hamilton (1999) for a full discussion of the Kalman filter.

main criterion for the accuracy of the indicators is the extent to which they are successful in mimicking the annual movements in the benchmark series. The timeliness of the quarterly source data also has important implications for how early sufficiently reliable quarterly estimates can be prepared, after the end date for a reference period. These indicators were also carefully selected with an eye to the set of indicators used by STATIN in estimating each category annually. Where more than one indicator was identified for a particular expenditure group, a weighted index was created. These weights were selected from an algorithm that generated the highest correlation between the changes in the combined indicator with the GDP.

4.1 Final Consumption Expenditure

Final consumption expenditure consists of private and public spending. In regard to private consumption spending, the candidate indicators included general consumption tax (GCT) & special consumption tax (SCT) receipts from local transactions, total imports of goods & services and a composite production index reflecting quarterly value added from the agriculture, manufacturing, electricity & water and transport, storage & communication sectors. The latter indicator is consistent with STATIN's method of estimating consumption of locally produced commodity and is premised on the assumption that the output of these sectors is purchased by Jamaican consumers. Also consistent with the commodity flow approach, we combine the tax data with the series on imports, to capture the broad disaggregation of household spending on domestically produced and imported goods and services. Table 2 depicts the correlation between private consumption spending and the above-mentioned indicators. Based on the strength of the correlations the composite index consisting of imports and tax receipts was chosen as the most suitable indicator for the private expenditure group[8].

[8] The major problem with the selected index is that import trade data in Jamaica is not timely, which means that updates of the estimates may relay on forecasts.

Table 2: Correlation between changes in Private Consumption Spending and Changes in Potential Indicators	
	Private Consumption
GCT & SCT	0.751
Import of Goods & Services	0.892
Production Composite Index	0.852
Index: Import & GCT & SCT (90,10)	***0.894***

4.1.1 Government Consumption Spending

Analogous to the indicators used by STATIN to estimate annual GDP, movements in Government's spending on total programmes & wages, wages, programmes, and Government's expenditure less interest payments were considered as possible indicators. Table 3 shows the correlation between the changes in these indicators and changes in the annual estimates of nominal government consumption spending produced by STATIN.

Table 3: Correlation between changes in Government Consumption Spending and changes in Potential Indicators	
	Government Consumption
Government Expenditure (net of interest payments)	0.792
Programmes & Wages	0.049
Programmes	0.055
Wages	***0.885***

The correlation results indicate that wages move more closely with Government's spending, compared with the other indicators[9].

4.2 Gross Capital Formation

Gross capital formation is divided into gross fixed capital formation and changes in stocks for both the government and the private sector. Given the relatively small

[9] This seems counter intuitive because programmes also represent government's purchase of goods and services within the economy. The clear rationale however is that programmes may include deferred expenditure and as such has been discounted by STATIN as a good indicator of current consumption.

contribution of the 'increase in stocks' sub-division[10], focus was placed on indicators for gross fixed capital formation. Probable indicators for this expenditure category include foreign direct investment spending (in Jamaica Dollars), capital goods imports and central government capital expenditure[11]. Table 4 shows the correlation between gross capital formation and the abovementioned indicators. Based on the correlation of the changes in capital goods imports and changes in investment spending, this indicator was chosen as the most suitable indicator.

Table 4: Correlation between changes in Investment Spending and changes in Potential Indicators

	Gross Capital Formation
Capital Expenditure (Central Govt)	0.607
Direct Investment (J$mn)	-0.737
Capital Goods & Raw Mat Imports (J$mn)	0.620
Capital Goods Imports (J$mn)	***0.934***

4.3 Exports and Imports of Goods & Services

Quarterly data on export and import of goods and services from Balance of Payments statistics are the natural proxies/indicators for the estimates prepared by STATIN. Table 5 shows that the correlation between the two sets of estimates are reasonably high.

Table 5: Correlation between in changes Exports and Imports of Goods & Services and changes in Potential Indicators

	Export of Goods & Services	Import of Goods & Services
Export of Goods & Services	***0.988***	
Import of Goods & Services		***0.860***

[10] Between 1990 and 2002, gross fixed capital formation accounts for approximately 98.9 per cent of gross capital formation.

[11] There is a temptation to combine government's capital expenditure (a proxy government's capital formation) and capital goods imports (a proxy for investment spending in the private sector). We recognise however that this combination will result in double counting, given that government activities will also be captured in capital goods imports.

4.4 Deflators

The aim of this paper is to generate quarterly estimates of real expenditure. STATIN, however, only produces nominal GDP by the expenditure method. In this context, it is necessary to identify appropriate deflators to convert the quarterly nominal estimates to constant price estimates. This represented the main data challenge for the paper, given that there are no benchmarks available to test the adequacy of the deflators. To partly offset this deficiency, we also opted to identify the best proxy deflators for the annual estimates produced by STATIN. The deflators for the indicators were, in some cases, different from the ones employed for the annual estimates. This section discusses the choices of the deflators for both the related series and the benchmarks.

Both private and government consumption spending were deflated using an appropriate average consumer price index (CPI). The indicators were deflated using an index generated from a series of three-month average CPI. For gross capital formation, we identified the implicit deflator for the construction sector, generated from the production accounts, as an appropriate deflator for the annual estimates prepared by STATIN. For the quarterly indicators, the index of housing and other housing expenses sub-index within the CPI was employed. Annual import and export price indices are available from STATIN, which, when augmented by an appropriate proxy for price inflation in Jamaica's import and export of services, were considered the best proxies for deflating the annual nominal estimates. The development of quarterly deflators for the indicators was however, produced by a fairly involved method[12].

Jamaica's imports are disaggregated into the standard end-use classification (consumer goods, raw materials and capital goods). U.S. export price indices, taken from the Bureau of Labour Statistics in the United States for similar categories of goods, were used as proxies of Jamaica's goods import prices. The U.S. export prices were used because the U.S.A. is Jamaica's principal trading partner, accounting for around 46 per cent of total imports between 1998 and 2002. One exception was the fuel category for which the West

[12] At the time of the development of this paper, STATIN had promised to provide the author with quarterly import volumes, which could be used to generate more appropriate deflators. We anticipate that the receipt of this data will improve the quality of the analysis.

Texas Intermediate index of crude oil price was used. A list of import categories and their respective proxies are presented in the appendix, Table 1. To customise this index for Jamaica, the weights of the commodities in the Jamaican import basket were applied to the individual US indices.

For exports, implicit prices are readily available for selected major traditional and other traditional exports, including bauxite, alumina, sugar and banana. Since tourism is Jamaica's main foreign exchange earner, outside of remittances, it was important to also include this export service[13]. The travel sector accounts for the largest share of export earnings followed by alumina, with both accounting for over 90.0 per cent of the value of exports used in the index (see Table 2 in Appendix). In the case of exports, the same deflators were employed in the conversion of both the annual STATIN estimates and the quarterly indicators. Consistent with the supply side estimates, all the constant price series were based in 1996.

Procedurally, the quarterly estimates of the items of expenditure were generated by converting to 1996 prices, both the annual estimates from STATIN and the quarterly indicators with the relevant deflators as discussed above. The constant price annual benchmarks were then interpolated with the constant price indicators via both the DLSM and SSM[14].

Given the absence of constant price estimates by STATIN at the annual level, the evaluation of the output from the DLSM and SSM was conducted from in two steps. Firstly, we evaluated the relative presence of the "step problem" between the two sets of estimates, using simulated quarterly BI ratios and looking for structural breaks in these

[13] It is important to recognise that the use of implicit prices (ratio of export value to volume) for the export data creates potential problems. Variations in these prices may reflect changes in the quality of the product from month to month and therefore the price received but not changes in the underlying price of the product measured at a consistent quality. Moreover, the proxy used for tourism prices represents the average daily expenditure per tourist and not his actual expenditure per unit of tourism services and may therefore reflect changes in the quantity of tourism services consumed as well as price changes.

[14] We recognise that it would have been equally possible to interpolate the nominal annual data and then deflate the quarterly estimates using the identified deflators, appropriately adjusted for their relationship with the annual proxies.

ratios in the first quarter of each year. Secondly, we compared the aggregated quarterly GDP derived from the two methods with the quarterly estimates currently produced by STATIN over common samples. The idea is that the two methods (supply side estimates and demand side estimates) should in theory generate the same estimates for a particular economy. Assuming that the quarterly estimates produced by STATIN are more reliable, the goodness of fit of the respective methods with respect to these estimates should provide a perspective on which one is relatively sounder. This exercise involves the evaluation of estimated growth rates and Theil U statistics from the two competing models.

5.0 Results and Analysis

The interpolation result from the DLSM is found in Appendix B and that from the SSM is found in Appendix C. A comparison of the year over year changes in the quarterly real estimates derived from the DLSM and the SSM are found in Appendix D. The most significant observation is that the estimates from the DSLM more closely track the changes in the indicator, than the estimates from the SSM, because the state space model smoothes out the volatility in the indicators.

The SSM also appeared to be less consistent compared with the DLSM, when account is taken of the BI ratios. Appendix E presents the relative plots of simulated quarterly BI ratios for the various components of spending. The simulated BI ratios for the SSM are more volatile than those for the DLSM, in particular, the ratios for public consumption and gross capital formation. Table 5 in the appendix confirms this as the relative presence of the step problem is more pronounced in the SSM ratios.

Despite the apparent shortcomings of the SSMs in respect of conformity with the indicators and in terms of the step problem, the aggregated quarterly GDP generated from this method has better in sample forecasting properties. Table 6 in the appendix highlights that the SSM has lower mean squared error, root mean square error and Theil U statistics, relative to the DLSM. A decomposition of the Theil statistics into its constituent proportions reveals that the main source of the poor fit of the DLSM is the

variance proportion. The SSM, conversely, has a larger covariance proportion, suggesting that a greater proportion of the error generated within sample is unsystematic. Consistent with the higher co-movement of the DLSM estimates with the indicator and the relatively lower level of step problem, the bias proportion for this model is lower than the SSM.

This fairly startling discovery is indicative of a shortcoming of the DLSM method. When the indicator is volatile, the DLSM will project this volatility into the estimates. We find that even though the summation condition holds and the step problem is minimised, the goodness of fit of this class of model tends to suffer under these conditions. The SSM, however, will tend to smooth the volatility in the estimates and therefore improve the goodness of fit. The latter interpolation is to be preferred, as economic agents will more engage in consumption smoothing than suggested by the volatility in the indicators.

5.1 Stylised Facts: Quarterly Real Expenditure Components

The objective of this section is to determine and evaluate the basic time series patterns underlying the quarterly real estimates derived from the SSM. The data for each category of expenditure was decomposed into their trend, seasonal and cyclical components (see Appendix F). Table 10 below depicts the seasonal factors in the data.

Table10: Seasonal Factors

	Consumption		Gross		
Quarters	**Private**	**Public**	**Capital**	**Export**	**Import**
Q1	1.02	0.97	1.43	1.07	1.06
Q2	0.99	0.86	0.64	1.04	1.02
Q3	0.99	0.94	0.85	0.98	0.98
Q4	1.00	1.27	1.30	0.92	0.94

The indices indicate that there is no marked seasonal pattern in real private consumption spending, while public consumption has strong seasonality in the fourth quarter of each year, probably reflecting the pattern of salary adjustments in that sector. There is some diversity in the seasonal factors for gross capital formation. Both export and import of goods & services are typically above trend in the first half of the year and below trend in the second half. This is not surprising for exports because that pattern is consistent with

the pattern of tourist arrivals to the Island. The expectation for imports, however, was that there would have been relatively higher volumes in advance of the Christmas season.

The cyclical component (Appendix E) indicates that real consumption expenditure grew strongly between the beginning of 1993 and end–1995. There was sustained recession in this category of spending between 1996 and 2000, followed by a gradual recovery since 2001. There is no clearly discernible relationship between this cycle and real interest rates. What is noticeable however is that real consumption expenditure fell off in early 1996 when real rates were dramatically increased, and started to recover in a context of a sustained reduction in real rates after 1998. The investment and import cycles are not markedly different from private consumption and, as expected, investment does not appear to be explained by real interest rates. The data indicates that there has been a sustained growth in gross capital formation since the beginning of 2000, probably associated with the accelerated programme of public sector asset divestment. Public consumption has a regular pattern that appears to coincide with the election cycle.

6.0 Conclusion

In the last few years, the interest in short-term national accounts statistics has increased considerably. The availability of suitable statistics to depict an image of the economy with a short delay and in a reliable way has become one of the main challenges for Jamaica. More importantly, there is the need for higher frequency data as economic processes and activities are enacted rapidly over time. In these regard the above work provides a valuable contribution in estimating and updating a quarterly expenditure series for Jamaica. Of note, some of the indicators, in particular, gross capital formation, can be enhanced.

Based on the results from the two competing models, the Denton's Least Square Model better projects the changes in the indicators into the quarterly estimates, but this will, in the context of a volatile indicator, lead to questionable in sample properties of the estimates.

The paper has, in the main, addressed some of the main methodological issues in generating quarterly estimates of expenditure. Further refinements are possible in terms of improving the quality of the indicators and in relation to extrapolating the items of expenditure beyond the available data.

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APPENDICES

Table 1: Import Categories and their Respective Proxies

Import Category	Index used as Proxy /1
Consumer Goods	
Foods	Foods, Feeds & Beverages
Non-durables	Nondurables, manufactured
Durables	Durables, manufactured
Raw Materials	
Food	Agricultural foods, feeds & beverages, excluding distilled beverages
Other	Industrial supplies and materials, nondurable
Capital Goods	
Transport & equipment	Machinery and Transport Equipment (SITC)
Construction	Inputs to construction industries
Other Capital Goods	Capital goods

/1 BEA End Use Export Indices for the U.S.A.

Table 2: Terms of Trade Weights

Import Category	**Weights**	**Selected Exports**	**Weights**
Consumer Goods	**33.8**	Tourism	64.8
Foods	9.7	Alumina	26.2
Non-durables	11.0	Coffee	0.1
Durables	13.1	Cocoa	1.0
Raw Materials	**50.4**	Sugar	6.7
Food	7.1	Banana	1.2
Fuel	14.4	**Total**	**100**
Other	28.9		
Capital Goods	**15.8**		
Transport & equipment	3.0		
Construction	5.3		
Other Capital Goods	7.5		
Total	**100.0**		

Table 3

Quarterly Real GDP Series Using Denton Least Square

	Private Consumption	Public Consumption	Gross Capital Formation	Export of Goods	Imports of Goods	Total GDP
Mar-93	30749	7730	12153	13233	14767	49098
Jun-93	32224	6989	13306	13375	16242	49652
Sep-93	48597	6058	17952	15291	21560	66339
Dec-93	56538	7631	22816	19341	25869	80457
Mar-94	46121	6052	15529	21991	24645	65048
Jun-94	39604	5973	14823	19376	25309	54466
Sep-94	39517	5814	15368	21137	26007	55830
Dec-94	42997	7125	17835	22319	27902	62373
Mar-95	38515	5742	15849	25292	24612	60785
Jun-95	43391	5723	15930	23040	28783	59301
Sep-95	45954	9058	15916	26121	32455	64594
Dec-95	52843	8091	21721	30623	45363	67916
Mar-96	43922	6817	18141	28489	34832	62536
Jun-96	40690	9867	16467	26499	36090	57432
Sep-96	40655	8614	15597	24725	33360	56230
Dec-96	41073	7179	20318	26377	29660	65287
Mar-97	38828	7018	17011	24671	35231	52297
Jun-97	41794	8297	14566	23329	35111	52875
Sep-97	43267	10642	23362	25385	35745	66912
Dec-97	39633	10734	14862	29431	36880	57780
Mar-98	40450	9798	12538	27600	35732	54653
Jun-98	38433	8890	13317	25521	39156	47005
Sep-98	38497	11065	12330	27295	39048	50139
Dec-98	42295	9834	22827	28429	43512	59873
Mar-99	38291	7845	12546	28951	36134	51500
Jun-99	36824	9009	15217	25617	37814	48853
Sep-99	41726	10153	13379	29922	37497	57683
Dec-99	45688	10174	17028	31595	41954	62530
Mar-00	42133	8510	18190	34311	41663	61481
Jun-00	39938	10734	14725	32866	42999	55265
Sep-00	41687	9696	15052	35242	43848	57829
Dec-00	46516	10592	16152	38970	49980	62251
Mar-01	47167	9365	19458	36653	52459	60184
Jun-01	43742	7203	15826	31996	50738	48029
Sep-01	44447	12758	19112	32935	51687	57565
Dec-01	45849	11500	16258	37644	56838	54413
Mar-02	43388	10966	16809	34587	52002	53747
Jun-02	44076	12025	20788	33966	54363	56492
Sep-02	47007	11756	19752	37567	59944	56138
Dec-02	46909	12979	21637	39224	57251	63496

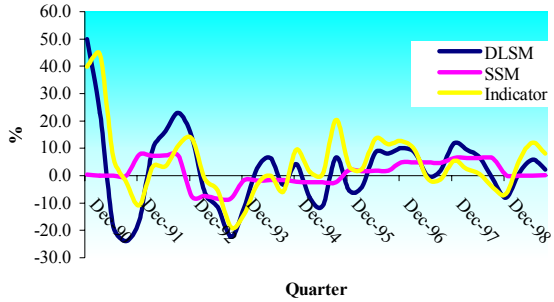
Table 4

Quarterly Real GDP Series Using State Space Model

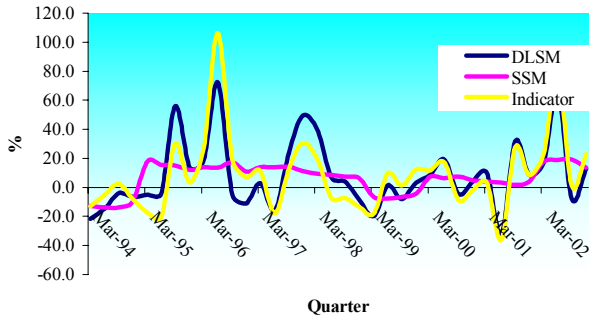
	Private Consumption	Public Consumption	Gross Capital Formation	Export of Goods	Imports of Goods	Total GDP
Mar-93	42068	6246	16300	15688	19619	60683
Jun-93	41569	6297	16377	15573	19619	60197
Sep-93	41917	6341	16455	15425	19607	60531
Dec-93	42555	9524	17094	14554	19592	64135
Mar-94	42208	5458	15740	21614	25975	59045
Jun-94	41530	5419	15670	21424	25977	58066
Sep-94	41918	5462	15743	21359	25964	58518
Dec-94	42583	8625	16402	20425	25947	62088
Mar-95	45416	6422	17251	26780	32813	63056
Jun-95	44558	6260	17125	26458	32818	61583
Sep-95	45026	6288	17194	26446	32800	62154
Dec-95	45703	9644	17846	25391	32782	65802
Mar-96	41956	7310	17622	26905	33481	60312
Jun-96	41214	7107	17404	26680	33504	58901
Sep-96	41257	7385	17432	26749	33487	59336
Dec-96	41912	10674	18065	25757	33471	62937
Mar-97	41270	8312	17461	26045	35747	57341
Jun-97	40448	8083	17179	25867	35760	55816
Sep-97	40557	8435	17155	25980	35739	56388
Dec-97	41246	11861	18006	24925	35720	60319
Mar-98	40371	9105	15312	27452	39366	52873
Jun-98	39449	8787	14969	27367	39383	51189
Sep-98	39594	9070	14956	27565	39359	51826
Dec-98	40262	12625	15775	26460	39340	55781
Mar-99	41157	8514	14767	29270	38350	55358
Jun-99	40112	8094	14188	29153	38374	53173
Sep-99	40290	8467	14219	29453	38347	54083
Dec-99	40970	12106	14996	28209	38328	57953
Mar-00	43129	9143	16265	35634	44622	59548
Jun-00	42026	8604	15713	35450	44647	57146
Sep-00	42219	9111	15678	35809	44620	58198
Dec-00	42901	12674	16463	34495	44600	61934
Mar-01	45906	9512	17870	34987	52930	55344
Jun-01	44764	8888	17381	34864	52954	52943
Sep-01	44924	9261	17276	35362	52929	53893
Dec-01	45611	13166	18128	34015	52909	58010
Mar-02	45969	11202	19901	36457	55890	57638
Jun-02	44743	10566	19429	36435	55919	55255
Sep-02	44951	11028	19411	36955	55889	56455
Dec-02	45716	14930	20245	35496	55862	60525

APPENDIX D

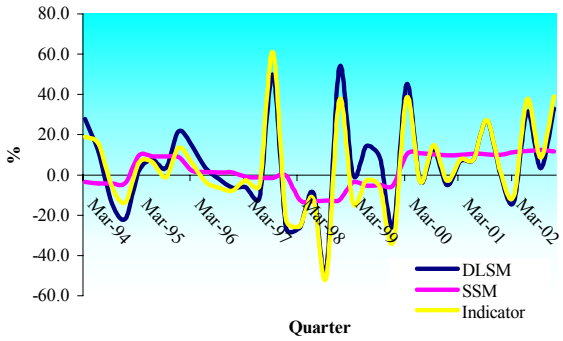
Changes in Estimates of Private Consumption Spending (1994:1-2002:4)



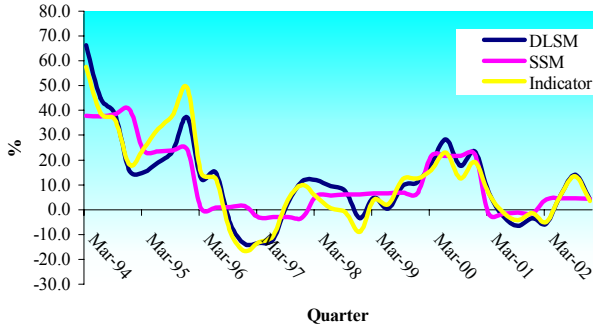
Changes in Estimates of Public Consumption Spending (1994:1-2002:4)



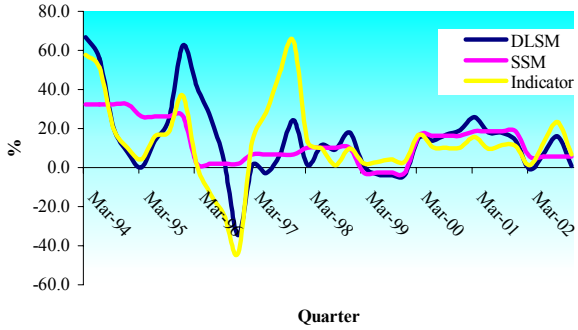
Changes in Estimates of Gross Capital Formation (1994:1-2002:4)



Changes in Estimates of Export of Goods & Services (1994:1-2002:4)



Changes in Estimates of Import of Goods & Services (1994:1-2002:4)



APPENDIX E

Figure 1
Comparative BI ratios (DLSM & SSM)
Private Consumption Expenditure (%)

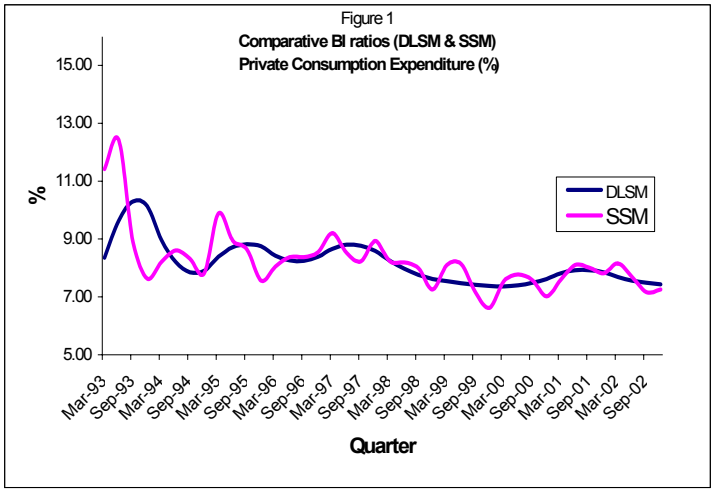


Figure 2
Comparative BI ratios (DLSM & SSM)
Public Consumption Expenditure (%)

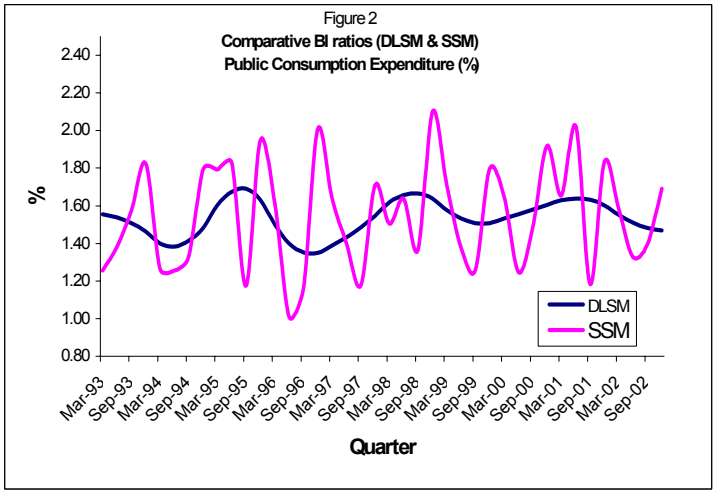


Figure 3
Comparative BI ratios (DLSM & SSM)
Gross Capital Formation (%)

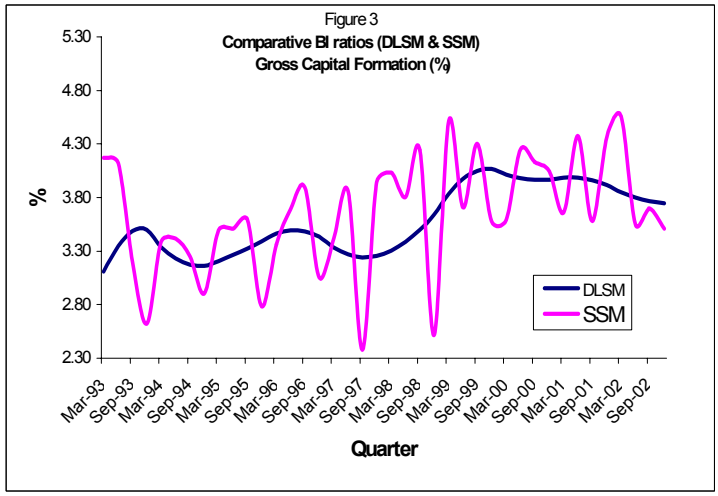


Figure 4
Comparative BI ratios (DLSM & SSM)
Export of Goods & Services (%)

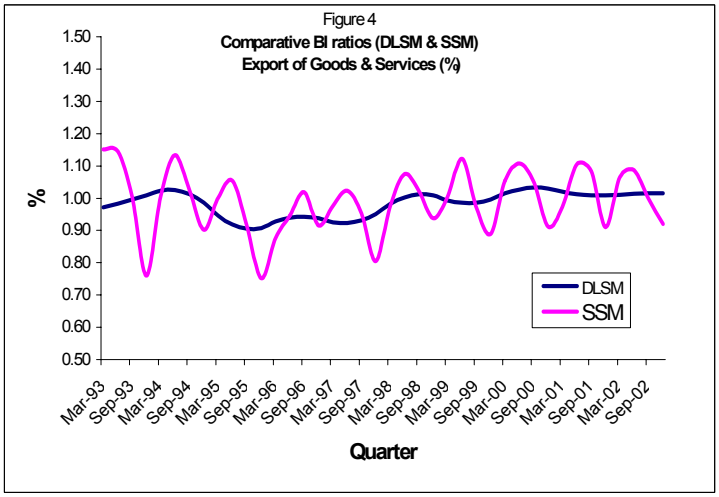


Figure 5
Comparative BI ratios (DLSM & SSM)
Import of Goods & Services (%)

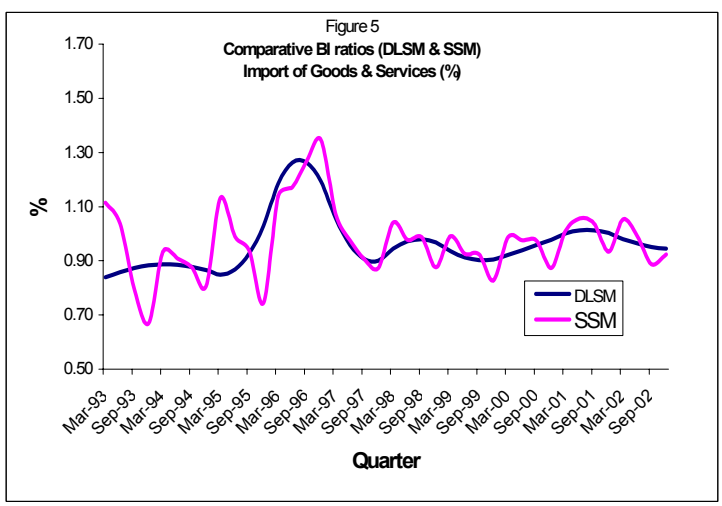
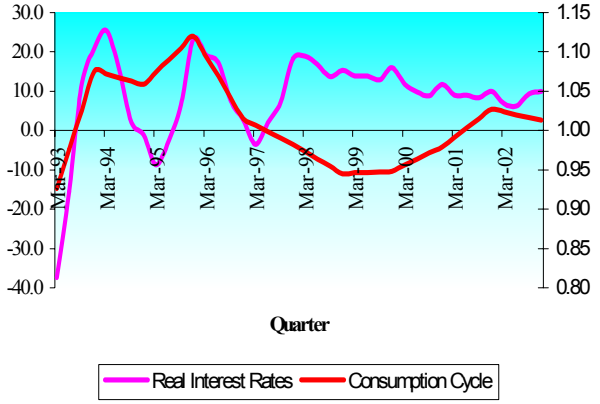


Table 5: Model Assessment Denton Least Squares: BI Ratios					
	Consumption		Gross		
	Private	Public	Capital	Export	Import
Stdev in BI Ratio	0.72	0.09	0.31	0.04	0.10
Average Step	0.43	0.03	0.23	-0.06	-0.27
Average (-) Step	0.71	0.14	0.41	-0.02	-0.05
Average (+) Step	0.14	-0.08	0.05	-0.10	-0.48
State Space Model: BI Ratios					
	Consumption		Gross		
	Private	Public	Capital	Export	Import
Stdev in BI Ratio	1.07	0.28	0.54	0.10	0.13
Average Step	-11.64	33.41	-19.28	-18.15	-28.22
Average (-) Step	-14.09	60.97	-22.62	-29.15	-30.86
Average (+) Step	-9.18	5.86	-15.93	-7.14	-25.58

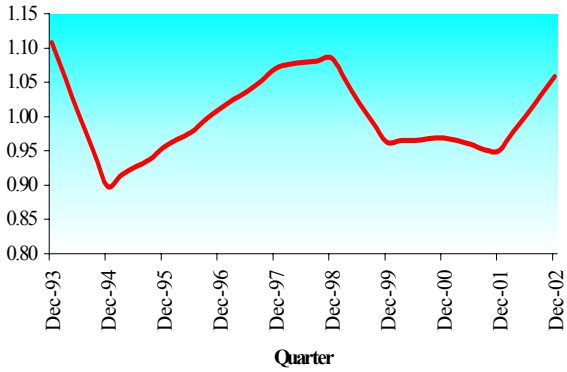
Table 6 Model Forecast Evaluations Insample Forecast. Sample 1997:1 2002:04		
Model	**Denton's**	**State Space**
MSE	135.81	34.19
RMSE	11.65	5.85
MAE	9.80	5.37
Theil U	0.86	0.76
Bias Proportion	0.00	0.03
Variance Proportion	0.86	0.65
Covariance Proportions	0.14	0.32

APPENDIX F: Cyclical Patterns of Expenditure Components

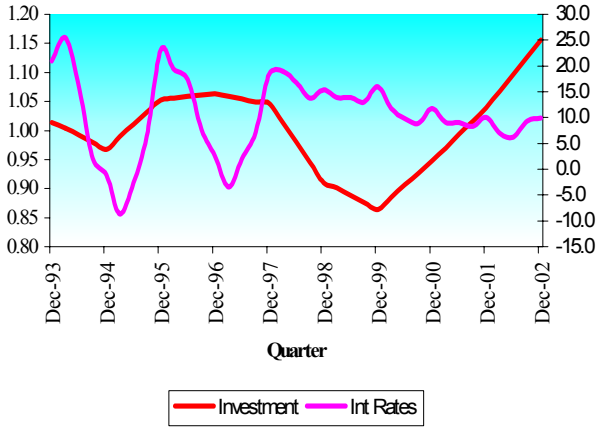
Private Consumption Spending: Cycle



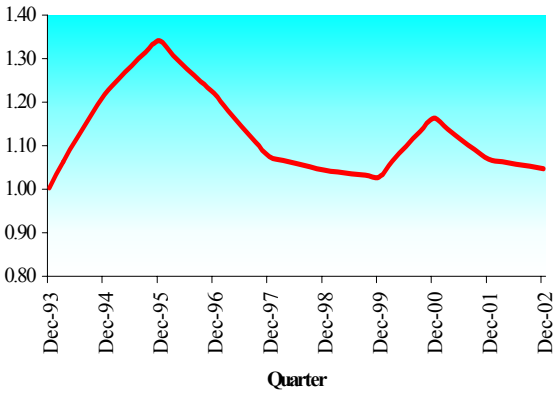
Public Consumption Spending: Cycle



Gross Capital Formation: Cycle



Export of Goods & Services: Cycle



Import of Goods & Services: Cycle