THE CHAOTIC RECEIPTS GROWTH MODEL: INTERNATIONAL TOURISM

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Abstract: *International tourism receipts are expenditures by international inbound visitors. These receipts include payments to national carriers for international transport. The basic aims of this paper are: firstly, to create a relatively simple chaotic receipts growth model that is capable of generating stable equilibria, cycles, or chaos, and secondly, to analyze the world receipts growth stability in the period 1995-2018. This paper confirms the existence of the stable growth path of the world receipts in the observed period.*

Keywords: *Receipts, International tourism, Growth, Stability, Chaos.*

1. INTRODUCTION

Global tourism suffered its worst year in 2020. According to the World Tourism Organization (UNWTO), the collapse in international travel shows an estimated loss of USD 1.3 trillion in export revenues. Also, the pandemic has put between 100 and 120 million direct tourism jobs at risk. The negative impact of the COVID-19 pandemic on global tourism has carried on into 2021 (UNCTAD, 2020).

This paper uses the elements of chaos theory. Namely, chaos theory started with Lorenz‘s (1963) discovery of complex dynamics arising from three nonlinear differential equations leading to turbulence in the weather system. Li and Yorke (1975) discovered that the simple logistic curve can exhibit very complex behavior. Further, May (1976) described chaos in population biology. Chaos theory has been applied in economics by Benhabib and Day (1981,1982), Day (1982, 1983,1992,1997.), Grandmont (1985), Goodwin (1990), Medio (1993,1996), Lorenz (1993), Jablanovic (2016, 2018, 2019), among many others.

International tourism receipts are expenditures by international inbound visitors, including payments to national carriers for international transport and any other prepayment made for goods or services received in the destination country.

2. THE CHAOTIC RECEIPTS GROWTH MODEL

The chaotic international tourism receipts growth model is presented by the following equations:

$$Y_t = C_t + I_t + G_t + Nx_t \qquad (1)$$

$$C_t = \alpha\, Y_{t-1}^{\ 2} \qquad 0 < \alpha < 1 \qquad (2)$$

$$I_t = \beta\, Y_{t-1} \qquad 0 < \beta < 1 \qquad (3)$$

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$G_t = \gamma \, Y_t \qquad 0 < \gamma < 1 \qquad (4)$

$Nx_t = \lambda \, Y_t \qquad 0 < \lambda < 1 \qquad (5)$

$R_t = \chi \, Y_t \qquad 0 < \chi < 1 \qquad (6)$

with Y – the gross domestic product (GDP), I – investment, C– consumption, Nx – net exports, G – government spending, R – the international tourism receipts, α – the marginal propensity to consume, β – the investment rate, γ- the government expenditure rate, λ – the net exports rate, χ – the international tourism receipts rate.

Now, putting (1), (2), (3), (4), (5), and (6) together we immediately get:

$$R_t = \left[\frac{\beta}{(1-\gamma-\lambda)}\right] R_{t-1} - \left[\frac{\alpha}{\chi\,(\gamma+\lambda-1)}\right] R_{t-1}^{\;2} \qquad (7)$$

Further, it is assumed that the current value of the international tourism receipts is restricted by its maximal value in its time series. This premise requires a modification of the growth law. Now, the international tourism receipts growth rate depends on the actual value of the international tourism receipts, R, relative to its maximal size in its time-series R^m. We introduce r as r = R/R^m. Thus e range between 0 and 1. Again we index e by t, i.e., write r_t to refer to the size at time steps t = 0,1,2,3,... Now the international tourism receipts growth rate is measured as

$$r_t = \left[\frac{\beta}{(1-\gamma-\lambda)}\right] r_{t-1} - \left[\frac{\alpha}{\chi\,(\gamma+\lambda-1)}\right] r_{t-1}^{\;2} \qquad (8)$$

This model given by equation (8) is called the logistic model. For most choices of α , β , γ , λ, and χ there is no explicit solution for (8). Namely, knowing α , β , γ , λ, and χ and measuring r_0 would not suffice to predict r_t for any point in time, as was previously possible. This is at the heart of the presence of chaos in deterministic feedback processes. Lorenz (1963) discovered this effect – the lack of predictability in deterministic systems. Sensitive dependence on initial conditions is one of the central ingredients of what is called deterministic chaos.

3. THE LOGISTIC EQUATION

It is possible to show that iteration process for the logistic equation

$$z_{t+1} = \pi \, z_t \, (1 - z_t) \,, \; \pi \in [0, 4], \; z_t \in [0,1] \qquad (9)$$

is equivalent to the iteration of growth model (8) when we use the identification

$$z_t = \left[\frac{\alpha\,(1-\gamma-\lambda)}{\chi\,\beta\,(\gamma+\lambda-1)}\right] r_t \quad \text{and } \pi = \left[\frac{\beta}{(1-\gamma-\lambda)}\right] \qquad (10)$$

Using (8) and (10) we obtain:

$$z_t = \left[\frac{\alpha\,(1-\gamma-\lambda)}{\chi\,\beta\,(\gamma+\lambda-1)}\right] \left\{ \left[\frac{\beta}{(1-\gamma-\lambda)}\right] r_{t-1} - \left[\frac{\alpha}{\chi\,(\gamma+\lambda-1)}\right] r_{t-1}^{\;2} \right\} =$$

$$= \left[\frac{\alpha}{\chi\,(\gamma+\lambda-1)}\right] r_{t-1} - \left\{\frac{\alpha^2 (1-\gamma-\lambda)}{\chi^2\,\beta\,(\gamma+\lambda-1)^2}\right\} r_{t-1}^{\;2}$$

On the other hand, using (9) and (10) we obtain:

$$z_t = \pi z_{t-1} (1 - z_{t-1}) =$$

$$= \left[\frac{\beta}{(1-\gamma-\lambda)} \right] \left[\frac{\alpha (1-\gamma-\lambda)}{\chi \beta (\gamma+\lambda-1)} \right] r_{t-1} \left\{ 1 - \left[\frac{\alpha (1-\gamma-\lambda)}{\chi \beta (\gamma+\lambda-1)} \right] r_{t-1} \right\} =$$

$$= \left[\frac{\alpha}{\chi (\gamma+\lambda-1)} \right] r_{t-1} - \left\{ \frac{\alpha^2 (1-\gamma-\lambda)}{\chi^2 \beta (\gamma+\lambda-1)^2} \right\} r_{t-1}^{\ 2}$$

It is obtained that:

- For parameter values $0 < \pi < 1$ all solutions will converge to $z = 0$;
- (ii) For $1 < \pi < 3{,}57$ there exist fixed points the number of which depends on π;
- (iii) For $1 < \pi < 2$ all solutions monotnically increase to $z = (\pi - 1) / \pi$;
- (iv) For $2 < \pi < 3$ fluctuations will converge to $z = (\pi - 1) / \pi$;
- (v) For $3 < \pi < 4$ all solutions will continously fluctuate;
- (vi) For $3{,}57 < \pi < 4$ the solution become „chaotic“ wich means that there exist totally aperiodic solution or periodic solutions with a very large, complicated period. This means that the path of z_t fluctuates in an apparently random fashion over time, not settling down into any regular pattern whatsoever.

4. EMPIRICAL EVIDENCE

The main aim of this paper is to analyze the international tourism receipts' growth stability in the period 1995-2018. In this sense, it is important to use the logistic model (11):

$$r_t = \pi r_{t-1} - \omega r_{t-1}^{\ 2} \tag{11}$$

where r– the international tourism receipts, $\pi = [\beta / (1 - \gamma - \lambda)]$, $\omega = [\alpha / \chi (\gamma + \lambda - 1)]$.

Now, model (11) is estimated (see Table 1).

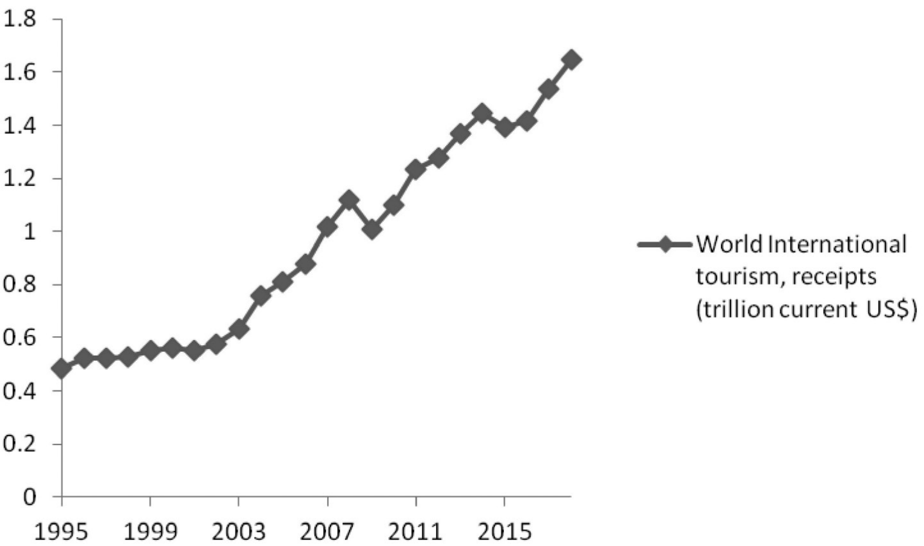

Figure 1. International tourism, world, Receipts (trillion current US$)

Source: https://data.worldbank.org/indicator/ST.INT.RCPT.CD?view=chart

Table 1. The estimated model (11): World International tourism receipts, 1995-2018

	R=0.82063 Variance explained: 67.34%		
		π	ω
World	**Estimate**	1.319674	0.401628
	Std.Err.	0.192264	0.255931
	t(21)	6.863870	1.569281
	p-level	0.00000	0.131528

Source: Authors research.

The international tourism receipts monotonically increased from 0.509 trillion current US \$ to 1.766 trillion current US \$ in the observed period. Namely, according to the logistic equation, for $1 < \pi < 2$ all solutions monotonically increase to $z = (\pi - 1) / \pi$.

5. CONCLUSION

This paper creates the international tourism receipts chaotic growth model. For most choices of α, β, γ, λ, and χ there is no explicit solution for the growth model (11). Namely, knowing α, β, γ, λ, and χ and measuring r_0 would not suffice to predict r_t for any point in time, as was previously possible.

A key hypothesis of this work is based on the idea that the coefficient $\pi = [\beta / (1-\gamma-\lambda)]$ plays a crucial role in explaining the local growth stability of the international tourism receipts, where, β – the investment rate, γ- the government expenditure rate, λ – the net exports rate.

An estimated value of the coefficient π confirms stable growth of the international tourism receipts in the observed period.

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