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Optimal Monetary Policy at the Zero Lower Bound on Nominal Interest Rates in a Cost Channel Economy

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Abstract

It has been widely debated what a central bank should do to stimulate the economy when the nominal interest rate is at the zero lower bound (ZLB). The optimal monetary policy literature suggests that monetary policy inertia, i.e., committing to continue a zero interest regime even after the ZLB is not binding, is a way to get the economy out of recession. In this paper, I examine whether this result holds when monetary policy has not only the conventional demand-side effect but also a supply-side effect on the economy. To accomplish this objective, I incorporate the cost channel of monetary policy into an otherwise standard new Keynesian model and evaluate the optimal monetary policy at the ZLB. The study reveals several important insights in the conduct of the optimal monetary policy in a cost channel economy at the ZLB. Importantly, the discretionary policy requires central banks to keep interest rates at the ZLB for longer in a cost channel economy compared to no-cost channel economies. Further, cost channel economies introduce a policy trade-off between inflation and output gap. In contrast, under commitment policy, the simulation exercise shows that the central bank is able to terminate the zero interest rate regime earlier in a cost channel economy than otherwise. It is also revealed that the cost channel generates substantially high welfare losses, under both discretionary and commitment policies. Accordingly, abstracting the cost channel in these types of models can lead to under estimation of welfare losses.

Key Words: *Optimal Monetary Policy, Zero Rates on Nominal Interest Rates, Cost Channel of Monetary Policy, New Keynesian Model, Liquidity Trap*

JEL Classification: *E31, E52, E58, E61*

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1. Introduction

The zero lower bound on nominal interest rates (ZLB) is no longer just a theoretical interest. Nominal interest rates were at zero lower bound in the recent past in many countries across the globe.[1] It has been widely debated what a central bank should do to stimulate the economy when the aggregate demand is weak, even when the nominal interest rate is at zero level.[2] Optimal monetary policy literature suggests that monetary policy inertia, i.e. committing to continue a zero interest regime even after the ZLB is not binding, is a way to get the economy out of recession. In this paper, I examine whether this result holds when monetary policy has not only the conventional demand-side effect but also a supply-side effect on the economy.

In optimal monetary policy literature, there are two main policies which attempt to stabilise the economy in terms of inflation and output following a shock to the economy, namely, discretionary policy and commitment policy. Under discretion, the central bank takes the current state of the economy and private sector expectations as given. Under this policy, the central bank optimises in each period; therefore, any promises given by the bank are not credible. On the other hand, under commitment policy, the central bank chooses a path for current and future inflation as well as output and commits to that. Therefore, under commitment, if the central bank is credible, it can adjust private sector expectations [see Walsh (2010, pp. 357-364)]. Nobel laureates Finn E. Kydland and Edward C. Prescott, in their seminal paper "Rules Rather than Discretion: The Inconsistency of Optimal Plans" [henceforth; Kydland and Prescott (1977)], showed how an announcement of commitment to a low inflation regime by monetary authorities might create lower private sector inflationary expectations. They argued that if this monetary policy is then changed and interest rates are reduced to give a short-term lift to employment, credibility of policy makers will be lost and conditions may worsen.

However, literature on optimal monetary policy at the ZLB thus far has abstracted an important characteristic of the economy, i.e. the cost channel of monetary policy.[3] The cost channel is said to be present in an economy if the changes in nominal interest rates affect the

[1] Some central banks have pushed short-term nominal interest rates below the zero lower bound. In the present study, I consider short-term nominal interest rates to be constrained by the zero lower bound.

[2] During the past decade, central banks around the world, including the Federal Reserve Bank of the USA had to resort to unconventional monetary policies due to ZLB constraints. Two main such unconventional policies that have been considered are forward guidance and balance sheet policies. However, in this paper, my focus is only on conventional monetary policy with the interest rate instrument.

[3] Chattopadhyay and Ghosh (2016) conducted a study on optimal monetary policy at the ZLB in a cost channel economy with varying degree of interest rate pass-through. Their methodology is similar to the methodology used in this paper and they report results similar to mine. Both papers were written in the same time period, but independently.

supply-side of the economy. It has been found by many recent studies[4] that the cost channel is an important channel of monetary policy in the USA and other developed countries. Ravenna and Walsh (2006), utilising a new Keynesian forward looking model, theoretically showed that the cost channel affects optimal monetary policy in important ways.

Presence of the cost channel could affect the policy outcomes of new Keynesian studies which examine zero lower bound policies. In general, the cost channel makes changes directly to the current inflation as well as the current output gap due to changes in nominal interest rates, other things being equal. In addition, when the cost channel is active in the model, it accelerates future inflationary expectations if the monetary authority commits to a tight monetary policy. This again raises current inflation. Consequently, the presence of the cost channel may affect the optimal monetary policy at the ZLB.

The main objective of this paper is to examine central bank policy options at the ZLB in a cost channel economy. Specifically, this study inquires when a central bank should exit the zero nominal interest rate regime. In this regard, I consider both discretionary and commitment polices, although the study mainly focuses on commitment policies. I consider a variation of the standard new Keynesian model to accomplish the above objective. To carry out simulations, I calibrate the model to the economy of the USA.

The main findings are as follows: a) the discretionary policy requires central banks to keep interest rates at the zero lower bound for longer in a cost channel economy compared to no-cost channel economies. b) Under commitment policy, the simulation exercise shows that the central bank is able to terminate the zero interest rate regime earlier in cost channel economies than otherwise. c) The cost channel generates substantially high welfare losses, under both discretionary and commitment policies.

The rest of the study is structured as follows. In section 2, I review the relevant literature on the optimal monetary policy at the ZLB and the optimal monetary policy with the cost channel. Section 3 describes the model, steady states and optimal dynamic paths. Model simulations and results are given in section 4. Section 5 concludes the study.

2. Literature Survey

In this section, I review the relevant literature under two main sections. Firstly, literature about optimal monetary policy at the ZLB is reviewed. Secondly, optimal monetary policy literature in a cost channel economy is reviewed. The main focus in the literature review is new Keynesian models as they are the most relevant to the present study.

[4] For example, see Barth and Ramey (2001), Christiano et al. (2005), Kim and Lastrapes (2007), Henzel et al. (2009), Ravenna and Walsh (2006) and Chowdhury et al. (2006).

2.1 Optimal Monetary Policy at the ZLB

The evolution of the new Keynesian framework where management of private sector expectations is incorporated explicitly into economic modelling has improved the analysis of the optimal monetary policy at the ZLB. The importance of explicitly considering non-linearities in analysing the behaviour of the new Keynesian model at the ZLB has been shown by many scholars. Among them, Fernández-Villaverde et al. (2012) showed how the decision rules and the equilibrium dynamics of the model are substantially affected by the non-linear features at the ZLB.

Although there are few policy options within the traditional interest rate rule to get out of the ZLB constraint, the most accepted solution is the commitment to a policy. Krugman (1998) puts it as follows: "monetary policy will in fact be effective if the central bank can credibly promise to be irresponsible, to seek a higher future price level". He argues that under these conditions the liquidity trap boils down to a credibility problem. Private agents expect that any monetary expansion carried out by the central bank at the ZLB would be reverted immediately once the economy has recovered. Such expectations may not stimulate the economy in the recession. As a solution, Krugman suggests that the central bank should commit to a policy of high future inflation over an extended horizon.

Following Krugman's work, many proved in more complex dynamic models that the commitment to a policy plan which is facilitated by forward guidance is one way of getting out of the slump. Eggertsson and Woodford (2003) studied optimal commitment policy with ZLB in an inter-temporal model in which the natural rate of interest is allowed to take two different values. The natural rate of interest was assumed to become negative unexpectedly in the beginning and then move to a positive level with certain probability in every period. They explored how the existence of the zero lower bound affects the optimal conduct of monetary policy with regard to both inflation and output. Eggertsson and Woodford recommended a form of price-level targeting rule that should bring about the constrained optimal equilibrium if the central bank is credible. Jung, Teranishi and Watanabe (2005; henceforth JTW) considered a similar set up to Eggertsson and Woodford (2003) with perfect foresight, however, they considered an exogenous AR (1) process to the natural rate of interest. Both Eggertsson and Woodford (2003) and JTW found that at the ZLB, under commitment, the central bank should continue zero nominal interest rates even after the natural rate of interest returns back to the positive level. Doing so, the central bank can stimulate the economy by generating higher inflationary expectations. Extending this work, Hasui et al. (2016) considered the optimal commitment policy in an economy with inflation persistence. They argued that inflation persistence changes the central bank's objective from achieving target inflation rate to inflation smoothing. Therefore, agents expect an accommodative monetary policy, in turn, increasing inflationary expectations. This produces an acceleration in inflation and allows the central bank to terminate the ZLB policy earlier compared to an economy without inflation persistence.

The above line of research assumes that the central bank is fully credible, to the extent that private agents believe the commitments. Bodenstein et al. (2012) relaxed the assumption of the fully credible central bank. In a new Keynesian set up, they found that at the ZLB, the central bank faces a severe time-inconsistency problem. Initially, a promise to keep the nominal interest rate low for an extended period raises inflationary expectations. Further, it lowers current and future real interest rates, and thus stimulates current output. However, once the economy has emerged from the slump, it is not optimal to keep interest low any longer. Accordingly, they found that if a central bank's announced promises are not credible, then the economy goes through a deeper recession than otherwise.

All the studies specified above are based on the central bank optimising social welfare. There is another line of research which studies the performance of simple monetary policy rules at the ZLB. Here, the monetary authority commits to a particular type of rule such as the Taylor rule [Taylor (1993)]. Studies such as Fuhrer and Madigan (1997), Eggerston and Woodford (2003), Wolman (2005), Coenen et al. (2004), and Nakov (2008) examine this problem. These studies, in general, show that if the target inflation rate is closer to zero, simple policy rules such as the Taylor rule, can generate significant welfare losses. However, Eggerston and Woodford (2003) and Wolman (2005) showed that the policy rules formulated in terms of a price level target can considerably reduce these welfare losses. In contrast, Hasui et al. (2016) showed that the performance of price-level targets in an economy with inflation persistence is substantially low.

2.2 Optimal Monetary Policy with the Cost Channel

Ravenna and Walsh (2006) were the first to show that the presence of the cost channel alters the optimal monetary policy problem in important ways. They showed that the interest rate changes carried out to stabilise the output gap lead to inflation fluctuations when a cost channel is present. As a consequence, the output gap and inflation fluctuate in response to productivity and demand disturbances, even when the central bank is setting policy optimally. They assumed that a cost channel is present in the economy when firms' marginal cost depends directly on the nominal interest rate. Following Ravenna and Walsh (2006), others analysed the optimal monetary policy with the cost channel from different perspectives and found that the cost channel is important when analysing the optimal monetary policy. Chattopadhyay and Ghosh (2016), written independent of this paper, consider optimal monetary policy in a cost channel economy. They report similar results to this paper under both optimal discretionary and optimal commitment policies using a new Keynesian model at the ZLB. In addition to the two optimal policies, they consider a policy called the 'T-only' policy. Under the T-only policy, the central bank chooses and announces the optimal exit time of a zero interest rate regime and promises to exercise the discretionary policy following the exit. Chattopadhyay and Ghosh show that this policy closely replicates the commitment policy both under presence and absence of the cost channel.

Fiore and Tristani (2013) studied optimal monetary policy in a model of the credit channel with the cost channel of monetary policy. Using a second-order approximation of the welfare function, they showed that welfare is directly affected not just by the volatility of inflation and the output gap, as in the standard case where there are no financial frictions, but also by the volatility of the nominal interest rate and credit spreads. Credit spreads affect optimal monetary policy through the cost channel. Higher credit spreads make borrowing costly for firms by increasing marginal cost of production. Overall, the authors concluded that the monetary authorities ought to pay attention to financial market friction.

Tillmann (2009) studied the optimal monetary policy with an uncertain cost channel. He concluded that the larger the degree of uncertainty about the cost channel, the smaller the interest rate response to inflation. He incorporated uncertainty of the cost channel into the model since the effectiveness of the cost channel varies significantly over time and across countries. Therefore, the monetary authority may not be certain about the effectiveness of the true role of the cost channel at a given time. The framework of his study is new Keynesian, which has a policymaker who plays a zero-sum game against an evil agent who sets the parameters such that the welfare loss is maximised. In the model, an uncertain policy maker should overestimate the quantitative importance of the cost channel when setting interest rates. In this sense, the policymaker is less aggressive than under certainty.

Studies show that optimal monetary policy in the presence of the cost channel leads to an increased indeterminacy region. Surico (2008) studied the conditions that guarantee equilibrium determinacy in a standard sticky price new Keynesian model augmented with a cost channel. Surico showed that a central bank that assigns a positive weight to the output gap in the reaction function makes the economy more prone to multiple equilibria compared to the standard case. His results are robust to forward-looking, current, and backward-looking policy rules. Surico suggested that, when the cost channel is empirically important, trying to limit cyclical swings in real activity may result in undesired volatility of inflation and output.

The next section presents the model, derives steady states and analyses the optimal dynamic path following a negative shock to the economy.

3. The Model

I consider a new Keynesian forward looking inter-temporal model to study the cost channel economy at the ZLB. This model is more suitable for the present analysis as it incorporates private sector expectations explicitly into the model. The model is based on JTW and Ravenna and Walsh (2006). I extend these authors' models to incorporate both the cost channel and the ZLB. The basic model is standard; however, a brief exposition is presented here to self-contain the analysis. The exposition is based on Ravenna and Walsh (2006); however, their model has been simplified by ignoring the government and taste shocks. Following them, I

assume the cost of labour must be financed at the beginning of the period. However, their assumption that the full labour cost has to be financed externally at the beginning of the year has been relaxed.

The model economy consists of three main sectors, namely, households, production and monetary authority. Financial intermediaries are also part of the economy, where firms borrow money to finance their wage bill. These players interact with each other in assets, goods and labour markets.

3.1 Households

There is a large number of identical infinitely-lived households in the economy. The preferences of a representative household are defined over a composite good C_t and time devoted to employment N_t. Households maximise the expected present discounted value of utility:

$$E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{C_{t+i}^{1-\sigma}}{1-\sigma} - \chi \frac{C_{t+i}^{1+\eta}}{1+\eta} \right],$$

where $\beta \in (0, 1)$ is a subjective rate of discount, $\sigma > 0$ is the coefficient of relative risk aversion and $\eta > 0$ is elasticity of labour supply. The composite consumption good consists of differentiated goods produced by monopolistically competitive final goods producers. There is a continuum of such producers of measure 1. C_t is defined as follows:

$$C_t = \left[\int_0^1 C_{jt}^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}},$$

where c_{jt} is the consumption of the good produced by firm j and θ (> 1) is the elasticity of substitution between varieties. The price elasticity of demand for the individual goods is determined by θ. As θ increases, the different goods become closer substitutes. According to this specification, consumer demand and the aggregate price index are given by,

$$C_{jt} = C_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\theta} C_t \quad \text{and} \quad P_t = \left[\int_0^1 {P_{jt}}^{1-\theta} dj \right]^{1/(1-\theta)},$$

respectively. The price of the final good of firm j at time t is P_{jt}.

Households receive their labour income at the beginning of the period at the nominal wage rate of W_t. They enter the period t with cash holdings of M_t and make deposits D_t at the

financial intermediary. Accordingly, household's consumption expenditures are restricted by the following cash-in-advance constraint:

$$P_t C_t \leq M_t + W_t N_t - D_t,$$

and budget constraint:

$$M_{t+1} + D_t + P_t C_t \leq M_t + W_t N_t + R_t D_t + \Pi_t,$$

where Π_t is the profit income received from owning financial intermediaries and R_t is the gross nominal interest rate. It is also assumed that households are subject to a solvency constraint that prevents them from engaging in Ponzi-type schemes.

By maximising household utility subject to budget constraint, the following first order conditions (FOCs) are obtained:

$$C_t^{-\sigma} = \beta E_t \left(\frac{R_t P_t}{P_{t+1}}\right) C_{t+1}^{-\sigma}, \quad (1)$$

$$\frac{\chi N_t^{\eta}}{C_t^{-\sigma}} = \frac{W_t}{P_t}, \quad (2)$$

$$P_t C_t = M_t + W_t N_t + D_t. \quad (3)$$

The next section describes the production sector of the economy.

3.2 Production Sector

Firms in this model use no capital in the production process. They have to pay wages at the beginning of the period, before realising sales proceeds. The production technology is given by $y_{jt} = A_t N_{jt}$, where y_{jt} is total demand for good j in period t, N_{jt} is employment by firm j in period t and A_t is an exogenous aggregate productivity factor. The staggered price setting of Calvo (1983) is used assuming each firm resets its price in any given period only with probability $1 - \omega$. Firms set their prices independent of other firms and of the time elapsed since the last adjustment. By considering the optimal price chosen by each firm, it is well-known, as shown by Gali (2002) and others, that this standard production sector specification leads to the following inflation adjustment equation, mostly known as the new Keynesian Phillips curve (NKPC):

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \hat{\psi}_t, \quad (4)$$

where π_t is the rate of inflation between time $t-1$ and t, $\hat{\psi}$ is the percentage deviation of real marginal cost around its steady state[5] (which is the same for all the firms) an $\varkappa = \frac{(1-\omega)(1-\omega\beta)}{\omega}$. The cost channel model deviates from the standard new Keynesian model in the specification of the marginal cost. The marginal cost is different in the cost channel model than in the standard model due to the borrowing of the wage bill. What follows is the derivation of the corresponding real marginal cost with regard to the cost channel model.

Assume a firm takes out a loan worth JW_tN_t from financial intermediaries to cover part of its nominal wages of W_tN_t. Accordingly, J ($J \in [0, 1]$) denotes the portion of the wage bill covered by firms using external loans at time t. If $J = 1$, firms borrow the full wage bill externally. If $J = 0$, that means the firm does not take out loans externally to cover the wage bill.

Accordingly, the real marginal cost is given by:

$$\psi_t = \left(\frac{W_t}{P_t}\right)\left(\frac{N_t}{Y_t}\right)[1 + J(R_t - 1)] \tag{5}$$

The log linearised real marginal cost (see Appendix A for derivation) is:

$$\hat{\psi} = (\sigma + \eta)x_t + J\hat{R}, \tag{6}$$

where x_t is the output gap given by $(\hat{Y}_t - \hat{Y}_t^f)$. The percentage deviation of output around its steady state is $\hat{Y}_t$, and $\hat{Y}_t^f$ is the percentage deviation of flexible price output around its steady state at time t.[6] The percentage point deviation of nominal interest rate around zero inflation steady state value of R is $\hat{R}_t$.

Accordingly, the NKPC adjusted for the cost channel, is derived using equations (4) and (6) as follows:

$$\pi_t = \beta E_t\pi_{t+1} + \kappa(\sigma + \eta)x_t + \kappa J\hat{R}_t. \tag{7}$$

[5] Throughout this paper, a hat sign (ˆ) denotes the percentage deviation of the concerned variable around its steady state.

[6] Equilibrium flexible price output is discussed in detail below.

It is clear from equation (7), that when $J = 1$, the NKPC boils down to Ravenna and Walsh (2006) and, when $J = 0$, it turns to the standard NKPC. Iterating this equation forward yields the following:

$$\pi_t = \kappa \sum_{k=0}^{\infty} \beta^k E^t\left[(\sigma + \eta)x_{t+k} + J\hat{R}_{t+k}\right].$$

This equation shows that current inflation not only depends on the current and future path of the output gap but also on the current and future path of the nominal interest rates. The latter influences current inflation directly due to the inclusion of the cost channel in the model.

Log linearising the Euler equation given by (1) yields the well-known dynamic IS equation:

$$x_t = E_t x_{t+1} - \sigma^{-1}\left(\hat{R}_t - E_t\pi_{t+1}\right) + u_t,$$

where u_t is an exogenous demand disturbance term.

Since I am comparing the results with JTW, to be compatible with their model, I introduce natural rate of interest (r_t^n) as defined by JTW.[7] Accordingly, the dynamic IS equation becomes this:

$$x_t = E_t x_{t+1} - \sigma^{-1}\left[\hat{R}_t - E_t\pi_{t+1} - \hat{r}_t^n\right], \quad (8)$$

where $\hat{r}_t^n$ is the percentage point deviation of the net natural interest rate around its zero inflation steady state value of r^n. At the zero inflation steady state, nominal interest rate is equal to natural rate of interest rate.[8] Accordingly, at the zero inflation steady state, the following result holds:

$$R = 1 + r^n = \frac{1}{\beta}$$

Aggregate Resource Constraint

The economy I consider in this model is a simple economy. It abstracts from aggregate demand components such as investments, government purchases or net exports. Accordingly, aggregate resource constraint of the economy is given by this:

[7] JTW defines the natural interest rate as follows: $r_t^n = \sigma E_t[(y_{t+1}^p - y_t^p) - (g_{t+1} - g_t) + \left(\frac{1}{\beta} - 1\right)$, where y_t^p is the potential output and g_t is a disturbance that fluctuates independently of changes in the real interest rate.

[8] At the zero inflation steady state, I assume the potential growth in the economy to be zero and that there will be no disturbances to the natural rate of interest. Accordingly, the natural interest rate at zero in addition steady state is equal to $\frac{1}{\beta} - 1$. From the Euler equation given by equation (1), it is easy to and the zero in addition steady state value of the net nominal interest rate is also equal to $\frac{1}{\beta} - 1$.

$$Y_t = C_t,$$

where Y_t is the aggregate production.

Flexible Price Equilibrium

The model developed above is characterised by three distortions. The first of them is the presence of market power in the goods market due to the monopolistic competition among firms. The second is due to price rigidity. These two distortions are basic in the standard new Keynesian model. The third distortion is specific to this study, and it is due to the cost channel. In the following section, I relax the price rigidity assumption and examine the equilibrium output under flexible prices.

Suppose that all firms adjust prices optimally in each period, i.e. prices are fully flexible. When prices are fully flexible, all firms charge the same price. Each firm sets its price equal to a markup, $\delta \left(= \frac{\theta}{\theta-1} > 1\right)$ over its nominal marginal cost, which is constant over time. Hence, it follows that the real marginal cost will also be constant and equal to the inverse of the optimal markup chosen by firms.[9] Let superscript f denote the flexible price equilibrium values of relevant variables. Accordingly:

$$\frac{\left[1 + j(R^f - 1)\left[\frac{W_t}{P_t}\right]^f\right]}{A_t} = \frac{1}{\delta}$$

Hence:

$$\left[\frac{W_t}{P_t}\right]^f = \frac{A_t}{\delta\left[1+J\left(1+R_t^f-1\right)\right]} \tag{9}$$

Households equate the real wage to the marginal rate of substitution between leisure and consumption. From equation (2):

$$\left[\frac{W_t}{P_t}\right]^f = \frac{\chi N_t^{\eta}}{C_t^{-\sigma}} \tag{10}$$

Combining Equation (9) and (10) together with production function and resource constraint yields the following:

[9] See Walsh (2010, pp. 334-335) for a detailed description of the flexible price mechanism.

$$\frac{A_t}{\delta\left[1+J\left(1+R_t^f-1\right)\right]}=\frac{\chi\left[\frac{Y_t^f}{A_t}\right]^{\eta}}{\left[Y_t^f\right]^{-\sigma}}$$

Hence:

$$Y_t^f=\left[\frac{A_t{}^{(1+\eta)}}{\chi\delta\left[1+J\left(1+R_t^f-1\right)\right]}\right]^{\frac{1}{\sigma+\eta}}$$

This shows that the equilibrium flexible price output is distorted by monetary policy as the nominal interest rate is an argument in the equation and the presence of market power in the goods market. With regard to the distortions by monetary policy, for example, an increase in nominal interest rate decreases labour demand, which in turn reduces the equilibrium level of flexible price output. This distortion is directly due to the inclusion of the cost channel in the model.

The steady state value of the flexible price output is given as follows:

$$Y^f=\left[\frac{1}{\chi\delta[1+J(R^f-1)]}\right]^{\frac{1}{\sigma+\eta}}$$

where R^f is the steady state value of the flexible price nominal interest rate.

The steady state value of the flexible price output is also distorted by monetary policy and monopolistic competition. If $J = 0$, then by construction the cost channel is eliminated and the distortion is also eliminated. On the other hand, if the nominal interest rate is zero (or $R^f = 1$), the distortion brought in by the cost channel is eliminated. Distortion due to monopolistic competition can be eliminated by setting $\delta = 1$.

Next, I specify the objective of the monetary authority and its problem.

3.3 Monetary Authority

The monetary authority has one monetary instrument, which is the short-term nominal interest rate. It attempts to minimise the loss function:

$$L_0=\frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t\{\pi_t^2+\lambda x_t^2\} \tag{11}$$

where λ is a positive parameter representing the weight assigned to output stability. This loss function has been derived using second-order Taylor expansion of the utility of the

representative household. Woodford (2003) derived this for a standard new Keynesian model, while Ravenna and Walsh (2006) derived this for a new Keynesian model with a cost channel, similar to the present model.

3.4 Optimisation Problem

The central bank minimises equation (11) subject to equations (7), (8) and the ZLB condition. The problem is as follows:

$$Min\,\frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t\{\pi_t^2+\lambda x_t^2\}, \tag{12}$$

Subject to,

$$x_t = E_t x_{t+1} - \sigma^{-1}\left(\hat{R}_t - E_t\pi_{t+1} - \hat{r}_t^n\right)$$

$$\pi_t = \beta E_t\pi_{t+1} + \kappa(\sigma+\eta)x_t + \kappa J\hat{R}_t$$

and

$$\hat{R}_t + R - 1 \geq 0. \tag{13}$$

This problem cannot be solved by applying standard solution methods for rational expectations models because of the complications brought in by the non-linear constraint in equation (13). To make the analysis more tractable, I consider the agents with perfect foresight under both discretion and commitment policies in the following sections.

In this analysis, following JTW, it has been considered that the economy is in a liquidity trap following a large negative demand shock to the natural interest rate. The natural rate of interest follows an AR(1) process following the shock and converges to steady state value in and after period one. The AR(1) process is as follows:

$$\hat{r}_t^n = \rho^t\epsilon_0 + r^n \text{ for } t = 0,1,2,3..., \tag{14}$$

where ϵ_0 is the large negative shock that occurs in the time $t = 0$, and ϱ is the persistence of the shock ($0 < \rho < 1$).

The optimisation problem under each commitment and discretionary policies is considered in the following sections.

Optimisation under Discretion

Under discretion, the central bank treats the optimisation problem as a sequential optimisation problem. Accordingly, the central bank makes whatever decision that is optimal in each period without committing to future actions. The central bank chooses

(x_t, π_t) in order to minimise the objective function given by equation (12) subject to adjusted NKPC, the dynamic IS curve and the ZLB constraint. The Lagrangian method is used to solve this constrained optimisation problem. Accordingly, the problem with perfect foresight is as follows:

$$L = \beta^t \left\{ \frac{1}{2}(\pi_t^2 + \lambda x_t^2) + \mu_t \left[x_t - x_{t+1} + \sigma^{-1}\left(\hat{R}_t - \pi_{t+1} - \hat{r}_t^n\right) \right] + \delta_t \left[\pi_t - \beta\pi_{t+1} - \kappa(\sigma + \eta)x_t - \kappa J \hat{R}_t \right] + \nu_t\left(\hat{R}_t + R - 1\right) \right\}, \quad (15)$$

where μ_t, δ_t and ν_t are Lagrangian multipliers.

Under discretion, the central bank optimises in each period. Accordingly, the Karush-Kuhn-Tucker (KKT) conditions of the problem are the following:

$$\begin{gathered} \pi_t + \delta_t = 0, \\ \lambda x_t + \mu_t - \kappa(\sigma + \eta)\delta_t = 0, \\ \mu_t \sigma^{-1} - \kappa J \delta_t + \nu_t = 0, \\ x_t - x_{t+1} + \sigma^{-1}\left(\hat{R}_t - \pi_{t+1} - \hat{r}_t^n\right) = 0, \\ \pi_t - \beta\pi_{t+1} - \kappa(\sigma + \eta)x_t - \kappa J \hat{R}_t = 0, \\ \nu_t\left(\hat{R}_t + R - 1\right) = 0, \\ \nu_t \leq 0, \\ \hat{R}_t + R - 1 \geq 0. \end{gathered}$$

Steady State under Discretion

At steady state, define $x_t = x, \pi_t = \pi, r_t^n = r^n, \delta_t = \delta, \mu_t = \mu, \nu_t = \nu, \hat{R}_t = \hat{R}$ *and* $\hat{r}_t^n = 0$. Also define R_{ss} as the value of the gross nominal interest rate relevant to the particular steady state.[10] Accordingly, the KKT conditions become the following:

$$\begin{gathered} \pi + \delta = 0, \\ \lambda x + \mu - \kappa(\sigma + \eta)\delta = 0, \\ \sigma^{-1}\mu - \kappa J \delta + \nu = 0, \\ \pi = \hat{R} \\ (1 - \beta)\pi - \kappa(\sigma + \eta)x - \kappa J \hat{R} = 0. \end{gathered}$$

Potentially there can be two steady states in the system, an interior solution and a corner solution. First, I will consider the interior solution. In this case, the nominal interest

[10] According to the steady state definition of variables, Rss = $\hat{R}$+ R.

rate is strictly positive, i.e. $R_{ss} > 1$. According to the KKT conditions, $\nu = 0$. Substituting these into the above steady state conditions and solving the linear system of equations yields:

$$\pi = 0,\ x = 0,\ R_{ss} = 1 + r^n = R,\ \mu = 0,\ \delta = 0 \text{ and } \nu = 0.$$

In this steady state, inflation and output gap is zero. This steady state minimises the loss of the central bank's objective function.

Now turn to the corner solution. Here, the nominal interest rate has hit the zero lower bound, i.e. Rss = 1. Accordingly, $\widehat{R} = 1 - R$. The solution for ν in the linear system of equations given above is (results for other variables are given in the appendix B):

$$\nu = -\frac{[\lambda(1-\beta) + \kappa(J\lambda - \kappa(\eta+\sigma)\big(\eta + \sigma(1-J)\big)]r^n}{\kappa\sigma(\eta+\sigma)}$$

As required by the KKT conditions, ν is strictly negative at the corner solution for the following values of J:

$$J < \frac{\lambda(1-\beta) + \kappa^2(\eta+\sigma)^2}{\kappa(\lambda + \kappa\sigma(\eta+\sigma)}$$

Therefore, there exists a second steady state at the ZLB when J is sufficiently small. JTW show that there is a second steady state under discretion for a no-cost channel economy, i.e. when $J = 0$. For the baseline parametrisation values set at the calibration section below, the maximum value of J to have a second steady state is 0.9. This steady state does not minimise the central bank loss function since both inflation and the output gap have been deviated from zero.

The Friedman rule [Friedman (1969)] of zero nominal interest rate is not optimal in this model. One reason for this different conclusion is the absence of any explicit role for money in the utility approximation of equation (11), as shown by Walsh (2010, p355). Another reason is, as mentioned by JTW, the central bank loss functions defined in these types of optimisation studies do not include the existence of shoe-leather cost. Friedman argues that distortions due to shoe-leather costs are proportional to nominal interest rates, and therefore, these distortions can be eliminated by setting nominal interest rate to zero.

Optimisation under Commitment

Under commitment, the central bank optimises the system and commits to a current and future policy plan. I assume full credibility of the central bank. Accordingly, the central bank specifies the desired levels of inflation and the output gap for all possible dates and the states of nature. The central bank is assumed to choose a state contingent sequence$\{x_t, \pi_t\}_{t=0}^{\infty}$ which minimises its objective function given by equation (12) subject to the adjusted NKPC, the dynamic IS curve and the ZLB constraint. Accordingly, the KKT conditions are as follows:

$$\pi_t - (\beta\sigma)^{-1}\mu_{t-1} + \delta_t - \delta_{t-1} = 0,$$

$$\lambda x_t + \mu_t - \beta^{-1}\mu_{t-1} - \kappa(\sigma + \eta)\delta_t = 0,$$

$$\sigma^{-1}\mu_t - \kappa J\delta_t + \nu_t = 0,$$

$$x_t - x_{t+1} + \sigma^{-1}\left(\hat{R}_t - \pi_{t+1} - \hat{r}_t^n\right) = 0,$$

$$\pi_t - \beta\pi_{t+1} - \kappa(\sigma + \eta)x_t - \kappa J\hat{R}_t = 0,$$

$$\nu_t(\hat{R}_t + R - 1) = 0,$$

$$\nu_t \leq 0,$$

$$\hat{R}_t + R - 1 \geq 0.$$

Since lagged values of the Lagrange multipliers appear in the KKT conditions, it is clear that the KKT conditions are history dependent. Accordingly, the optimal choice of inflation, the output gap and the nominal interest rate depend on the past values of the endogenous variables. If the central bank deviates from its policy plan (a credibility loss), the outcome would be different.

Steady State under Commitment

Consider the steady state variables defined under discretionary policy. In the steady state under commitment, the KKT conditions derived above become these:

$$\pi - (\beta\sigma)^{-1}\mu = 0,$$

$$\lambda x + (1 - \beta^{-1})\mu - \kappa(\sigma + \eta)\delta = 0,$$

$$\sigma^{-1}\mu - \kappa J\delta + \nu = 0,$$

$$\pi = \hat{R},$$

$$(1 - \beta)\pi - \kappa(\sigma + \eta)x - \kappa J\hat{R} = 0.$$

It can be shown that the interior solution (i.e. $R_{ss} > 1$) is exactly the same as in the discretionary case as follows:

$$\pi = 0,\ x = 0,\ R_{ss} = 1 + r^n = R,\ \mu = 0,\ \delta = 0 \text{ and } \nu = 0.$$

This shows that under each policy, the interior solution converges to the same steady state with zero inflation and output gap minimising the central bank loss function.

Now turn to the corner solution under commitment. The solution for ν is as follows:

$$\nu = \frac{[J(1+\kappa)\lambda + \kappa\sigma(\eta+\sigma) + \beta(J\lambda + \kappa(\eta+\sigma)\big(\eta + \sigma(1-J)\big)]r^n}{\kappa(\eta+\sigma)^2}$$

The sign of ν, which is the Lagrangian multiplier of the ZLB constraint, is strictly positive. This contradicts the KKT conditions. Therefore, under commitment there does not exist a second steady state at the ZLB.

3.5 Optimal Path under Discretion

Consider that a large negative shock occurred to the natural interest rate, which converges to its steady state level over time. Assume the ZLB is binding until time T^d (i.e., $t = 0, 1, \ldots T^d$) and not binding thereafter (i.e., $t \geq T^d + 1$).

Consider the dynamic path where $t \geq T^d + 1$. Here, $\nu_t = 0$. Accordingly, the KKT conditions under discretion can be stated as follows:

$$\pi_t + \delta_t = 0, \tag{16}$$

$$\lambda x_t + \mu_t - \kappa(\sigma+\eta)\delta_t = 0, \tag{17}$$

$$\mu_t\sigma^{-1} - \kappa J\delta_t = 0, \tag{18}$$

$$x_t - x_{t+1} + \sigma^{-1}(\hat{R}_t - \pi_{t+1} - \hat{r}_t^n) = 0, \tag{19}$$

$$\pi_t - \beta\pi_{t+1} - \kappa(\sigma+\eta)x_t - \kappa J\hat{R}_t = 0. \tag{20}$$

From equations (16) – (18):

$$\lambda x_t + \kappa[\sigma(1-J)+\eta]\pi_t = 0. \tag{21}$$

Combining this result with equations (19) and (20) yields:

$$\pi_{t+1} = \tau\pi_t - \zeta\hat{r}_t^n, \tag{22}$$

$$Where\ \tau = \frac{J\kappa\sigma a + \lambda - \kappa(\sigma+\eta)a}{J\kappa\sigma a + J\lambda\kappa + \lambda\beta}, \zeta = \frac{J\lambda\kappa}{J\kappa\sigma a + J\lambda\kappa + \lambda\beta}\ and\ a = -\kappa[\sigma(1-J)+\eta].$$

When $J = 0$, i.e. when firms do not borrow externally to finance the wage bill, equation (22) is identical to JTW, which is given by $\pi_{t+1} = \beta^{-1}\left(1 + \frac{\kappa^2(\sigma+\eta)^2}{\lambda}\right)\pi_t$. Since τ is always greater than unity as shown by JTW, this difference equation has a bounded solution which is given by $\pi_t = 0$.

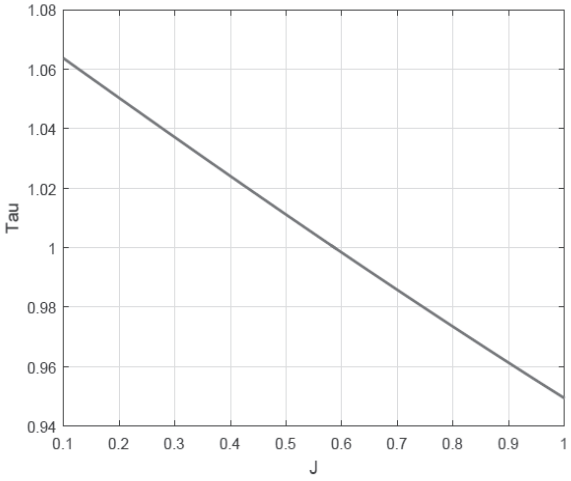
However, when $J > 0$, τ is not necessarily greater than unity. The value depends on the parametrisation. To have an idea about the value of τ, I plot the value of the coefficient with different values of J given in Figure 1.[11] It shows that the value of τ is greater than unity for smaller values of J (when $J < 0.59$), while it is less than unity for higher values of J.

The fact that τ becomes less than unity for higher values of J reveals an important difference between cost channel and no-cost channel economies. First, for larger values of J, equation (22) has a stationary solution. This means π_{T^d+1} does not necessarily take the value zero as shown in the case $J = 0$. Further, according to equation (21), x_{T^d+1} does not take the value zero. Accordingly, when $J > 0$, the central bank may not necessarily increase interest rates at time T^{d+1}. Therefore, when J is larger, the central bank does not necessarily increase interest rates one-to-one with the exogenous natural rate of the interest rate. Nakov (2008) found a similar result under discretionary policy when he considered that the natural interest rate follows a stochastic AR(1) process; however, he did not consider a cost channel economy.

Further, the fact that $|\tau| < 1$ means that there are multiple equilibria under discretionary policy. This leads to the equilibrium policy path selection. In the following simulation exercise, I consider the policy in which the economy returns to the zero inflation steady state on or before the 100th quarter.

[11] The parameters are set to baseline values as defined in section 4.1.

Figure 1: J vs τ for baseline parametrisation



4. Simulation and Results

4.1 Calibration

I calibrate the model for the US economy, with the baseline specification given in Table 1. The parameter values are within the standard new Keynesian parameter values and are carried over from Ravenna and Walsh (2006) and JTW. Still, the choice of two parameter values is worth noting here. Firstly, the weight on output in the loss function, (λ) is set at 0.25 in the baseline calibration. However, underlying theory implies a much smaller value for λ.[12] Most monetary policy literature, including Ravenna and Walsh (2006), employs a large value for λ considering the empirical relevance. Accordingly, I chose a large value for λ. Secondly, as mentioned before, the zero inflation steady state value of the natural interest rate is the value that has been calculated under the assumption that there is no growth in the potential output. Accordingly, the steady state value of the natural rate of interest is set at $\frac{1}{\beta} - 1$. These values are based on a time period equal to three months (one quarter).

[12] Theoretical value of $\lambda = \frac{(1-\beta\omega)(1-\omega)(\sigma+\eta)}{\omega^{\theta}} = 0.01$, when $\theta = 11$. See Ravenna and Walsh (2006) for the derivation of the theoretical value of λ.

Table 1: Parametrisation

Parameter	Description	Domain	Baseline Value
β	Discount rate in the utility function	(0,1)	0.99
σ	Coefficient of relative risk aversion	(0,∞)	1
η	Elasticity of labour supply in the utility function	(0,∞)	0.5
ω	Share of firms that cannot adjust prices optimally	[0,1)	0.75
$\varkappa$	Slope parameter used in NKPC	(0,∞)	0.09
λ	Weight on output in the loss function	(0,∞)	0.25
ϱ	Natural interest rate shock persistence parameter	[0,1)	0.7
r^n	Steady state value of the natural rate of interest	[0,∞)	$\frac{1}{\beta}-1$
J	Share of working capital to be financed externally	[0,1]	1

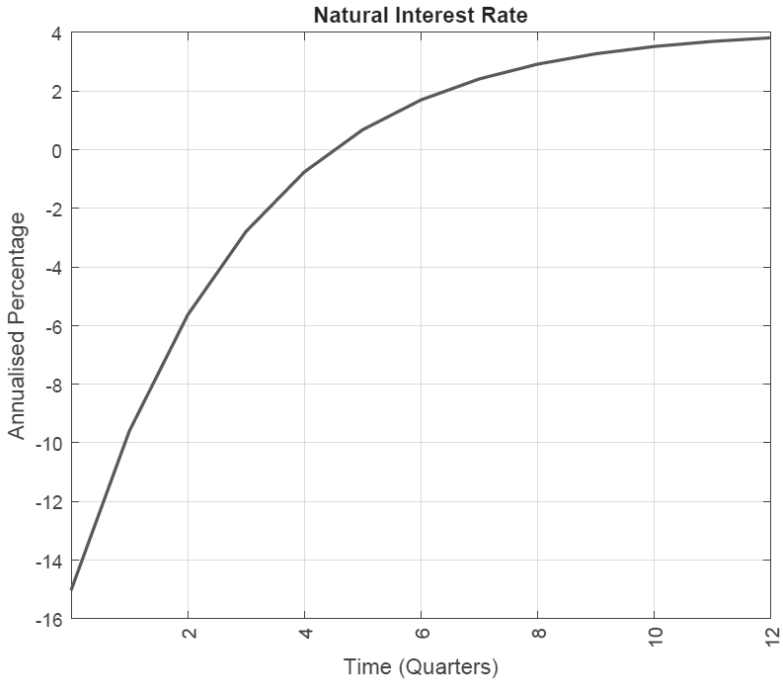
4.2 Simulation

In the baseline simulation, I consider the initial shock to the economy of the size of $\epsilon_0 = -0.05$, which is equivalent to around a 19 per cent drop in the annualised natural interest rate. In these simulations, I consider three values for J.[13] They are two extreme values J = 0 and J = 1, and a more empirically relevant value of J = 0.6. The dynamic path of the exogenous natural interest rate due to the large negative demand shock is depicted in Figure 2.[14] The figure shows that the natural interest rate drops to -15 per cent and returns to a positive level by the fourth quarter following the shock.

[13] I used the software Matlab (version R2016a) to facilitate the simulations.

[14] Relevant values given in the results are in annualised figures.

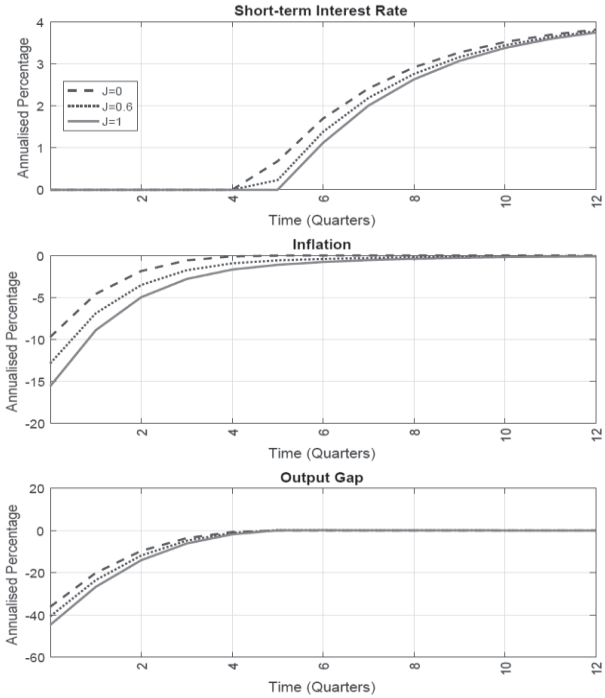
Figure 2: Path of natural rate of interest



4.3 Dynamic Path under Discretion

The dynamic path of the variables under discretionary policy is depicted in Figure 3. The solid lines depict the dynamics of the case when the cost channel of monetary policy is active (i.e. $J = 1$), the dashed lines depict the case in which such channel is not active (i.e. $J = 0$) while the dotted lines depict the case $J = 0.6$. The case $J = 0$ is identical to JTW. Notice that, following the demand shock, the economy gets into a deeper recession in a cost channel economy. This is observed in inflation and output gap plots. The reason for that is, when the cost channel is active, a sudden drop in nominal interest rates directly affects the cost of production negatively. Consequently, it amplifies deflation. Accordingly, under discretion, the central bank has to keep short-term nominal interest rates at zero level longer in a cost channel economy to minimise the loss. This is the main difference of the policy between cost channel and no-cost channel economies under discretion. The top plot in the panel shows that the central bank exits the zero interest rates regime in the fifth quarter in a cost channel economy compared to the fourth quarter in a no-cost channel economy.

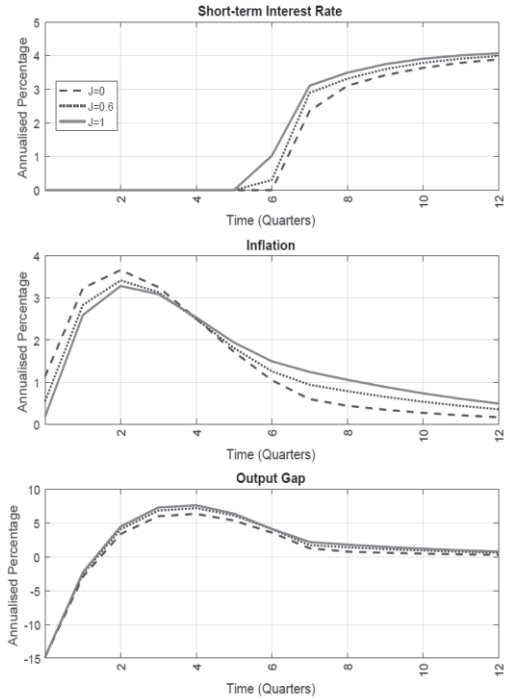
Figure 3: Path of variables under discretionary policy



4.4 Dynamic Path under Commitment

Now I turn to the commitment policy. The reaction of the model economy due to a large negative shock under commitment is depicted in Figure 4. The main result is opposite to the discretionary regime. Now the central bank in a cost channel economy exits the zero nominal interest rate regime earlier than the no-cost channel economy. This is observed in the bottom plot, which shows the path of the nominal interest rate. The reason for that is, in a cost channel economy, agents expect higher inflation once the central bank starts exiting zero interest rates. Because under commitment policy agents expect more inflation in a cost channel economy, the central bank promises to terminate zero interest rate policy early. This fact is confirmed in the inflation plot under commitment. When the central bank starts increasing short-term interest rates, the cost channel economy experiences a higher inflationary regime. Accordingly, the top plot in the panel shows that the central bank exits the zero interest rates regime in the fifth quarter in a cost channel economy compared to the sixth quarter in a no-cost channel economy.

Figure 4: Path of variables under commitment policy



Under commitment, both in cost channel and no-cost channel economies, the monetary authority attempts to stabilise the output gap and inflation in the short-term. However, under discretion, the monetary authority attempts to stabilise inflation and the output gap in the medium-term. These facts are observed in Figure 3 and Figure 4. For example, under discretion, the initial drop in inflation is -15 per cent, compared to zero inflation under commitment in cost channel economies.

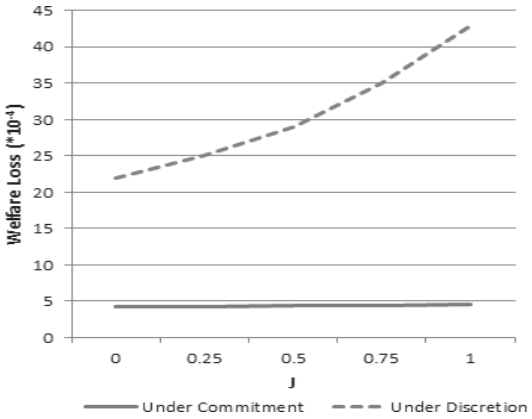
4.5 Welfare Losses

In this section, the welfare losses under optimal policy are considered. I consider welfare losses in two ways. Firstly, the more natural measurement of welfare loss in these kind of models, i.e. by evaluating the central bank's objective function given in equation (11). However, the welfare units found in that way do not have a proper interpretation. Therefore, I also consider the consumption equivalent welfare loss.

Figure 5 depicts welfare losses of optimal monetary policy at the ZLB under both discretion and commitment for alternative values of *J* evaluated using the central bank loss function. The figure shows a well-known result in the optimal monetary policy literature at the ZLB: that welfare loss under commitment policy is less than under discretion. The reason for this is that the use of expected inflation is unavailable under the discretionary policy, as there is no incentive to implement promised inflation ex-post. The ZLB, therefore, generates significant additional welfare losses under discretionary policy.

With regard to the cost channel, welfare loss under both discretion and commitment is high compared to no-cost channel economies (compare the cases when $J = 0$ and $J = 1$ in Figure 5). The negative impact of the cost channel on welfare under discretionary policy is substantially high compared to its impact under commitment policy. In cost channel economies, under commitment welfare loss increases by only 9 per cent, compared to a 95 per cent increase under discretion. Demirel (2013) in a different context also found that, in a cost channel economy, a switch from discretion to commitment in monetary policy yields greater welfare gains relative to a no-cost channel economy.

Figure 5: Welfare loss for different values of J



In the consumption equivalent of welfare analysis, I consider the percentage loss of consumption under each policy compared to the steady state consumption.[15] In line with

[15] Method of calculation of consumption equivalent welfare is based on Adam and Billi (2007). Adam and Billi (2007, Page 748) show that the utility equivalent percentage loss of consumption in the steady state is given by: $p = 100 * \frac{1}{\sigma}\left(-1 + \sqrt{1 + \frac{2(1-\beta)L'}{1/\sigma}}\right)$, where $L' = \frac{1}{2}\frac{\omega\theta(1+\zeta\theta)}{(1-\omega)(1-\omega\beta)}\sum_{i=0}^{\infty}\beta^i(\pi_{t+i}^2 + \lambda y_{t+i}^2)$ and ζ is elasticity of a firms' real marginal cost. In addition to the baseline parameterisation given in Table 11, following Adam and Billi (2007), I set $\theta = 7.66$ and $\zeta = 0.47$ for this calculation.

above results, I find under commitment policy in a cost channel economy, the loss of consumption is 0.037 percent compared to 0.033 percent loss without the cost channel. Under discretion, with the cost channel, loss of consumption is 0.428 percent compared to 0.244 percent loss without cost channel.

4.6 Sensitivity Analysis

In order to determine the robustness of the results, I perform some sensitivity analysis in this section. I examine various values of parameters and consider the exit timing of a zero interest rate regime in cost channel and no-cost channel economies. I start with alternative sizes of shocks and their persistence. Table 2 presents results.[16] As expected, the table shows that, when the shock size is high and persistent, it takes longer to exit the zero interest rate regime. Further, the result that I found for the baseline parametrisation is valid here too. That is, under discretionary policy, it takes an equal or longer time to exit a zero interest rates regime in a cost channel economy compared to a no-cost channel economy. In contrast, under commitment policy, it takes a shorter or equal time to exit a zero interest rate regime in a cost channel economy.

Table 2: Sensitivity Analysis: Shock Size and its Persistence

		Shock and its Persistence											
		ε= -0.02			-0.05			-0.1			-0.3		
		ρ=0	0.5	0.7	ρ =0	0.5	0.7	ρ =0	0.5	0.7	ρ =0	0.5	0.7
T^d	J=0	0	0	1	0	2	4	0	3	6	0	4	9
	J=1	0	1	2	0	2	5	0	3	7	0	5	10
T^c	J=0	0	1	2	1	3	6	2	5	8	4	7	11
	J=1	0	1	2	1	3	5	2	4	7	3	6	10

Next, I examine the sensitivity of results to the following variables: a share of firms who cannot optimise prices in each period and labour supply elasticity under commitment policy. The results are given in Table 3. The table shows that when the prices are relatively flexible (when ω takes relatively smaller values) and also when they are relatively rigid (when ω takes relatively larger values), there is no difference between a cost channel economy and a no-cost channel economy.

[16] Recall $T^d(T^c)$ is the time, which denotes that the ZLB is binding under discretionary (commitment) policy.

Table 3: Sensitivity Analysis: Price Rigidity and Labour Supply Elasticity under Commitment

		Price Rigidity		
		ω=0.3	ω=0.75	ω=0.9
η=0.01	J=0	5	6	6
	J=1	5	5	6
η=0.5	J=0	5	6	6
	J=1	5	5	6
η=1	J=0	5	6	6
	J=1	5	5	6

I also considered the sensitivity of results with regard to the discount factor. Results do not change to various values of β, a result that was found by JTW for a no-cost channel economy. It is confirmed here for the cost channel economies too.

4. Conclusion

In this study, I incorporated the cost channel of monetary policy into an otherwise standard new Keynesian model and evaluated the optimal monetary policy at the zero lower bound on nominal interest rates. The novelty of the study is that this is the first time a new Keynesian type study has been performed to analyse the optimal monetary policy at the ZLB with the cost channel. I considered that the economy was initially in a recession with a liquidity trap following a large negative demand shock. The solution methodology was different to the standard new Keynesian model as the ZLB brings non-linearity into the model. I followed the JTW solution methodology in a perfect foresight environment, which solves the problem considering that the economy is already at the ZLB.

The study reveals some important results in the conduct of the optimal monetary policy in a cost channel economy at the ZLB. Importantly, the discretionary policy requires central banks to keep interest rates at the zero lower bound for longer in a cost channel economy. This is because, in cost channel economies, the deflation is high and persistent due to a large negative demand shock compared to no-cost channel economies. Further, cost channel economies introduce a policy trade-off between inflation and output gap. This result contradicts the finding by JTW that short-term interest rates follow a one-to-one exogenous natural rate of interest following a negative demand shock in a no-cost channel economy.

Under the commitment policy with a fully credible monetary authority, the simulation exercise has shown that the central bank is able to terminate the zero interest rate regime earlier in a cost channel economy than otherwise. This result is in contrast to the results

found under discretionary policy. The reason for that is, in a cost channel economy, the private sector has inflated inflationary expectations. This is because the cost channel increases future cost of production, and in turn, inflation when the central bank starts tightening monetary policy on a future known date.

Welfare losses are calculated using the central bank's objective function. It was revealed that the cost channel generates substantially high welfare losses, both under discretionary and commitment policies. Accordingly, abstracting the cost channel in these types of models can lead to under-estimation of welfare losses.

The robustness of the results was examined using a sensitivity analysis. The basic results found in the baseline parametrisation were confirmed in the sensitivity analysis. It was found that the difference between a cost channel economy and a no-cost channel economy is marginal with regard to the timing of the termination of zero interest rates when prices are relatively flexible or relatively rigid.

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Appendices

A.1 Log linearising real marginal cost

Taking log of (5) and substituting $A_t = \frac{Y_t}{N_t}$ yield:

$$ln\psi_t = ln\left[\frac{W_t Y_t}{P_t N_t}\right] + ln[1 + J(R_t - 1)] \tag{23}$$

For simplification purposes denote (23) as follows:

$$\ln\psi_t = \ln S_t + \ln V_t, \tag{24}$$

where $S_t = \left[\frac{W_t Y_t}{P_t N_t}\right]$ and $V_t = [1 + J\,(R_t - 1)]$.

At steady state (24):

$$\ln\psi = \ln S + \ln V. \tag{25}$$

Log linearised equation given by taking the difference of (24) and (25):

$$\hat{\psi}_t = \hat{s}_t + \hat{v}_t. \tag{26}$$

Now consider $\hat{s}_t$:

$$\hat{s}_t = \hat{w}_t - \hat{p}_t + \hat{y}_t - \hat{n}_t,$$

Using (2), $\hat{s}_t = \eta\hat{n}_t + \sigma\hat{c}_t$. Define x_t as output gap leads to:

$$\hat{s}_t = (\sigma + \eta)x_t.$$

Now consider $\hat{v}_t$:

$$\hat{v}_t = \ln[1 + J(R_t - 1)] - \ln[1 + J(R - 1)],$$

$$\hat{v}_t \approx J(R_t - 1) - J(R - 1),$$

$$\hat{v}_t \approx J(R_t - R),$$

$$\hat{v}_t \approx J\hat{R}_t.$$

Substituting this result in (26) yields:

$$\hat{\psi} = (\sigma + \eta)x_t + J\hat{R}$$

A.2 Results for corner solution under discretion

$$\pi = -r^n,$$

$$x = -\frac{(1-\beta+J\kappa)r^n}{\kappa(\eta+\sigma)},$$

$$R = 1,$$

$$\mu = -\beta\sigma r^n,$$

$$\delta = -\frac{r^n(-1+\beta+J\kappa)\lambda + \kappa\sigma(1-\beta)(\eta+\sigma)}{\kappa^2(\eta+\sigma)^2}.$$

Investigating Growth Performance of Sri Lanka

K. K. C. Sineth Kannangara[1]

Abstract

This study starts with an analysis of macroeconomic determinants on growth in the case of Sri Lanka, deploying the Autoregressive Distributed Lag (ARDL) approach using annual data from 1960 to 2018. Key findings of the study reveal that utilising the available policy spaces to create an investment conducive climate and to support exports is essential while revisiting the imports structure to understand the necessary potential improvements. Unexpectedly, total employment does not show a significant influence on the movement in real GDP, emphasising the challenging need for labour market reforms for enhancing workplace efficiency and proper labour management. Results show that the civil war arrested the revival of the economy and rejected the tourism-led growth hypothesis. Beyond the ARDL model, a Generalised Least Squares Panel Data model is employed, to analyse the impact of regional integration in the South Asian context on the growth of the Sri Lankan economy. Results of the Fixed Effects models prove that trade liberalisation drives the growth of panel economies and the existence of a non-linear positive relationship between export concentration and real per capita GDP growth. Accordingly, one could conclude that the growth of SAARC economies could flourish with trading amongst themselves, accompanied by free trade agreements.

Key Words: *Panel Data Model, ARDL Model, Economic Growth, Sri Lanka*

JEL classification: *C33, C39, F14, O47*

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1. Introduction

There is a consensus that economic growth increases the wealth of a country by alleviating poverty. According to pervasive literature which discusses different frameworks of economic development, growth of an economy could be coming from different pathways, such as physical capital accumulation (Solow, 1956, Swan, 1956, Kaldor, 1961), productivity improvements (Solow, 1962, Mankiw et al., 1992), improvements in human capital stock (Schultz, 1961, Barro, 1991, Becker et al., 1990), enhanced efficiency of financial markets (Levine et al., 1998) and improvements in external sector performance (Acemoglu, 2012, Grossman and Helpman, 1991). However, the pattern and speed of growth are inherently country specific.

Growth prospects of the Sri Lankan economy seemed promising and were well ahead of its Asian peers in the early post-independence era. At the time of independence in 1948, Sri Lanka was predominantly a small agrarian economy with Gross Domestic Product (GDP) of US dollars 953 million (current prices) and the share of agriculture was 62 per cent of GDP, while the services and industries sectors contributed 33 per cent and 5 per cent, respectively[1]. Since then, Sri Lanka pursued unique economic ideologies to reach a high and sustained development of the national economy. The government which was appointed in 1956, adopted a state-led inward looking approach along with the "welfare state model". However, the economy could not reach the anticipated performances through closed economic policies due to limitations of markets, lack of technical expertise, low productivity and increase in production costs, etc. (Menike, 2018). Later, growth prioritising inward looking policies were replaced by the outward looking policy package through economic liberalisation in 1977, that aimed at accelerating the economic growth and income generation by promoting exports and private sector investments, while opening avenues to reach external markets. Among other factors, this accelerated process of economic growth followed by privatisation policies introduced in the 1990s helped to transform the agriculture-based rural economy into a service-based modern economy, over time.

Remarkably, the Sri Lankan economy could not reap awaited outcomes of trade liberalisation mainly due to the rise of the so called "twin-political conflict" (Abeyratne et al., 2017; Abeyratne, 2004).[2] The economy started losing the momentum gathered over trade liberalisation a few years after opening its economy. The inevitable result was that Sri Lanka expended a long time span of almost 56 post independent years to pass through the US dollars 1000 per capita GDP (PGDP) level. Mainly, with the outbreak of the separatist struggle in the

[1] The services sector in the GDP constituted a share of 57.5 per cent by 2018, followed by the industrial sector (26.1 per cent of GDP), leaving a lesser share to the agricultural sector (7.0 per cent of GDP), which had held a dominant share in the early phases of post-independence.

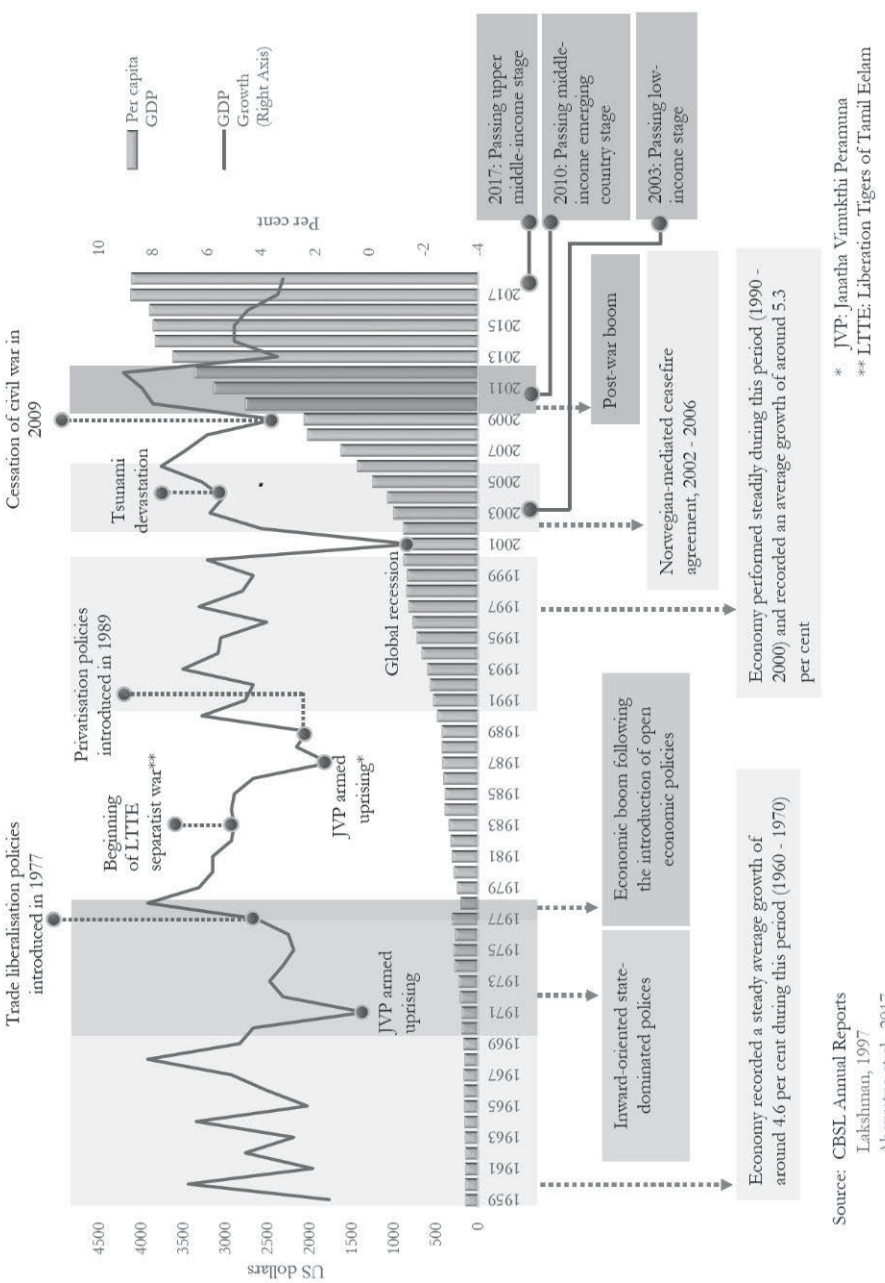
[2] "Twin-political conflict" - the Tamil separatist war in the North and the Sinhalese youth uprising in the South

early 1980s, successive governments were not able to enjoy the benefit of freedom to design long term macroeconomic policies to have sustained growth in the economy (Herath et al., 2014). Instead, they had to bear continued high military expenditure until the cessation of the separatist war with the Liberation Tigers of Tamil Eelam (LTTE) in 2009, which according to some researchers, caused a loss of both "blood and treasure" (Bandarage, 2008). After that, the economy started to gather its growth momentum, recording an average growth of 8.5 per cent during the 2010-2012 period. Explicitly, the economy upgraded with a numerous development in physical infrastructure during the post war era. Although it was not able to sustain such high germination for more than three years, the reduced risk and high return environment prevailed in the country during the conflict free period caused a high volume of foreign funds to flow into the economy while boosting new investments (Figure 1).

Noticeably, the country showed strong economic performances during some periods (Duma, 2007), despite overwhelming burdens stemming from the prolonged war. Concurrently, socio-economic development led by "welfare first" policies brought the country on par with developed and emerging market economies while paving the way for being an "aberration" in the sense of social development, (Lakshman, 1997). However, the economy is still highly vulnerable to the shocks emanating from economic imbalances; high twin debt and twin deficit levels, volatile exchange rate, frequent natural disasters, various policy and political swings all put together contribute to the sluggishness of the growth (Weerakoon et al., 2019; Dunham and Kelegama, 1997; Arunatilake et al., 2001).[3] At the same time, many critics agree that the Sri Lankan economy has many idle avenues to improve, although it is growing significantly below potential. These developments in the spheres of polity and economy question the effectiveness of macroeconomic policies and are also worrisome for policymakers. In this backdrop, this study aims to analyse the effect of some selected leading macroeconomic variables, including export, import, capital formation, and earnings from tourism and employment, on the growth of the Sri Lankan economy. It collates annual data from several reliable sources constituting a sufficiently long period of 1960-2018 and uses the Autoregressive Distributed Lag (ARDL) approach in the analysis. It also uses a mix of controls depicting changes in macroeconomic, socio-political (such as civil conflict) and institutional (such as relaxing trade policies) segments of the economy, as crucial factors determining the economic growth of Sri Lanka. Besides, the use of the ARDL framework, which, to the best of the knowledge of the author, is a new approach for analysing economic growth in Sri Lanka.

[3] Twin debt: domestic debt and foreign debt
Twin deficit: current account deficit and budget deficit

Figure 1: Evolution of Sri Lankan Economy



Source: CBSL Annual Reports
Lakshman, 1997
Abeyratne et al., 2017

Further, regional integration within the proximate parts of the South Asian region, is dramatically increasing over different dimensions. It has been the topic of many available pieces of literature, which identifies regional integration as the next step of globalisation through trade liberalisation or open economic concepts (Mattli, 1999; Schiff and Winters, 2003). Therefore, this paper introduces a Generalised Least Square Panel Data model to study the regional growth of selected South Asian economies which belong to the South Asian Association for Regional Corporation (SAARC), and this distinguishes this study from others on the economic growth of Sri Lanka.

Both econometric analyses of this study, ARDL and panel data model, highlight the importance of trade liberalisation policies on growth. Although total employment as a proxy for the labour force has supported the growth of the Sri Lankan economy, this lacks explanatory power. Notably, growth is negatively related to tourism earnings in the long run, but there is a positive impact on growth in the short run. Also, socio-political instability caused by the civil conflict provides evidence about the detrimental effects on growth, as expected. The findings of the fixed effect model for selected South Asian economies agree with the key findings of the ARDL model while gross capital formation and FDI support the per capita GDP growth of panel economies. Also, the results make evident the existence of a non-linear positive relationship between export concentration, measured by the Hirschman Herfindahl index and real per capita GDP growth of panel economies. Accordingly, the author wishes to emphasise the vital importance of having a broader long term plan for the integrated development of each sector, labour market reforms, diversified export base and deepened trade relationships with the regional economies, and for the high and sustained development of the Sri Lankan economy.

The remainder of this paper is structured as follows. Section 2 depicts a historical overview of Sri Lanka's growth trajectory since independence, along with a literature survey. Section 3 discusses the theoretical framework. The empirical analysis, including data and methodology, and a description of variables and data, are presented in Section 4. Section 5 contains the results and Section 6 concludes with a discussion on the policy implications.

2. Historical overview and literature survey

2.1 Pre-1977

While gaining independence in 1948, Sri Lanka was recognised as a comparatively better off economy compared to many of its Asian peers, in terms of performance indicators such as per capita GDP. However, looking back a few decades later, many countries that started at a lower level, have surpassed Sri Lanka in respect of economic performance emphasising the need for reviewing the domestic economic policies (Table 1).

By 1956, Sri Lanka was facing a demanding situation in managing foreign assets due to increase of unnecessary import bills along with the widened budget deficit, while the government had to survive with costly welfare facilities and soaring unemployment levels prevailing in the economy (Manike, 2018). Therefore, closed economic policies were proposed as appropriate and accordingly, "redistribution and poverty alleviation" were given the priority focus on the inward looking policies, while de-prioritising growth. Thus, various restrictions were imposed on imports, accompanied by extensive social welfare programmes, including food subsidies, retentive free education and free health care facilities, mainly aimed at improving the living conditions of the people (Abeyratne et al., 2017). As a result, the country performed well in

Table 1: Per capita gross domestic product (PGDP) of selected South Asian economies (as a percentage of US PGDP)

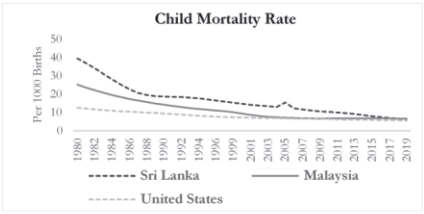
Country	PGDP			
	1950	1960	1970	1979
Malaysia	14.6	16.7	15.6	23.2
Sri Lanka	**11.4**	**10.2**	**9.4**	**9.4**
Philippines	10.3	11.4	11.7	13.3
Thailand	9.9	9.5	11.7	13.4
Pakistan	9.0	7.8	8.4	7.6
South Korea	7.6	8.2	11.8	24.8
India	7.1	7.5	6.5	5.7

Source: Athukorala and Jayasooriya, 1994, Table 3.3

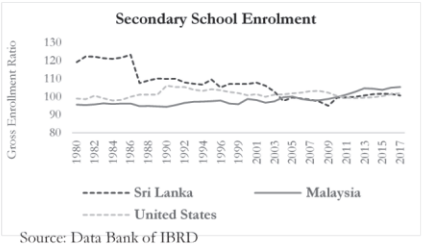
achieving a higher level of development as reflected by social development indices, on par with peer economies (Figure 2)[4]. However, implementation of such "welfare state" policies became a futile efforts due to high unemployment, low productivity, inadequate technical soundness, increased production costs along with high imported raw material costs, and limited access to external markets, so on (Manike, 2018). The market-oriented then government set their priorities for the continuation of the private sector dominated export policies inherited from the colonial administration, along with welfare programmes such as universal free education and health care facilities.

[4] IBRD: International Bank for Research and Development

Figure 2: Socio-economic Development of Sri Lanka

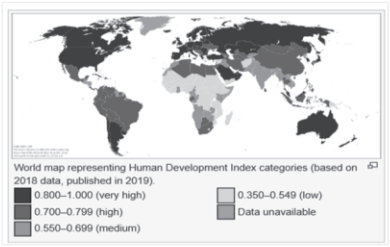


Source: Data Bank of IBRD



Source: Data Bank of IBRD

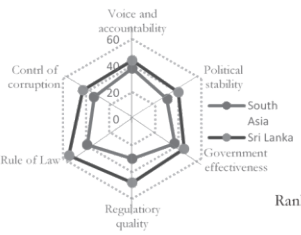
Human Development Index - 2018



Sri Lanka ranked 71 among 170 countries with 0.780 index value, included in high HDI category

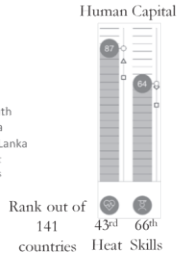
Source: United Nations Development Programme; Human Development Reports

Governance Indicators - 2018



Source: Worldwide Governance Indicators

Global Competitiveness Index - 2019

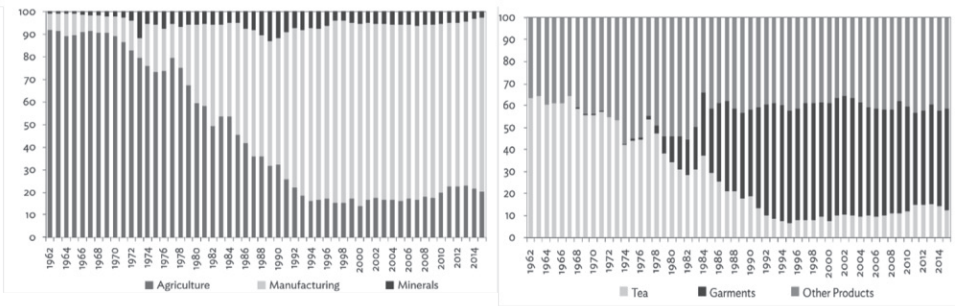


Source: World Economic Forum

2.2 Introduction of liberalisation policies in 1977

The gradual introduction of liberalisation policies prioritising economic growth paved the way for domestic investors to reach external markets. Policy reforms introduced in 1977 included reductions and simplifications of tariffs and taxes, which facilitated further expansion of trade in the country. It further helped strengthen its trade relations with European and far eastern nations through its strategic positioning in the east-west maritime trade route that runs back to the pre-colonial era (Athukorala and Jayasooriya, 1994). Thereby, it exerted an unprecedented influence on the growth of exports and increasing domestic consumption (Herath et al., 2014). As a result, the country's growth seemed to be producing promising results, reflected by the higher growth of the economy recorded in the latter part of the 1970s. Notably, the trade reforms caused a significant takeoff in terms of export performance in Sri Lanka (Abeyratne et al., 2017). As a result, the export composition leaned towards more technology based manufacturing industries from labour intensive industries. In contrast, primary export goods shifted from tea to garments benefitting from quickly attracted foreign investments and supported by the comparative advantage of the country with abundant labour (Figure 3). Moreover, Sri Lanka's trade relations with other economies were strengthened

Figure 3: Sri Lanka's Composition Exports (% of total exports)



Source: Abeyratne et al., 2017, Figure 1.6 and 1.7

through several trade agreements such as APTA (1975), GSTP (1989), ISFTA (1998) PSFTA(2005), SAFTA (2004) and SLSFTA (2018) and Siriwardhana (2000) discusses that Sri Lanka gained from the bilateral trade relationships with South Asian Partners.[5] There are many pieces of literature which discuss the positive externalities of trade openness through export promotion and import substitution including Lucas (1988), Barro (2001), Hausman et al. (2005), Giovanni and Levchenko (2009), whereas some other researchers discuss the detrimental effects of export and import with growth (Ulasan, 2012, Yanikkaya, 2003). However, we could expect that sectors with high expertise could grow faster. Workers in industries with higher comparative advantage, such as export oriented industries, could improve quickly due to enhanced proficiency in production, compared to import competing industries.

Unfortunately, Sri Lanka could not reap the anticipated benefits of the liberalisation policy package, due to several reasons. Firstly, social unrest, driven by the elevated level of unemployment and population growth arrested the revival of the economy. The educated unemployment went up during this period due to the low capacity of the labour market to provide white-collar jobs absorbing the increased level of educated youth produced by free education programmes (Dickens and Lang, 1991). Secondly, conflicts prevented successive governments from implementing long term development plans, instead they had to bear massive military financing (Athukorala and Jayasooriya, 2013). Thirdly, some literature attributes the underperformance of the liberalisation policy package to not accounting for the resulting adverse spillover effects on the multi-ethnic social fabric (Athukorala and

[5] SAFTA: South Asian Free Trade Agreement signed in 2004 with Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka
ISFTA: Free Trade Agreement signed between India and Sri Lanka in 1998
APTA: Asia Pacific Free Trade agreement includes, Bangladesh, China, India, South Korea, Sri Lanka and Laos signed in 1975
PSFTA: Pakistan – Sri Lanka Free Trade Agreement came in to being in 2005
GSTP: Agreement on Global System of Trade Preferences
SLSFTA: Sri Lanka –Singapore Free Trade Agreement signed in January 2018

Jayasooriya, 2015).[6] On the other hand, although the exports sector boomed significantly, the inadequate and less diversified export base is yet left as a critical challenge. Notably, the current account deficit widened as import expenditure outpaced export earnings due to the increase in oil imports and the import of non-productive goods such as personal vehicles while increasing the vulnerability of the economy to external shocks.[7]

Further, the early 25 years of the protracted separatist war (1983-2009) brought devastating effects in terms of the loss of human and physical resources which could otherwise have been invested in the building up of physical and social infrastructure (Bandarage, 2008). For example, the defense expenditure as a percentage of GDP is equivalent to 5.7 per cent in 1990 and escalated to 14 per cent of GDP in 2008, when the battle intensified.[8] Other than the direct socio-economic impacts, it caused significant indirect effects on the economy, leaving hardship on policymakers and people (Thambiah, 1986). Lindgren (2004) discusses the direct and indirect economic costs of an armed conflict under three dimensions, namely external relations, the national economy and households. Direct expenditures on external relations include foreign debts, and indirect damages on external relations comprise of capital flight, discouragement of new foreign investments, emigration of the skilled workforce and reduction of tourist arrivals. Destroyed infrastructure and farmland, underutilisation of existing productive capacity, increased military expenditure and costs on refugee care are direct costs on the national economy. The economy lost many production opportunities as a result of the destruction situation, uncertainty and missed education opportunities for combatants. It increased investments for the short term and high returns, instead of the long term while imposing the indirect costs on the national economy. In the case of households, direct prices include death, injuries and illness, and indirectly they face food scarcity and inflation costs.

[6] "The liberalisation reform package was implemented in a non-uniform and discriminatory manner; it favoured different regions, sectors, and particular segments of the population"(Athukorala and Jayasooriya, 2015).

[7] Sri Lanka Development update, IBRD, 2019

[8]

Defense expenditure as a share of GDP

CBSL Annual Report 1996	Per cent
Salaries and Wages	1.7
Other expenditure	4.0
CBSL Annual Report 2008	Per cent
Salaries and Wages	2.0
Other expenditure	12.0

Source: Annual Reports – Central Bank of Sri Lanka (CBSL)

2.3 Post conflict era: 2009 onwards

Cessation of the LTTE separatist war in 2009 marks the beginning of a new era in the Sri Lankan economy. During the post war period, the tradeoff between military expenses and development, along with enhanced investor confidence instigated as a result of favourable state policies and the political stability (Bastian, 2013), resulted in an upsurge in the investments in physical infrastructure.[9] Supportively, the findings of many researchers, including Hausmann (2005), Mankiw et al. (1992) and Bal et al. (2016) show that capital formation exerts a positive impact on economic growth. Thus, we could expect that such massive investments in capital formation should have supported the growth of the Sri Lankan economy.

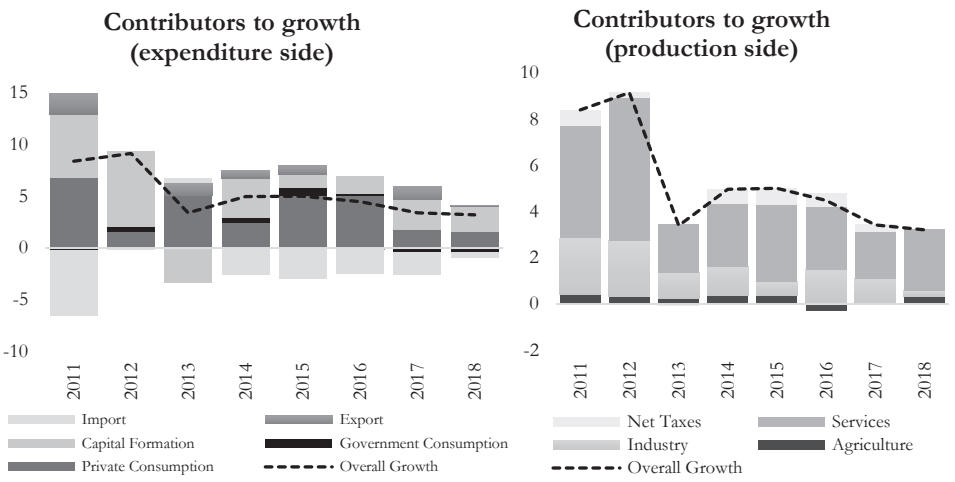
The economy seemed to be bouncing back while unleashing its potential and reached US dollars 3000 per capita GDP level within the first two years of the end of the conflict, although the developments in the recent past have brought down such optimistic expectations.[10] At the same time, some critics agree on the fact that the said infrastructure boom in Sri Lanka was a "debt-fueled" phenomenon and question its sustainability (Athukorala and Jayasooriya, 2015). However, expenditure based contribution to GDP growth shows that private consumption and investments represented by capital formation have contributed more towards the growth of the modern service economy, followed by exports (Figure 4). Over time, the economy has transformed in to a service based economy, gradually deviating from its traditional agriculture base. Given this situation, the economy is hopeful of regaining many missed opportunities, especially in the tourism industry.

[9] Sri Lanka performed as the most improved country in the South Asian region. In terms of infrastructure development, it records a value of 69.2, being the best country in the region, followed by India.

Source: World economic forum, 2019

[10] The International Monetary Fund (IMF) announced Sri Lanka as a middle-income emerging country in 2010 and it was graduated as an upper-middle-income country in 2018 with a GDP per capita of US dollars 4,102 (International Bank for Research and Development).

Figure 4



Source: Department of Census and Statistics, Sri Lanka

Tourism is been considered as one of the most promising sectors in the conflict-free environment. Successive governments have instigated diversified frontline policies targeting the development of the tourism industry and, especially the improved level of mobility across the country due to the safe and peaceful environment in the post war era which provided the much needed impetus to boost investments in tourism (Fernando, 2016).[11] For example, several massive tourism projects, naming few, the Kuchchaweli Beach Resort project and the Dedduwa Development Project were launched after 2010, and the Dedduwa Development Project is known as the biggest tourism project thus far initiated in Sri Lanka covering 1800 hectares. Such projects capitalise the inherited potential as well as left opportunities in the country to grow as one of the best tourist destinations in the world while supporting inclusive development (Fernando, 2017). Particularly the country as a UNESCO world heritage site with its renowned rich natural landscape, diverse ecosystems, and glorious cultural heritage, is enriched with a high potential to improve the tourism industry as the prime foreign exchange earner of the country (Buultjens et al., 2016).[12] Further, a case study conducted by Chandralal (2010) shows that tourism growth in Sri Lanka could improve the property values of Sri Lanka, which in turn could support the growth of the economy. However, recent updates display a

11

i. The ten-year master plan for tourism development, 1966 to 1977
ii. The "five hubs plus tourism" strategy, 2010
iii. Tourism Development Strategy, 2011-2016
iv. Sri Lanka Tourism Strategic Plan, 2017 – 2020

12 UNESCO - The United Nations Educational, Scientific and Cultural Organisation

sharp decline in tourist arrivals in the aftermath of the Easter Sunday incident, which indicates the vulnerability of the tourism sector on political stability and social security, while agreeing with the fact that peace is not only the sufficient factor in developing the tourism industry (Lokuhetti et al., 2013).

A parallel transformation could be observed in the labour market, along with the structural changes which underwent in the economy. Accordingly, the services sector absorbed a significantly higher share of employees while leaving a lesser share in the agriculture sector, which was comparably high during the time of independence. Yet, the provincial distribution of employments shows that a higher number of employees in states are engaging primarily in agriculture related jobs. In contrast, services-related white collar jobs have become popular among the employees in urban areas (Abeyratne et al., 2017) (Figure 5). Mainly, the universal free education policies have resulted in generating an educated labour force in the country becoming 92 per cent literal by 2018. However, enhancing the quality of labour appropriately empowering persons with necessary skills is required to improve the competitiveness of our exports in the global markets as well as to avoid the structural barriers along the path of graduating to the developed stage (Ganatlilaka et al., 2010).

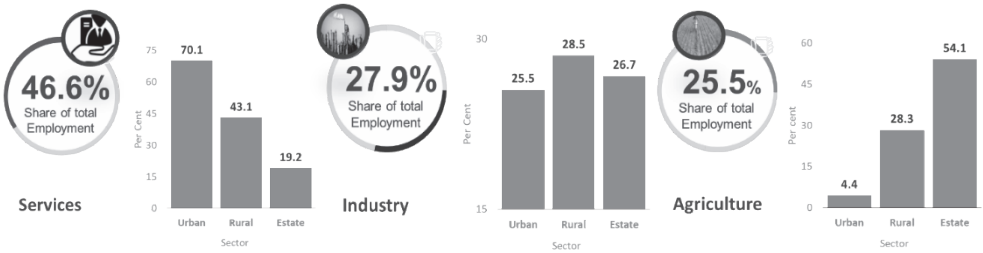
On the other hand, government led policies, those aimed at forming a government sector engineered economy, caused a drastic increase in the public sector employment in Sri Lanka. Many researchers discuss the low efficiency of the public sector which not only nurtured economic inefficiency (Athukorala, 1994) but also transformed the wealth towards the public sector and deprived the private sector opportunities through rent-seeking (Gelb et al., 1991). Further, female labour force participation and employability in Sri Lanka need improvements considering different avenues such as social and cultural factors, high unemployment among well educated women and familial expectations as discussed by Malhotra and DeGraff (1997).

2.4 Regional integration of SAARC economies - 1985

The South Asian Association for Regional Cooperation (SAARC) came into being in 1985, with a broader view of accelerating economic integration in South Asian economies through mutual collaboration and assistance (Rahman et al., 2012). Some scholars find South Asia to be the least integrated region in the world when integration is measured in terms of trade in goods, capital and ideas (Ahmed and Ghani, 2007). Some other literature shows that the developments in terms of institutional and economic cooperation of SAARC countries are very limited (Rajapakse and Arunatilake, 1997; Iqbal, 2006). It is identified that FDI and terms of trade are the drivers of deepening and widening reciprocal regional growth (Zaman et al., 2011, Ali, 2014). Although India, the largest economy in the region, leads the regional growth Ali (2014) emphasises that the lack of resources in the region impedes economic integration.

Further, Hesse (2009) studies export diversification and economic growth using a panel of 99 countries and highlights the importance of export diversification using the Hirschman Herfindahl (HH) index.[13]

Figure 5: Employment in major sectors in 2018

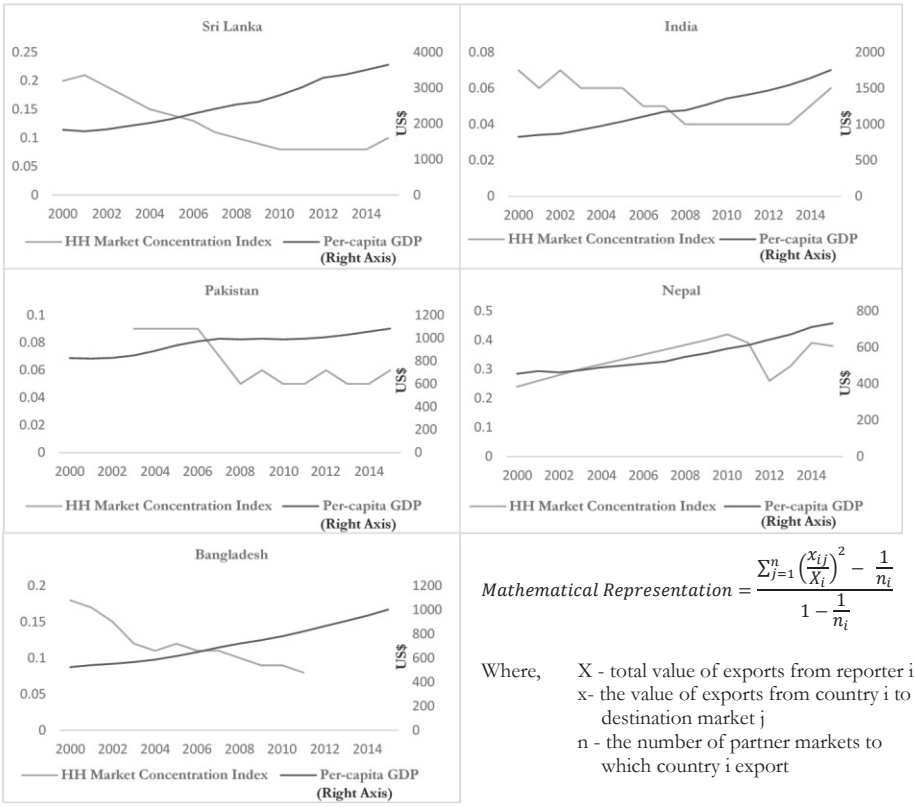


Source: Department of Census and Statistics, Sri Lanka

Figure 6 shows the behaviour of export concentration of selected South Asian economies, measured by the HH index and GDP per capita. Accordingly, Sri Lanka, India and Bangladesh show a clear inverse relationship between per capita GDP and the HH index, whereas Pakistan shows mixed performance. However, Nepal, being a country with more than 50 per cent trade relations only with India, does not show the expected pattern between export concentration and per capita GDP. Further, Ahmed and Ghani (2007) find that reduced trade barriers and trade reforms in the economies of the SAARC region need to be more competitive, stable, and adaptable. Further, FDI is an influential tool for accelerating economic growth of developing countries, as it creates channels to enhance the growth process of the beneficiary economy as well as the host economy (Barrel and Pain, 1997), not only through transferring technology but also by sharing technical know-how, creating employment, and improving the quality of human capital via exposure and skills development (Alfaro, 2003, Alfaro and Chauvin, 2016). Further, in the Sri Lankan context, Rajapakse and Arunatilake (1997) uses the gravity model to examine the impact of intra-SAARC trade and show that there is considerable

[13] "Hirschman Herfindahl index is a measure of the dispersion of trade value across an exporter's partners. A country with trade (export or import) that is concentrated in a very few markets will have an index value close to 1. Similarly, a country with a perfectly diversified trade portfolio will have an index close to zero", IBRD Interpretation. Link to manual: *http://wits.worldbank.org/WITS/doc/TradeOutcomes-UserManual.pdf*.

Figure 6: Dispersion of Trade and Per Capita GDP of Selected South Asian Economies



$$Mathematical\ Representation = \frac{\sum_{j=1}^{n}\left(\frac{x_{ij}}{X_i}\right)^2 - \frac{1}{n_i}}{1 - \frac{1}{n_i}}$$

Where, X - total value of exports from reporter i
x- the value of exports from country i to destination market j
n - the number of partner markets to which country i export

Source: TCdata360, International Bank for Research and Development (IBRD)

potential for further enhancing bilateral trade relations of Sri Lanka with other SAARC economies. Moreover, as shown in Figure 7, although inter regional trade share shows a highly volatile pattern, Sri Lanka's current trade relations with other countries in the SAARC region show an increasing tendency, in terms of both volume and share of total trade.

Figure 7: Sri Lanka's Trade with SAARC Countries

Source: CBSL annual report 2017, statistical appendix, Table 84 & 85

2.5 Other country studies

Barro (1991) examined the growth rate of real per capita GDP in a cross-section of 98 countries for the period 1960-1985 and found that a higher share of physical investment to GDP exists in countries with higher human capital. Barro (1996) further expanded Barro (1991) using a panel of 100 countries and showed that improvements in terms of trade boost growth. Barro (2001) established a positive relationship of international openness (ratio of exports plus imports to GDP) and terms of trade (the ratio of export prices to import prices) with the growth of GDP. Levine and Renelt (1992) studying 119 countries manifest the fact that average GDP growth rate is positive and robust to the share of trade in GDP and investment. Further, Hausman et al. (2005) study growth accelerations of 110 countries and shows that the terms of trade shock and financial liberalisation are statistically significant parameters. The study also makes it evident that social chaos, such as armed external or internal conflicts do not bring a significant effect on the likelihood of growth accelerations. Research even convinces FDI to be an obvious determinant of growth. Borensztein et al. (1998) use a panel of 69 developing countries for a twenty year period, and results show that FDI contributes more to the growth compared to domestic investment. On the contrary, Carkovic and Levine (2002) find in an analysis of 72 countries over the period 1960-1995 that there is no robust significant relationship of FDI on growth. Further, among other researchers, Alfaro (2003), Karimi and Yusop (2009), and Zhang (2001) using cross-country data suggest that there is an ambiguous effect of FDI on growth.

3. Theoretical Framework

3.1 A Brief introduction to growth theories

Solow Growth Model: Solow (1956) discusses the long run relationship between real income with the growth of capital stock, growth of labour force and exogenous technological advances.

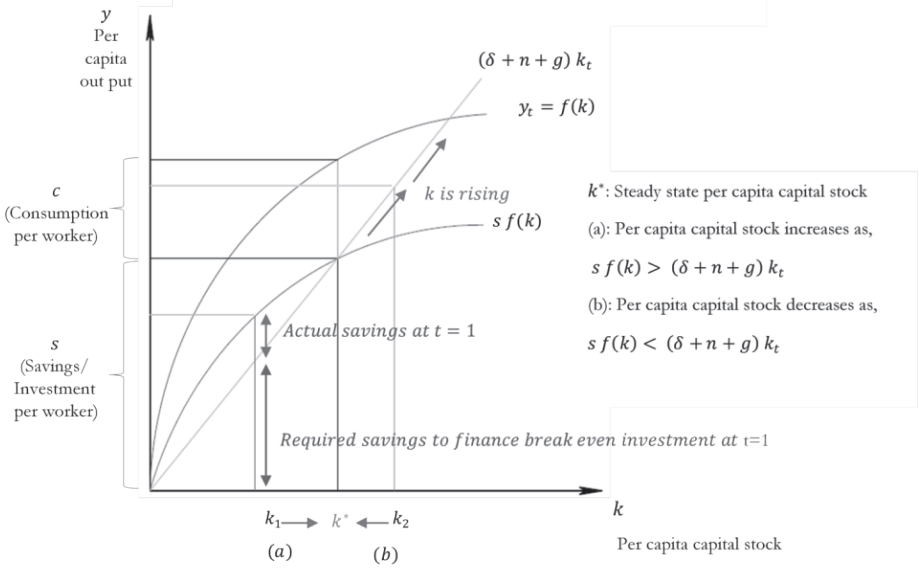
Consider the aggregate production function,

$$Y_t = A_t H_t^{\propto} K_t^{\beta} \quad (1)$$

Where Y_t is aggregate output, A_t denotes total factor productivity, K_t represents the physical capital stock, H_t is the aggregate human capital stock, and $\propto$ is the elasticity of final output to the human capital stock, which could be represented by, $\propto = \frac{\partial Y_t}{\partial H_t}.\frac{H_t}{Y_t}$ and β is the elasticity of final output to the physical capital stock, which could be represented by, $\beta = \frac{\partial Y_t}{\partial K_t}\frac{K_t}{Y_t}$ and $k_t = \frac{K_t}{H_t}$. The introduction of depreciation to the model shows that the steady-state level of per capita capital stock does not change, as the amount of investments equals the amount of depreciation, $\delta\kappa$. However, with the introduction of new technologies and new investments, capital is accumulated over time, and steady-state potential will grow with large capital stock and a high level of output. Change in capital stock could be represented by $\Delta\kappa$, where $\Delta k = k_t - k_{t-1}$. Thus, the investment, I in the period t is $(\delta k_{t-1} + \Delta k)$. Accordingly, $\Delta k = I_t - \delta k_t$, and at the steady state, investment equals the savings. Thus, $\Delta\kappa = s\, f(\kappa) - \delta\kappa_t$, where s is the $\Delta\kappa = s\, f(\kappa) - \delta\kappa_t$, where s is the marginal propensity to save. If we consider the technological change (g), and population growth (n), capital accumulation is represented by, $\Delta k = s\, f(k) - (\delta + n + g)\, k_t$, and graphically shown in Figure 8.[14]

[14] $\delta\, k_t$: Depreciation of capital
$n\, k_t$: Capital required for new workers
$g\, k_t$: Capital required to cover enhanced efficiency of workers

Figure 8: Solow Growth Model



3.2 An Introduction to Econometric Analysis

Selecting the model that suits a given data set is crucial in a time series analysis. If one does not select the appropriate methodology or use a wrong specification, the model will generate unrealistic estimates. Further, any econometric regression should at least capture interactions and integrations of variables over time as well as distinguish the long run (elasticity) and short run (slope) behaviour of the data. A simple illustration of the basic model selection criteria is shown in Figure 9.

3.2.1 ARDL model:

The ARDL model also referred to as the bounds cointegration technique, is formed using two main components: **the autoregressive element** for which the current value of the dependent variable is considered to be a function of past values itself, and **the element of distributed lag** in which current and past values of explanatory variables are considered to be a function of the dependent variable. ARDL is a standard least squares regression method which is widely used in the regression analysis due to many econometric advantages over other cointegration techniques such as the residual approach of Engle and Granger (1987) or the maximum likelihood approach introduced by Johansen and Julius (1990). Pesaran et al. (2001) show that the ARDL approach can be applied irrespective of the fact that we use (I_0), (I_1) or a mix of (I_0) and (I_1) variables. Further, after estimating the order of the ARDL, OLS estimation is prescribed for the regression, and the researcher could be free from identifying the order of

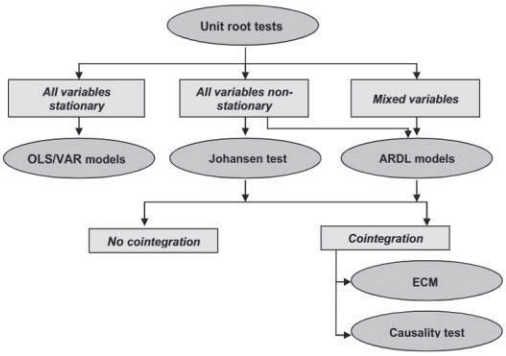
the underlying data, compared to general error correction estimation. Furthermore, this procedure can be used regardless of the sample size, very large or small, ensuring stable and consistent results in the long run. As explained by Enders (2004) and Wooldridge (2008), the estimated model best fits the actual data-generating process, only if the residuals satisfy the diagnostic tests. Accordingly, the presence of cointegration vectors for the existence of a long run relationship, satisfying the Bounds Test (F-test), and the absence of serial correlation and heteroscedasticity, confirm the fitness of the ARDL model. Akaike Information Criterion (AIC) should be satisfied for the model to fit statistically. Further, the model should be unbiased, i.e. normally distributed and stable, tested by recursive residual test for structural stability (CUSUM recursive estimates).

The general ARDL Model of order p and q, ARDL(p,q) takes the following regression form,

$$ARDL_{p,q} = Y_t = \mu + \sum_{k=1}^{p} A_k \, Y_{t-k} + \sum_{j=0}^{q} B_j \, X_{t-j} + \varepsilon_t \quad (5)$$

Accordingly, for an ARDL model, $Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + B_0 X_t + B_1 X_{t-1} + \cdots + B_q X_{t-q} + \varepsilon_t$; the short run effect (Static Effect) is $\frac{\partial Y_t}{\partial X_t} = B_0$ and the Long run Effect (Dynamic Effect) is, $\frac{\partial Y_T}{\partial X_t} = \frac{B_0 + B_1 + B_2 \ldots\ldots + B_q}{1 - A_1 - A_2 \ldots\ldots - A_p}$ and the Error Correction Model of the ARDL takes the form, $\Delta Y_t = B_0 \, \Delta X_t - \pi \, ECT_{t-1} + U_t$.[15]

Figure 9: Model Selection Criteria



Source: Shrestha and Bhatta (2018); Fig. 6

[15] Appendix A.1 provides a simple proof of static and dynamic effect coefficients of an ARDL Model.

3.2.1.1 Bounds Test: To overcome the problems of non-stationarity cointegration techniques are used in econometric analyses as a better way of distinguishing the existence of steady state equilibrium among variables. Further, if the variables in a regression are not cointegrating, the results are considered to be meaningless. Therefore, the Bounds test is used to determine the long-run relationship of a series (Pesaran et al., 2001), and the F-statistic value of the Bounds Test determines the existence of cointegration among variables. The null hypothesis of the test assumes, there is no co-integration among variables. When the F-value produces less than the lower critical bound values, we conclude that there is no co-integration, whereas, when F-statistic is higher than the upper critical bound value, the variables are said to be co-integrated. However, when F-statistics falls between the upper and lower bound values, the Bounds test produces inconclusive results.

3.2.1.2 AIC Criteria: Given a collection of models for a data set, the AIC criterion developed by Akaike (1981) is used to measure relatively how well a model fits statistically. Adding coefficients to a model lowers the sum of squares of residuals estimated in the model while reducing the degrees of freedom. Therefore, the optimal lag length of an ARDL model could be determined in terms of the results of AIC criterion. In E-views, the following formula is used to calculate the fitness of the model using AIC value.

$$AIC = -2\,ln\left(\frac{L}{T}\right) + 2\left(\frac{n}{T}\right)$$

Where,

n = Number of parameters estimated

T = Number of usable observations

L = Maximised value of the log of the likelihood function.

3.2.2 Panel data regression:

Regression which disregards the space and time dimensions of the pooled data and estimates the form $y_{it} = \propto + x_{it}\,\beta + u_{it}$, is a usual Ordinary Least Square (OLS) Regression, where, u_{it} is the disturbance term and $i = 1,2..,\ I\ and\ t = 1,2,..,\ T$ (Gujarati, 2004). If it is required to take special time-invariant individual features or unobserved heterogeneity of each cross sectional unit, we should let the intercept ($\mu_i;\ where\ u_{it} = \mu_i + v_{it}$) change for each unit. Then the model is known as a Fixed Effects (FE) Regression Model or Least-Squares Dummy Variable (LSDV) Regression Model. Same as above, the model could be controlled for time effects such as technological changes by introducing time dummies, and the disturbance term could be written as $u_{it} = \mu_i + \lambda_t + v_{it}$ (Gujarati, 2004). However, the FE Model suffers from an enormous loss of a degree of freedom, due to the introduction of a large number of fixed coefficients in the model. To overcome this problem, we can use the Random Effects

Regression (RE) Model or Error Components Model (ECM), which assumes μ_i as random (Baltagi, 2008) and is not correlated with the error term. Hence, if we do not include all relevant predictor variables in the analysis, the RE model can suffer from omitted variable bias. However, this model is most advantageous if it is required to include time variant characteristics. Accordingly, we can write the basic model equations as follows:

Panel OLS: $y_{it} = \alpha + x_{it}\beta + u_{it}$

FEM: $y_{it} = \alpha + x_{it}\beta + u_{it}$

Where; $u_{it} = \mu_i + v_{it}$; for cross-section fixed effects

$u_{it} = \mu_i + \lambda_t + v_{it;}$ for cross-section and period fixed effects

REM: $y_{it} = \alpha + x_{it}\beta_j + u_{it}$

Where; $u_{it} = \mu_{it} + v_{it}$

In a panel data analysis, the Hausman test is the econometric device which decides between the fixed effects (FE) model and the random-effects (RE) model (Greene, 2003), where the null hypothesis tests the preferred model being a random-effects model. Also, the Redundant Fixed Effects – Likelihood Ratio allows to check the significance of the cross-section effects, period effects and joint significance of effects in the restricted specification, using sums-of-squares, i.e. Chi-square test.

4. Data and methodology

4.1 The ARDL model for the growth of Sri Lanka

The ARDL model used to analyse the growth relationship of the Sri Lankan economy includes six independent variables: gross capital formation (CAPF), exports (EX), imports (IM), employment (EMP), tourist earnings (TE) and dummy variables, while real-GDP is being the dependent variable. Two dummy variables introduced in the model representing civil conflict (DWAR), and trade liberalisation (DTLIB) and, annual data from 1960 to 2018 are used in the analysis. The use of the ARDL approach for analysis of the growth of Sri Lanka is mainly justifiable since we have a mix of I_0 and I_1 variables and a sample of 59 observations. Further, many researchers, for example, Verma (2007), Gounder (2001) and Brida at al. (2016), have used the ARDL approach to determine growth relationships.

The ARDL model takes the following form:

$$(Real\_GDP)_{a,b,c,d,e,f} = \mu + \sum_{k=1}^{a} \propto_k Real\_GDP_{t-k} + \sum_{j=0}^{b} \beta_j CAPF_{t-j} + \sum_{l=0}^{c} \beta_l EX_{t-l} + \sum_{m=0}^{d} \beta_m IM_{t-m} + \sum_{n=0}^{e} \beta_n EMP_{t-n} + \sum_{p=0}^{f} \beta_p TE_{t-p} + DTLIB + DWAR + \varepsilon_t \quad (6)$$

Table 3 provides descriptive statistics and ADF test results and refer Table 4 for the details of the variables.

4.1.1 Checking the fitness of models[16]

Bounds test: The bounds test results show that the null hypothesis is rejected at 1% level I(1) Bound, 4.15 < F-statistic, 6.57. Accordingly, it is determined that there exists a long-run relationship among the variables at 1% level.

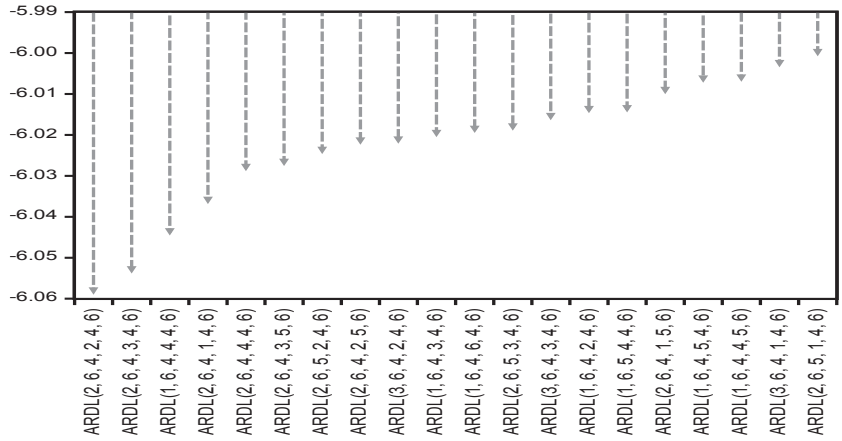
Table 2: Fitness of Models

Test Statistic	Value	Significance	I(0)	I(1)
F-statistic	**6.572313**	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	**3.06**	**4.15**

AIC criteria: The result of the AIC criteria given below shows that the sequence 2,6,4,2,4,6 is the proper lag length for real GDP, capital formation, exports, imports, employment and tourists earnings, respectively.

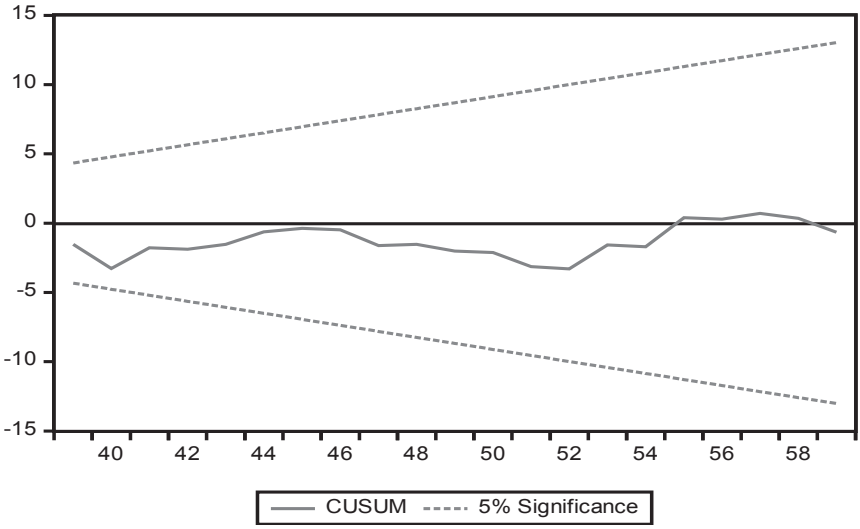
[16] Results of the Model 8 are used as the reference for this discussion.

Figure 10: Akaike Information Criteria (top 20 models)



Stability Diagnostics - Recursive estimates of CUSUM Test: The result of the CUSUM test shows that the model is stable at 5 per cent significance level.

Figure 11: Recursive estimates of CUSUM Test



4.2 Panel data model for the growth of South Asian economies

The panel data model used to analyse the integrated regional growth of selected five SAARC economies includes several regressor variables: gross capital formation (CAPF), imports (IM), exports (EX), foreign direct investment (FDI), HH index, time trend and a dummy variable representing trade liberalisation period of each country (DTLIB), with annual frequency for the period from 1975 to 2017 at constant 2010 prices.[17] Accordingly, there are 210 observations included in the panel, and per capita GDP (PGDP) is used as the predicted variable, paying due consideration to the relative comparison of the statistics of different countries.[18] Accordingly, the test equation takes the following form:

$$d\log(PGDP)_{it} = \propto + dlog(CAPF)_{it}\,\beta_1 + dlog(IM)_{it}\,\beta_2 + dlog(EX)_{it}\,\beta_3 + dlog(FDI)_{it}\,\beta_4 + (HH)_{it}\,\beta_5 + (HH)_{it}^{\,2}\,\beta_6 + (DTLIB)_{it}\,\beta_7 + t\,\beta_8 + u_{it};$$
$$where\ u_{it} = \mu_i + \lambda_t + v_{it} \quad (7)$$

The test results justify that the use of the two-way FE model fits the selected sample of data.

5. Empirical analysis and results

5.1 ARDL model

Table 5 summarises long run results of the ARDL analysis and short run results (Model 8) are given in Table 6. In general, long run impacts are higher compared to the short run impact of all variables used in the analysis. Results make it evident that gross capital formation exerts a robust positive impact on the real GDP growth of Sri Lanka, as expected and as manifest in many works of literature including Hausmann et al. (2005), Mankiw et al. (1992) and Bal et al. (2016). The results are statistically significantly different from zero at one per cent level. When the capital formation is increased by one per cent, real GDP will increase by 0.52 per cent in the long run. Increase in government spending for raising fixed capital could significantly

[17] All variables are as shares of GDP and in log difference form. Trade openness is defined as the sum of exports and imports as a share of GDP. A complete set of data of HH index is only available for 2000 - 2015 for selected five countries. Thus, models 4 and 5 include 80 observations in each model.

Out of the eight countries in SAARC, India, Pakistan, Sri Lanka, Bangladesh, and Nepal are the only countries included in the panel data model due to data constraints, which could otherwise lead to having a high number of null parameters in the regression matrix.

[18] Source: DataBank of the World Bank and TCdata360 of IBRD

boost economic activities over the near term mainly due to job creation, increase in consumption and developments in demand and supply conditions, as is also evident by the short run results of this study. Generally, an investment in the physical capital is associated with timing lags in terms of both implementation and value addition. Other than its direct impacts capital formation creates indirect impacts on growth through improved production capacity and technological improvements (Fisher, 1993).

Employment has excreted a detrimental effect on real GDP growth in the short run and becomes positive in the long run, though the results are not statistically significant. The result is in line with the discussions of Athukorala and Jayasooriya (1994) and Gelb et al. (1991) which direct us to surmise that employment in Sri Lanka is less utilised and if not, it would have boosted the growth of the economy than realised.

Table 3: Descriptive statistics and ADF test results

	Log (Real_GDP)	Log (Capital Formation)	Log (Exports)	Log (Imports)	Log (Employment)	Log (Tourist Earnings)
Mean	14.66	10.97	10.89	11.22	15.42	7.67
Median	14.60	10.91	10.93	11.29	15.43	7.92
Maximum	16.08	15.23	14.47	15.10	15.92	13.48
Minimum	13.39	6.86	7.39	7.49	14.95	1.66
Standard Deviation	0.81	2.73	2.50	2.63	0.32	3.57
Skewness	0.12	(0.03)	(0.14)	(0.15)	0.03	(0.36)
Kurtosis	1.84	1.73	1.54	1.61	1.65	1.99
Probability	0.18	0.14	0.07	0.08	0.11	0.15
ADF Unit Root Test	(I_1) -5.74***	(I_0) -3.53**	(I_1) -5.43***	(I_1) -6.15***	(I_0) -4.45***	(I_1) -4.60***
No. of Observations	59	59	59	59	59	59

Notes:

- Statistical significance at 1%, 5%, and 10% levels are indicated by ***, **, and *

Source: Author's Calculation

Table 4: Variables used in the ARDL model

Variable	Definition	Expected Relationship	Time Path	Literature Reference
Capital Formation	Total outlays on additions to the fixed assets of the economy and net changes in the level of inventories Source: Data Bank of IBRD	Positive		- Hausmann, 2005 - Fischer, 1993 - Mankiw, 1992
Exports	Value of all goods and other market services provided to the rest of the world Source: Data Bank of IBRD	Positive		- Ulasan, 2012 - Giovanni et al., 2009 - Hesse, 2009
Imports	Value of all goods and other market services received from the rest of the world Source: Data Bank of IBRD	Positive		- De Silva et al., 2013 - Yanikkaya, 2003
Tourist Earnings	Total earnings from tourism Source: Central Bank of Sri Lanka	Positive		- Buultjens et al. 2016 - Fernando, 2017
Employment	Total employed population Source: Central Bank of Sri Lanka	Positive		- Harris et al., 1969 - Abeyratne et al., 2017
DTLIB	0 → 1961 to 1976 1 → 1977 to 2017	Positive		- Herath, 2014 - Siriwardhana, 2000
DWAR	0 → 1961 to 1982 1 → 1983 to 2009 0 → 2010 to 2018	Negative		- Athukorala et al., 2015 - Ganegodage, et al., 2014 - Bandarage, 2008

Table 5: Long run results of selected ARDL models

Model	(8)	(9)	(10)
Capital Formation	0.5242***	0.4417***	0 .3109***
	[0.0490]	[0.1152]	[0.1148]
Exports	0.2494***	-0.0039	-0.3022
	[0.0970]	[0.2549]	[0.2517]
Imports	-0.4465***	-0.0548	0.4339
	[0.1367]	[0.3906]	[0.3928]
Employment	0.1548	0.1747	---
	[0.1457]	[0.2252]	
Tourist Earnings	-0.0411	-0.0843*	-0.1052**
	[0.0265]	[0.0454]	[0.0522]
R^2	0.9054	0.9072	0.8832
D.W. Stat	2.37	2.89	2.32
Bound test Statistic	6.57	6.42	6.62

Notes:

- Estimated by ARDL, all models satisfy coefficient diagnostic tests (serial correlation, heteroskedasticity and normality), stability diagnostics (recursive estimates, CUSUM test) and the Bounds test show the existence of long run relationship.
- Numbers in parentheses are standard errors
- Statistical significance at 1%, 5%, and 10% levels are indicated by ***, **, and *
- The dependent variable is log (real GDP), Capital Formation is log of gross capital formation. Exports, Imports and Tourists Earnings represent the log of total export, import and earnings from tourism, respectively. Employment is the total number of people employed in each year.

Source: Author's Calculation

Further, it is essential to mention that the country has a proper labour force database only after 1996.[19] Employment data used in this analysis is spliced together from several sources, including the annual reports of the Central Bank of Sri Lanka, the Employees' Provident Fund and labour force survey data. The sum of government and private sector employment is used as a proxy to capture the actual employment levels of the country before 1996. However, employment data from 1960 to 1996 presumably have a fundamental limitation of the exclusion of a relatively high self-employment sector, which mainly comprised own-account workers and unpaid family workers.

Although results show that earnings from tourism exert a weak but statistically significant impact on growth in the short run, results containing the long run impact of tourism on growth

[19] Labour Force Survey of Department of Census and Statistics, Sri Lanka; sample survey conducted once in two to three years

are unsatisfactory as opposed to Srinivasan et al. (2012) and Jayathilake (2013) suggest. When the effect of war is removed from the regression (Model 9), the negative impact becomes weaker.[20] Supportively Suresh and Senthilnathan (2014) show that growth and tourism earnings preserve a uni-directional causal relationship, from growth to tourism, not vise versa. The finding is justifiable since tourism has re-flourished after the war, and the current level of development in tourism could have depended on the level of GDP achieved thus far. However, the weaker performance of the sector in the aftermath of the Easter Sunday incident, and during unstable political situations, prove that stability and growth of the industry are highly vulnerable to the external and domestic shocks.

This study finds a significant positive impact from trade liberalisation and real GDP growth of the Sri Lankan economy. Results agree with the findings of Herath (2014) and Athukorala and Jayasooriya (1994). Further, imports negatively and exports positively drive the GDP growth in the long run, whereas both imports and exports show a detrimental impact on growth, in the short run. Findings of Abhayaratne (1996), and Shirazi and Manap (2005) agree with the findings in the short run. The long run negative impact of imports on economic growth could be coming in several ways. Consumer goods imports and import of intermediate goods such as petroleum, industrial materials, etc., hold a larger share of massive import bills, whereas non-productive goods import has increased over time while adding pressure to the current account deficit. Also, the less stable exchange rate has also contributed negatively to the import performance.

The negative impact of civil war on growth is a distinct finding, and other empirical and pragmatic evidence establishes the fact that the war arrested the revival of the economy, which otherwise would have been realised (Bandarage, 2008). For instance, the growth of agriculture, tourism and FDI were severely affected by the war. The error correction term provides a measure for the speed of adjustment to reestablish the dynamic model. The negative and significant results at one per cent level confirm that a long run equilibrium exists, and any deviation from the long run growth due to a shock could adjust at a speed of 48 per cent in the short run (Model 8).

[20] In both models 8 and 9, the short run impact of tourist earnings is positive but statistically not significant.

Table 6: Short run results of the ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG (REAL_GDP (-1))	0.196247	0.093081	2.108354	0.0472
D(LCPF)	0.179399	0.017506	10.24806	0.0000
D(LEX)	-0.023972	0.023468	-1.021489	0.3186
D(LIM)	-0.086588	0.023500	-3.684582	0.0014
D(LEMP)	-0.041920	0.033181	-1.263358	0.2203
D(LTE)	0.000542	0.009837	0.055109	0.9566
DTLIB	0.032993	0.005610	5.880893	0.0000
DWAR	-0.007682	0.005741	-1.338015	0.1952
Cointegration Eq (-1)	-0.476936	0.062013	-7.690957	0.0000

Notes:

- Results of the Model 8 is presented in this table.
- DWAR is the dummy to represent the war period and DTLIB is a dummy to represent trade liberalisation.

Source: Authors Calculations

5.2 Fixed effects model

Table 7 summarises the results of the panel data analysis. Notably, the results of the panel data model for the Sri Lankan economy is broadly in line with the results of the ARDL models. Results make it evident that capital accumulation, proxied by gross fixed capital formation, mainly supports the real per capita GDP growth of the region. Results are robust and statistically significantly different from zero at one per cent level in each mix of variables. The time trend shows a highly significant positive impact on per capita GDP growth, implying that there is a significant impact coming from time varying unobservable factors, such as technological progress on real per capita GDP growth of the South Asian economies. Imports show an unexpected adverse effect on real per capita GDP growth, agreeing with the results of the ARDL model.

Table 7: Results of panel data models for South Asian economies

Model	(1)	(2)	(4)	(5)
Capital Formation	0.0412** (0.0203)	0.0521*** (0.0181)	0.1596*** (0.0258)	0.1486*** (0.0282)
Imports	-0.0023 (0.0181)		-0.0267 (0.2548)	-0.0282 (0.0278)
Exports	0.0134 (0.0154)		0.0301* (0.0239)	0.0285 (0.0262)
FDI	0.5622 (0.4310)	0.4000 (0.3843)	0.6607 (0.3553)	0.6458* (0.3886)
Trade Openness		-0.0177 (0.0172)		
Trade Liberalisation		0.0131*** (0.0034)		
HH Index			-0.0275 (0.0444)	-0.2848** (0.1082)
HH Index ²				0.4436*** (0.2214)
Time trend			0.0015*** (0.0003)	
C	0.0290*** (0.0015)	0.0198*** (0.0029)	-2.9372*** (0.7043)	0.0617*** (0.0094)
Period	1975-2017	1975-2017	2000-2015	2000-2015
Observations	210	210	80	80
Model	FE Model	FE Model	FE Model	FE Model

Notes:

- Statistical significance at 1%, 5%, and 10% levels are indicated by ***, **, and *

Source: Author's Calculation

In contrast, exports show a positive relationship with the growth of per capita GDP, which is statistically significant at ten per cent significance level. Literature provides many examples supporting the above result, and Rashid et al. (2012) also confirm the same for India, Sri Lanka and Pakistan. As a robustness check, Model 2 uses trade openness in place of the export and import variables. Results highlight the dominant-negative impact of imports. Further, trade liberalisation shows a significant positive relationship with the growth of the selected South Asian economies. In the third model, the HH index is used as a proxy for the export concentration, which shows a detrimental relationship with real per capita GDP growth, and also agrees with the findings of Hesse (2009). The outcome is robust when non linearity of the HH-index and the time trend variable are included in the analysis. Notably, the results evident that there is a non linear relationship with export concentration and real per capita GDP growth of the selected countries. The findings of Rajapakshe and Arunatilaka (1997), suggest that the growth of SAARC economies could merely be supported by trading amongst themselves and show that domestic matters need to be resolved to attract FDIs. Supportively, our results show that there is a positive relationship between FDI and growth of the region, as initially expected, although it has low explanatory power. Further, cross-section fixed effects are higher for Sri Lanka, followed by Nepal, indicating a higher sensitivity of these countries to the movements of macroeconomic variables.[21]

6. Conclusion

Since independence, Sri Lanka has endeavoured to achieve a high and sustained economic growth through diverse policy options. The growth performance of Sri Lanka has been modest on average, throughout the period under review. Invariably it is vital to pay attention to the inside-the-frontier determinants of growth and identifying the idle avenues to improve. In this context, this paper aims to empirically determine the effects of selected key macroeconomic variables on the growth of the Sri Lankan economy and to study the impact of the regional integration on the growth of the Sri Lankan economy, being a member of SAARC.

This study confirms that among other variables, gross capital formation and exports are the main contributors to the growth of the Sri Lankan economy, whereas imports and employment show detrimental impacts. Based on the results of this study, the author wishes

[21]

Country	Cross-section FE
Bangaladesh	0.003432
India	-0.001880
Nepal	0.010562
Pakistan	-0.025422
Sri Lanka	0.013308

to provide the following policy recommendations. Firstly, the import structure needs to be revisited to understand the necessary reforms while assessing potential improvements. Sri Lanka has many comparative advantages compared to other trading partners, and if effectively utilised the country would reap more benefits. Also, the country should find ways to diversify its export structure, to ensure that exports have higher value addition to the economy, as it would further promote economic growth. Sri Lanka needs proper diversification and promotion policies supporting export oriented industries and import substitution, and it emphasises the need for vertical and horizontal trade diversification (export basket and destinations) by moving away from primary products to high value added products. Also, policy reforms are needed to improve the competitiveness of our products in international markets, and to facilitate the small scale investors to reach global value chains.

Secondly, it is observed that there is no significant impact of employment on GDP growth. Sri Lanka is in a challenging situation in terms of labour productivity, and more specifically, the morale of employees to contribute effectively in their jobs needs to get a boost. Mismatches in supply and demand for labour hinders the expansion of industries, and economic development, whereas scarcity or shortages of labour seem to be structural impediments to growth. Further, labour market reforms are necessary for enhancing the flexibility in the management of labour and for increasing female labour force participation. Furthermore, the country needs to take appropriate policy initiatives to grow the knowledge base of the labour force, encouraging higher education, controlling educated unemployment, providing necessary skills development training for employees and dealing with out-migration of skilled labour. Particularly, Sri Lanka needs to make crucial policy measures to address the mismatch between the skills earned by graduates at the university level and skill demands of the markets to provide a steady and reliable supply to the market while supporting sustainable economic growth.

Thirdly, it should be emphasised that maintaining political and social stability in the country is essential, especially for enhancing the international competitiveness of tourism, as well as to attract foreign investments to the country. Notably, adverse effects on small scale stakeholders, due to skewed distribution of the industry towards larger scalers, should be studied and appropriate policy measures must be taken for the balanced growth of the industry. However, the performance of the tourism industry must be studied comprehensively, including sectoral distributions and the impact of globalisation on the growth of tourism, which are not covered under the purview of the current study.

Fourthly, based on the results of the analyse of South Asian economies, it is interesting to note that Sri Lanka moderately follows the growth pattern of the region, being a small open economy in the region. As the evidence is strong that there is a non linear positive relationship between export concentration and the growth of the selected South Asian economies, the need for having proper policies for export diversification is confirmed. Also, the importance

of taking necessary efforts further to deepen the trade relationships with the regional economies is emphasised, based on the results of both ARDL and the panel data model, which would otherwise drive the future growth thrust.

Finally, the author highlights the need for a broader long term plan for the sustainable development of each sector, while paying due attention to the interconnectedness of the industries. Many works of literature point out the fact that inconsistent macroeconomic policies hinder the economic growth of Sri Lanka. Thus, the need for immediate structural reforms to support trade and investments utilising the available policy spaces is emphasised as a policy outcome of this study. Further, misallocations in productive resources need to be addressed while minimising uneven resource distribution, combined with stringent regulatory measures for maintaining the quality of production and efficiency in fund allocation considering economic costs and benefits. On the other hand, integrated and long term strategies should be in place for supporting infrastructure developments to facilitate medium to the long run growth momentum of the economy. Also, in impeding an adverse investment climate in war-affected areas, structural reforms are necessary for inclusive growth of the economy, while mobilising labour abundant potential resources effectively. However, the increasing vulnerability of the country due to widening current account deficit, exchange rate volatility and increasing debt levels, disappoint investments, thus growth. The author further highlights the need for second-generation policy reforms in the country, such as doing business ranking and improving institutional quality, knowledge and infrastructure to attain higher regional growth.

The author also wishes to highlight the impact of omitted variable bias and measurement errors on the bias in the regression results. Further, recognising what drives the progressive change of the production structure should be one of the mainstream components of growth studies, as inside-the-frontier development is undoubtedly not enough for high and sustained growth of an economy. Therefore, as an extension of this study, an analysis on technological progress and total factor productivity growth of the economy could be carried out, in order to identify the structural factors that drive the growth thrust of the Sri Lankan economy. Further, with the purpose of overcoming some endogeneity issues inherent to the fixed-effect estimates of the panel data model, this study could be extended with a Dynamic Panel or Generalised Method of Moments (GMM) to analyse the growth of south Asian economies. Although many critics level their allegations against various economic and social factors being root causes of failure for reaching the expected level of growth, the author is of the view that negative contributors to inside-the-frontier growth need to be well identified and thought out, before making recommendations for policy initiatives to stimulate the future thrust of growth of the economy.

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Appendices

A.1 Short run (static effect) and long run (dynamic effect) relationships of an ARDL model

$$Y_t = A_0 + A_1 Y_{t-1} + B_0 X_t + B_1 X_{t-1} + U_t$$

Short run effect: $\frac{\partial Y_t}{\partial X_t} = B_0$

Long run Effect:

$$\frac{\partial Y_t}{\partial X_t} = B_0$$

$$\frac{\partial Y_{t+1}}{\partial X_t} = A_1 \frac{\partial Y_t}{\partial X_t} + B_1 = A_1 B_0 + B_1$$

$$\frac{\partial Y_{t+2}}{\partial X_t} = A_1 \frac{\partial Y_{t+1}}{\partial X_t} = A_1 (A_1 B_0 + B_1)$$

$$\frac{\partial Y_{t+3}}{\partial X_t} = A_1 \frac{\partial Y_{t+2}}{\partial X_t} = {A_1}^2 (A_1 B_0 + B_1)$$

$$\frac{\partial Y_{t+1+\infty}}{\partial X_t} = A_1 \frac{\partial Y_{t+\infty}}{\partial X_t} = {A_1}^{\infty} (A_1 B_0 + B_1)$$

Long run slope is the sum of all derivatives.

Slope (S_1)= $B_0 + [A_1 B_0 + B_1] + [A_1 (A_1 B_0 + B_1)] + \left[{A_1}^2 (A_1 B_0 + B_1)\right] + [{A_1}^{\infty} (A_1 B_0 + B_1)]$ ---(1)

$S_1 \, x \, A_1 = \{[A_1 B_0 + B_1] + [A_1 (A_1 B_0 + B_1)] + \left[{A_1}^2 (A_1 B_0 + B_1)\right] + [{A_1}^{\infty} (A_1 B_0 + B_1)]\} \, x \, A_1$ ---(2)

(1)–(2); $S_1 - S_1 A_1 = B_0 + B_0 \{(A_1 + {A_1}^2 + {A_1}^3 \ldots + {A_1}^{\infty}) - (A_1 + {A_1}^2 + {A_1}^3 \ldots + {A_1}^{\infty})\} + B_1 + B_1 \{(A_1 + {A_1}^2 + {A_1}^3 \ldots + {A_1}^{\infty}) - (A_1 + {A_1}^2 + {A_1}^3 \ldots + {A_1}^{\infty})\}$

$S_1(1-A_1) = B_0 + B_1$ and $S_1 = \frac{B_0 + B_1}{1 - A_1}$

Long run effect: $\frac{\partial Y_T}{\partial X_t} = \frac{B_0 + B_1 + B_2 \ldots\ldots\ldots + B_q}{1 - A_1 - A_2 \ldots\ldots\ldots - A_p}$

Error correction Model

$$Y_t - Y_{t-1} = A_0 + A_1 Y_{t-1} - Y_{t-1} + B_0 X_t - B_0 X_{t-1} + B_0 X_{t-1} + B_1 X_{t-1} + U_t$$

$$\Delta Y_t = A_0 - (1 - A_1) Y_{t-1} + B_0 \Delta X_t + (B_0 + B_1) X_{t-1} + U_t$$

$$\Delta Y_t = B_0 \Delta X_t - (1 - A_1) [Y_{t-1} - \frac{A_0}{1 - A_1} - \frac{(B_0 + B_1)}{(1 - A_1)} X_{t-1}] + U_t$$

$$\Delta Y_t = B_0 \Delta X_t - \pi [Y_{t-1} - \alpha - \beta X_{t-1}] + U_t$$

$$\Delta Y_t = B_0 \Delta X_t - \pi ECT_{t-1} + U_t$$

The Impact of Asset Quality on Profitability: A Panel Data Analysis of Domestic Commercial Banks in Sri Lanka

P. D. M. Sanathanee[1]

Abstract

This research attempts to determine the effects of asset quality on the banking profitability of commercial banks in Sri Lanka. This study is based on secondary data for the period 2008 to 2016, which are obtained from annual reports published by 9 commercial banks in Sri Lanka. The analysis based on panel fixed effect regression indicates that asset quality factors had a negative impact on the bank's profitability at a statistically insignificant level. This was mainly because asset quality does not solely determine the profitability of banks. Other factors such as capital adequacy, management efficiency, earnings performance and liquidity may also contribute to profitability. Based on the findings, this study recommends that improved investment assets levels and the low rate of non-performing assets needs to be realized through credit risk identification, measurement, monitoring and controlling, in order to achieve high asset quality levels. Accordingly, this study recommends that banks improve credit policy by obtaining collateral and adhering to strong credit risk assessment indicators by following post sanction risk monitoring mechanism.

Keywords: *Licensed Commercial Banks, Licensed Specialised Banks, Non-Performing Loans, Gross Domestic Product*

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1. Introduction

Banks engage in financial intermediation by efficiently mobilizing public funds and disbursing to different sets of economic agents in the forms of loans and advances. This intermediation role of banks supports to carry their financial and economic activities effectively. Hence, a bank's stability in a developing economy is noteworthy as any distress could affect the development plan of the public sector as well as profit and growth motives of private sector (Rajaraman & vasishtha, 2002).

According to Ombaba (2013), the stability of banking is a pre-requisite for economic development and resilience against financial crisis. Further, like any other business, the success of a banking business is mainly assessed based on financial performance, profitability and the quality of assets it possesses.

Assets quality refers to loan quality which associates low default risk. Nagle (1991) states that the problem of assets quality may become the future time bomb for banks. This was proved by Khalid (2012) in an empirical study based on Indian private banks. Yin (1999) referred that the deterioration of assets quality from the ignorance of loan quality by banks is one of the main causes behind the Asian Finance crisis in the early 1990s. Adhikary (2006) mentioned that lower assets quality/ non-performing loans (NPAs) reaching substantial amount may lead to bankruptcies and economic slowdowns as evidenced by the 2008 global crisis.

Considering the importance of managing the quality of assets in banks, "The Standards for Safety and Soundness" were brought in to force by the United States Federal Reserve Board in 1995, stipulating regular reporting obligation on assets quality for Board of Directors of banks in order to evaluate risk on the deformation of assets quality and to form assets quality supervision mechanism by banks to define problems that may arise on assets quality (Eze & Ogbulu, 2016). Further, 7 of the 25 fundamental principles determined by the Basel Committee on Banking Supervision (BCBS) for effective supervision of the banking system are related to assets quality of banks and loan risk management, thereby indicating that assets quality becomes an important aspect of supervision authorities.

Due to the above aspects, it is apparent that better asset quality fosters higher profitability and reduces the cost of failure. From an economic perspective, bad quality of assets leads banks to bankruptcy, damaging the smooth functioning of the economy. This has a contagious effect when it comes to financial assets, intermediary process and financial markets due to inter-linkages.

This research will assess the nature and the level of the inter-relationships between the asset quality of banks and the motive of profitability.

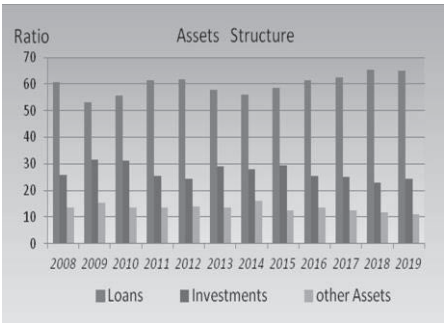
Accordingly, this study focuses on the impact of asset quality factors on the profitability of commercial banks in Sri Lanka and contributes to growing literature on bank asset quality management while suggesting measures for the policy development process.

Overview of the Banking Industry in Sri Lanka

The banking sector in Sri Lanka comprises of 26 Licensed Commercial Banks (LCBs) and 6 Licensed Specialised Banks (LSBs). Both LCBs and LSBs dominate the financial market by holding 62.1% of the total assets of the financial system out of which LCBs are the major category by holding 54.3%. Further, the importance of LCBs is significant when considering the magnitude of services they provide to the economy. There are 6 large domestic banks which are systematically important, representing a market share of 74% in terms of LCBs sector's assets out of the 26 LCBs.

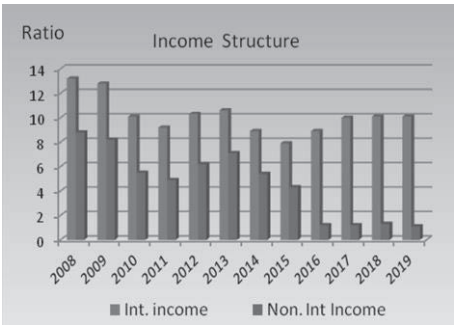
According to the Central Bank of Sri Lanka's Annual Report 2019, the asset portfolio of the banking sector was reported at Rs. 12.5 trillion by end of 2019 and loan portfolio (65%) represented the major component amounting to Rs. 8.1 trillion (Figure 1). Therefore, a bank's core business is built on loans that are disbursed to different segments in the economy. Hence, it is observed that the loan portfolio of banks is a significant component in the earning structure of banks which mainly accelerate the profit of banks (Figure 2).

Figure 1: Asset structure of Banks



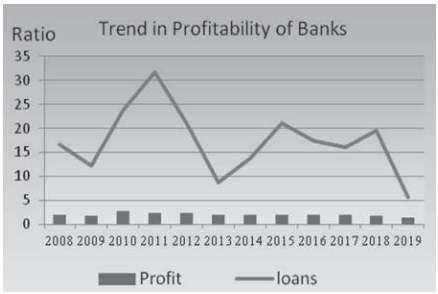
Source: Industry data (CEOs' presentation 2019Q4)

Figure 2: Income structure of Banks



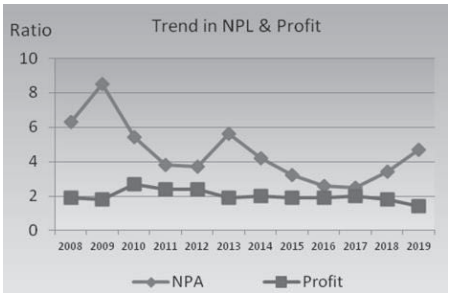
Source: Industry data (CEOs' presentation 2019Q4)

Figure 3: Trend in profitability and loans



Source: Industry data (CEOs' presentation 2019Q4)

Figure 4: Trend in NPAs and profitability



Source: Industry data (CEOs' presentation 2019Q4)

However, as depicted in Figure 3, even though the loan portfolio of banks mainly accelerates its profits, simultaneous change in profit (profit after tax) had not taken place over the period compared to the change reported in the loan portfolio. Further, an increase in bank profitability shown in Figure 4 is comparatively low when compared with the decrease reported in NPAs.

Significance of the Study

The findings of this study will enable bank managers to formulate strategies in order to enhance better management of their loans/assets portfolio in line with their investment and growth strategies and maximization of wealth goals.

From the perspective of regulators, this study will be useful in policymaking relating to the commercial banks' asset quality management which will result in further protecting of depositors' funds while enhancing the bank's financial performance and economic stability.

Further, this research will contribute to the existing finance related literature and further studies in the field of credit and finance.

2. Literature Review

Bank asset quality is a significant factor in banking research as high NPAs leads banks to bankruptcy. However, asset quality and bank efficiency are non-related because operating personnel are not normally involved in the selection and supervision of borrowers. Banks on

the edge of bankruptcy appear to have a high NPA ratio as well as low cost efficiency. Some studies show that the level of liquidated banks is high due to inefficient credit risk management Khalid (2012), Michael et al (2006), Ombaba (2013).

Streeter (2000) reports that asset quality management was considered one of the major management problems in banks in 2001 based on the self-administrated questionnaires served to the members of American Bankers Association Board which consists of one third of bank officials from all US Banks; the result of the above survey sufficiently proves that asset quality management is a common issue for bankers in practice. Similarly, G Miller (CEO of America Corp.) considered asset quality to be the second most important management issue and formed a task force specifically to handle rising bad assets.

De Yong (1997) observes that a bank's ranking is significantly affected by asset quality. Bank asset quality is always an important element for the evaluations of bank rating and management. Marshall (1999) also found that one of the main features the best community banks hold is good quality assets. Given that bad quality assets can prompt to downgrade a bank's rating, it becomes more difficult to earn depositors' trust, and such banks can therefore only attract deposits by offering a higher deposit rate.

According to Achou and Tenguh (2008), NPAs have an inverse relationship with bank profits. Hence, they suggest prudential credit risk management and safeguarding the assets of banks to protect investor's interest.

Kosmidou (2008) applied a linear regression model on 23 Greek commercial banks for the period of 1990 to 2002, using Return on Assets (ROA) and the ratio of loan loss reserve to gross loans to proxy profitability and asset quality respectively. The results showed a negative significant impact of asset quality to bank profitability. This was in line with the theory that increased exposure to credit risk is normally associated with decreased firm profitability.

Rajaraman, Bhaumik and Bhatia (1999) have explained the variations in NPAs across Indian banks through differences in operating efficiency, solvency and regional concentration. Rajaraman and Vasishstha (2002) in their empirical study have shown that a significant bivariate relationship exists between NPAs of public sector banks and inefficiency problems. Khalid (2012) examines the relationship between assets quality and operating performance of Indian private commercial banking industry. The analytical model showed that when a bank's assets quality become worse, it takes more resources for a bank to conduct non-value added credit receiving activities, which leads to poor performance. Using actual data of sample banks from 2006 to 2011, the bank's operating efficiency scores were obtained through regression which showed that assets quality and profitability were negatively related. He also explains that due to the large number of banks in India which resulted in dropping profit level, rising risk appetite and assets quality deterioration caused by pernicious competition, it led to bank runs.

Not only does a bank's assets quality affect its financial condition and operating results, but it also affects the soundness of the entire banking system.

Kwan and Eisenbis (1997) examined the relationship between problem loans and bank efficiency by employing the Granger Causality Technique and found that a high level of problem loans causes banks to increase spending on monitoring. Similar results were observed by Abata (2014) by studying the relationship among loan loss ratio, investments to assets ratio and return on assets of banks based on the financial information of the six largest banks in Nigeria. The research found a significant positive relationship between loans to asset ratio and bank profit.

Hempel et al (1994) observed that banks with high loan growth often assume more risk as credit analysis and review procedures are less rigorous. However, returns are high in such loans indicating a risk and return trade-off.

Sensitivity of bank profitability to macroeconomic variables has assumed greater importance in the wake of financial crisis. In general, increased economic growth leads to an increased demand for credit which allows them to increase their charges thereby increasing profitability. Demirguc-Kunt et al (2001) and Biker et al (2002) found a correlation between economic business cycle and credit growth. Demirguc-Kunt and Huizinga (2000) and Athanasoglou et al (2008) point towards a positive relationship between GDP growth and bank profit.

The effect of inflation can be substantial on the solvency of banks. If inflation is fully anticipated and interest rates are adjusted accordingly, then a positive impact on profitability will result. Alternatively, unexpected rises in inflation cause cash flow difficulties for borrowers, which can lead to premature termination of loan arrangement and precipitate loan losses. Guru et al. (2002) and Jiang et al. (2003) found that a high inflation rate leads to higher bank profitability. The study of Abreu and Mendes (2000) presented a negative coefficient for the inflation variable in European countries. Further, Demirguc-Kunt and Huizinga (2000) note that banks in developing countries tend to be less profitable in inflationary environments.

Research Problem

As per the recent financial data of LCBs highlighted in the paragraph on overview of the banking sector in Sri Lanka, less fluctuation in profitability was identified when compared to the high volatility in NPAs.

These results slightly deviate from the established findings of the empirical researches by Kosmidou (2008), Achous & Tenguh (2008), Rajaraman & vasishstha (2002) and Klein (2013) that present a significant strong negative relationship between the lower assets quality and bank profitability. Therefore, the relationship between the assets quality and profitability is worth being studied.

Based on the literature review, it is clear that only a few studies have been conducted to measure the impact of asset quality on banking profitability using both bank internal factors and macroeconomic factors particularly in the context of developing countries. Similarly, there are very few studies published about the Sri Lankan context due to data unavailability. This is perhaps due to the lack of sufficient published, disaggregated information on the micro management of NPAs and the nature of default.

Considering the gaps highlighted above, this paper derives the following research question:

What is the impact of assets quality factors on bank's profitability in the commercial banks of Sri Lanka?

Based on the literature review of this study, the null-hypotheses formulated are as follows:

H_0: Gross NPA to Gross Advances ratio, Net NPA to Net Advances ratio, Loans to Total Assets Ratio, Provision Coverage Ratio, GDP rate and Inflation rate do not have relationships with bank profitability.

H_1: Gross NPA to Gross Advances ratio, Net NPA to Net Advances ratio, Loans to Total Assets Ratio, Provision Coverage Ratio, GDP rate and Inflation rate have relationships with bank profitability.

3. Data, Model and Methodology

3.1 Data

Business models of banks are different in LCBs and LSBs in terms of the ownership structure; e.g., some government-owned banks mainly focus on housing financing, and some are fully dependent on SME financing. Therefore, these specialized banks were excluded from the sample in order to eliminate sample bias and inconsistencies.

Accordingly, this study is limited to include the largest domestic commercial banks that have similar business models. Those are namely, Hatton National Bank, Commercial Bank, Sampath Bank, Seylan Bank, Nations Trust Bank, National Development Bank, Pan Asia Banking Corporation, DFCC Vardhana Bank and Union Bank. State banks and small private banks were excluded from the sample since data of these banks may generate spurious results due to their exceptional business models.

Considering difficulty in accessing and obtaining information for a long period of time, this study considers financial information for the period 2008Q1 to 2016Q4 in order to derive a best-fitted estimation using 320 observations.

Data Sources

Data of banks were mainly obtained from publications such as their annual reports and websites. Macroeconomic variables are retrieved from annual reports published by the Central Bank of Sri Lanka and the publications of the Census and Statistics Department.

3.2 Variables

The literature review on banks' profitability studies suggests that bank profitability is determined by internal and external factors. Hence, this study considers profitability as the dependent variable, and asset quality variables as independent variables. Independent variables are divided into two sub categories such as bank internal asset quality factors and external macro-economic factors.

Dependent Variables

In this study, bank profitability is measured by Return on Assets (ROA)[1] and Return on Equity (ROE)

ROA: This ratio measures the percentage of profits earned per rupee of assets and thus is a measure of the efficiency of the company in generating profits on its assets (ROA =Net Profit/ Total Assets).

ROE: This ratio is defined as net profits expressed as a percentage of shareholder equity and reserves (ROE = Net Profit/ Shareholders' Fund). Accordingly, the mean of ROA and ROE has been taken as the dependent variable.

Independent Variables

Internal assets quality factors: As the bank internal asset quality factors, Gross NPA to Gross Advances (GNGA), Net NPA to Net Advances (NNNA), Net NPA to Total Assets (NNTA), Loans to total Assets (LTA) and Provision Coverage Ratio (PCR) will be presumed.

GNGA[2] : This ratio measures the quality of assets in a situation, where the management has not provided for loss on NPA. Gross NPA is measured as a percentage of Gross Advances (GNGA=Gross NPA/ Gross Advances).

NNNA[3] : This ratio is the most standard measure of asset quality and measures the Net NPA as a percentage of Net Advances (NNNA = Net NPA/ Net Advances).

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1 Kosmidou (2008), Abata (2014) considered ROA and ROE as key ratios for measuring profitability of banks.

2 Khalid (2012), Rajaraman and Vasishsta (2002) in their empirical studies have shown a negative significant relationship between NPA and efficiency parameters.

3 Rajaraman and Vasishsta (2002) used this proxy to determine efficiency of assets quality and negative relationship found.

NNTA[4] : This ratio indicates the efficiency of the bank in assessing credit risk and to an extent recovering the debts (NNTA = Net NPA/ Total Assets).

LTA[5] : This ratio explains a bank's primary objective of lending. A high ratio indicates a bank's willingness to interest bearing income sources. Loans to Assets ratio is measured as total Loans as a percentage of total Assets of the bank (LTA= Total Loans/ Total Assets).

PCR[6] : Provision coverage ratio is an indication of bank credit risk management and is measured by the provisions made by banks as a percentage of total NPA (PCR=provision made/ Total NPA).

External Assets Quality Factors: GDP growth rate (GDP) and Inflation rate (IR) are used as macroeconomic factors which are presumed to have an impact on bank profitability.

GDP[7] : GDP indicates overall growth in economy and it is expected to have a positive relationship with a bank's profits since economic growth would increase bank activity such as increase in a bank's funding sources and loan growth.

IR[8] : This illustrates overall percentage increase in the Colombo Consumer Price Index for goods and services of the economy. The relationship between a bank's profits and inflation is ambiguous since an increase in inflation would increase loan interest rates and enhance profits as well as increase the financing cost and reduce bank loan recoveries.

Description of variables and its relationships are elaborated in Table 1.

4 Rajaraman and Vasishsta (2002).

5 Abata (2014) studied the relationship between loans to assets ratio and bank profitability. A positive relationship found.

6 Christos K. Staikouras (1998) used provision coverage ratio as an independent variable and found a negative relationship on bank performace.

7 Demirguc Kunt et al (2001), Biker et al (2002) introduced economic variables such as GDP and Inflation to their studies to find out the sensitivity of bank profit for economic changes and found high positive correlations.

8 Refer above 7.

Table 1: Description of Variables

Variables	Notation	Description	Previous studies findings	Expected Relationship
Dependent (Profitability)	ROA ROE	Return on average total assets (ROA =Net Profit/ Total Assets) Return on shareholders' funds (ROE = Net Profit/ Shareholders' Fund).		
Independent (Assets Quality)				
Internal Factors:				
Gross NPA to Gross Advance (GNGA=Gross NPA/ Gross Advances)	GNGA	Lower ratio indicates better quality of assets. Low GNGA of banks increases interest income and decrease customer default cost. Hence a negative relationship is expected between profit and GNGA.	Negative significant relationship[2]	-
Net NPA to Net Advances (NNNA = Net NPA/ Net Advances)	NNNA	Net NPAs are gross NPAs net of provision and interest in suspense. Lower ratio indicates better quality of assets and contributes to enhance bank earnings while reducing customer default cost. Inverse relationship is expected.	Negative relationship[3]	-
Net NPA to Total Assets (NNTA = Net NPA/ Total Assets)	NNTA	Net NPAs are calculated by adjusting provisions against Gross NPAs. Lower ratio indicates the better performance of banks.	Negative relationship[4]	-
Loans to total Assets (LTA= Total Loans/ Total Assets).	LTA	Higher the loans increase assets portfolio of banks and accordingly improve bank earnings and profit. A positive relationship is expected.	Positive relationship[5]	+
Provision Coverage ratio. (PCR=provision made/ Total NPA)	PCR	Higher ratio indicates high level of bad assets of the bank and impact to reduce profit of the bank. An inverse relationship is expected.	Negative relationship[6]	-
External Factors:				
GDP Growth Rate	GDP	GDP is a general index for economic development. High GDP implies economic growth, business expansion and better quality of assets increasing bank profits. A positive relationship is expected.	Significant positive relationship[7]	+
Inflation Rate	IR	Inflation is associated with higher costs and reduces profits. Low inflation stabilizes the economy and improves the profit.	Some found positive relationship and some negative[8]	-/+

3.3 Model and Methodology

The existing literature and empirical findings suggest a linear form general model as similar studies conducted by Abata (2014), Khalid (2012), Swamy (2015) and many other researches used panel data to measure the relationship between the dependent variable and independent variable.

The primer model that was estimated by Abata (2014), Khalid (2012) and Swamy (2015) using panel techniques is;

$$Yit = \alpha + Xit + \delta i + \gamma t + \mathcal{E}it$$

Where *Yit* is the dependent variable and *Xit* is a ***k***-vector of regressors, and $\mathcal{E}it$ is the error terms for $i = 1, 2, \ldots\ldots, M$ cross-sectional units observed for dated periods $t = 1, 2, \ldots, T$. The α Parameter represents the overall constant in the model, while the δi and γt represent cross-sectional effects and period specific effects (random or fixed) respectively.

Based on the above, the following specification is designed for a panel regression method of this study to analyse the determinants of profitability

$$Y_{it} = \alpha + \beta_1 (GNGA)_{it} + \beta_2 (NNNA)_{it} + \beta_3 (NNTA)_{it} + \beta_4 (LTA)_{it} + \beta_5 (PCR)_{it} + \beta_6 (GDP)_{it} + \beta_7 (IR)_{it} + \delta i + \gamma t + \mathcal{E}_{it}$$

Where,

Y_{it} = Profitability (Mean of ROA and ROE) **i** for banks in year ***t***

α = constant. β_1, β_2, β_3, β_4, β_5, β_6 and β_7 are regression coefficients.

GNGA = Gross NPA to Gross Advance

NNNA = Net NPA to Net Advances

NNTA = Net NPA to Total Assets

LTA = Loans to Total Assets

PCR = Provision Coverage Ratio

GDP = GDP Rate

IR = Inflation Rate

δi = Cross sectional effect

γt = Time period effect

$\mathcal{E}_{it}$ = Error term

i = 10 banks, t = 2008Q1-2016Q4

As per similar studies of existing research literature, a Multiple Regression Model has been adopted for this study using panel data to measure the relationship among the independent and dependent variables. E-views will be used for the econometrics analysis.

3.4 Data and Assumptions

Panel data[9] has been used for this multiple regression model as it has the advantage of providing more informative data consisting of both the cross sectional information, which captures individual variability as well as the time series information that captures dynamic adjustment.

This study estimated a Hausman's specification test as per Greene, 2003 to select whether the best model is a fixed or random effect model to estimate the multiple regression of this study (Table 2).

Accordingly; H_0: individual effects are not uncorrelated with other variables.

H_1: Ho is not true.

Table :2 Correlated Random Effects - Hausman Test

Test cross-section and period random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	0.971058	7	0.9953
Period random	8.506501	5	0.1304
Cross-section and period random	8.464509	5	0.1324

Decision: if 0.05>Probability; Null is accepted.

As per the test values, probability values are higher than 0.05. Therefore, the null hypothesis is rejected indicating that individual effects of the regressors of this study are uncorrelated with other variables and a Fixed Effect Model is preferred over a Random Effect Model. Hence, a fixed effect model[10] is used and it is assumed that bank specific effects do not significantly vary.

[9] The combination of time series with cross sections can enhance the quality and quantity of data in ways that would be impossible using only one of these two dimensions (Gujarati, 638).

[10] "The slope coefficient on independent variable is the same from one entity to the next entity (Cross sections). Stock and Watson, 2003, p.289-290).

4. Data Analysis, Estimation and Empirical Results

4.1 General Behaviour of variables

As data represent time series, the general behaviour of independent and dependent variables was tested through descriptive statistics before running the regression model. Descriptive statistics explain the central tendency of variables (Table 3). Since the sample is greater than the 30 observations, two tail tests were carried out at 5 percent significant level (Appendices).

As per Table 3 below, mean ratios of the dependent variable (Y) and other independent variables (GNGA, NNNA, NNTA, PCR, GDP and IR) considered for this study were positive at 5% and 1% significant level respectively. However, the probability value of LTA (0.47) is identified at an insignificant level. Further, the low standard deviation value of independent variables, such as GNGA, NNNA, NNTA, LTA, PCR, and IR reflected that data points of them are extremely close to the mean.

Table 3: Descriptive Statistics

	Profitability (Y)	**GNGA**	**NNNA**	**NNTA**	**LTA**	**PCR**	**GDP**	**IR**
Mean	8.554	6.103	3.144	2.459	64.314	47.526	11165.03	5.334
Median	8.557	5.982	2.856	2.046	65.114	43.662	-2856.00	5.600
Maximum	15.326	14.30	8.929	8.580	79.662	145.67	75916.00	9.300
Minimum	2.423	1.323	-1.261	-0.806	49.161	8.553	28117.00	0.100
Std. Div.	**2.736**	**2.756**	**2.241**	**1.691**	**6.055**	**22.836**	**32210.46**	**2.835**
Skewness	0.109	0.519	0.644	0.944	-0.155	1.745	0.66083	-0.443
Kurtosis	2.328	2.796	3.226	3.796	2.872	7.364	2.05152	2.123
Probability	**0.0358**	**0.0005**	**0.0000**	**0.0000**	**0.4741**	**0.0000**	**0.0000**	**0.0000**

4.2 Multicolinearity

Correlation among variables was performed to identify multicolinearity. If a correlation coefficient matrix demonstrates correlation of 0.75 or higher among the variables, there may be multicollinearity. Other statisticians suggest that correlations of 0.90 or greater may indicate multicollinearity.[11]

[11] Wooldridge, J M., Introductory Econometrics, 4th Edition, Chapter15.

Accordingly, the correlations among independent variables of this study have been tested through a correlation matrix. Summarized results are given in Table 4 below. As per the results of the correlation matrix, correlations of all variables reported below the level of 0.75 representing a weak correlation position. Therefore, it can be concluded that proposed model does not suffer from any multicolinearity problem.

Table 4 exhibits correlation among the independent variables. Accordingly, strong negative correlation of GNGA is found between LTA, PCR and IR. Also, a weak positive relationship of GNGA is found between NNNA and NNTA, as well as NNTA over NNNA. Further, a weak negative correlation of PCR found with NNNA and NNTA.

Table 4: Correlation Matrix

	GNGA	**NNNA**	**NNTA**	**LTA**	**PCR**	**GDP**	**IR**
GNGA	1.00000						
NNNA	**0.710841**	1.00000					
NNTA	**0.632195**	0.**701184**	1.00000				
LTA	**-0.254711**	-0.140006	0.059984	1.00000			
PCR	**-0.496437**	**-0.647691**	**-0.640728**	0.007225	1.00000		
GDP	0.002897	0.012786	0.008301	-0.002238	-0.010083	1.00000	
IR	**-0.039283**	0.034701	0.011478	0.055684	0.039021	-0.050197	1.00000

4.3 Testing for stationarity

Stationarity has been tested to see whether the variables are mean reverting or not. According to Mahadeva and Robinson 2004**,** running an OLS on non-stationary data gives spurious regression results. However, a similar research conducted by Levin*,* Lin and Chu (2002) and Pesaran and shin (2003) tested the stationarity over the estimation period using LM unit root tests for balanced panels' series.

Accordingly, this research conducted an LM test and as per the summarized results exhibited in Table 5, independent and dependent variables of this study do not suffer any unit root problems at levels I (0) since null hypothesis of the variables named, Y, GNGA, NNNA, NNTA, LTA and PCR had been rejected at 5% significant level and the null hypothesis of GDP and IR had been rejected at 1% significant level. Hence, in general all variables are considered as mean reverting.

Table 5: Summary Results of Unit Root Tests

Variable	Levin, Lin, Chu Test	Pesaran, Shin Test	I(o) or I (I)
Profitability (Y)	0.0479*	0.0014*	I(o)
GNGA	0.0181*	0.0099*	I(o)
NNNA	0.0592*	0.0210*	I(o)
NNTA	0.0085*	0.0085*	I(o)
LTA	0.0510*	0.0012*	I(o)
PCR	0.0058*	0.0000**	I(o)
GDP	0.0000**	0.0000**	I(o)
IR	0.0000**	0.0000**	I(o)

*Stationary at 5% significant level ** Stationary at 1% significant level

4.4 Multiple regression estimation results

This section shows the regression analysis of domestic bank's profitability and asset quality factors including some macro variables. Using a fixed affect random model, the regression model has been run using E-views 9 application (Table 6).

Table 6: Summary Results of Model I

Variable	Coefficient	Std. Error	Probability
GNGA	-0.170118	0.079038	0.0322
NNNA	-0.201021	0.109761	0.0680
NNTA	-0.228048	0.134262	0.0904
LTA	-0.018371	0.025105	0.4649
PCR	0.008508	0.008773	0.3329
GDP	2.95E-06	4.35E-06	0.4983
IR	-0.003765	0.049520	0.9394
R-squared	**0.215776**		
Adjusted R-squared	0.197599		
Durbin-Watson stat	**0.536702**		

R-squared value[12] is the statistical measure to find out how close the data are to the fitted regression line. It is also known as the coefficient of multiple determinations for multiple regression. In general, the higher the R-squared (R^2), the better the model fits for data.

[12] The coefficient of determination is denoted ***R2***. It must be between 0 and 1, and it measures the proportion of the total variation in *y* that is accounted for by variation in the regressors.

From an empirical researcher's viewpoint, high R^2 values arise in the case of a spurious regression (Granger and Newbold, 1974). However, in the summary results of the regression model depicted in Table 6, R^2 stood at the level of 0.215776 which is at Moderate level and accepted for this study.

According to Greene (2002), R^2 will never decrease when another variable is added to a regression equation. Therefore, a solution is given by this for panel data regressions which have low R^2, to establish this result by adding lag dependent variables.

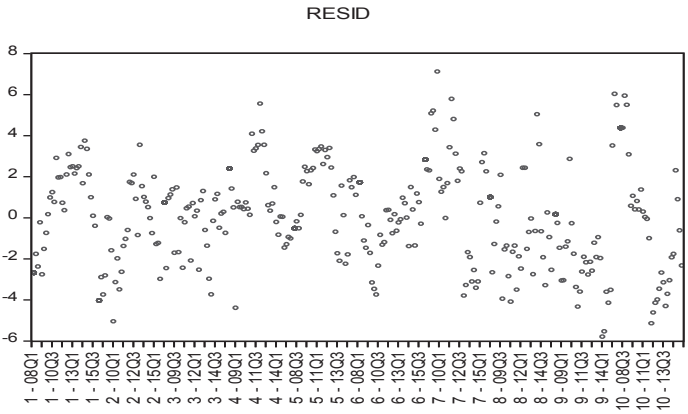
Hence, this study used lag dependent variables for the regression model to determine the movements in the dependent variable.

4.5 Testing for the Classical Assumptions (Robustness) of the Model

Hetroscedasticity

The scatter graph of the residuals does not show any fanning out of errors when the value of x is increasing (Figure 5).

Figure 5: Scatter Plot of errors



However, since it is unable to conclude whether the Var (ε) = σ^2 condition is satisfied, the Breusch-Pagan LM test for Heteroscedasticity was performed using the following hypothesis (Greene, (2002).

H_0 = Model is homoscedastic

H_1= H_0 is not true

Table 7: Results of Breusch-Pagan LM test

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	124.1971	45	0.0000
Pesaran scaled LM	8.348104		0.0000
Pesaran CD	-1.351489		0.1765

Null hypothesis is rejected at 1% significant level and therefore, it is concluded that none of specification suffers from either Heteroscedasticity of the model (Table 7).

Serial-correlation

The Durbin Watson[13] statistical test has been used to measure the autocorrelation in the residuals. The Durbin-Watson statistic always remains between 0 and 4. Durbin-Watson statistic of 2 means that there is no autocorrelation in the sample. Further, Greene (2002), mentions that the Durbin-Watson ratio is a clue to detect a nonsense regression where its value is low. As per Table 6 above, the Durbin-Watson value reported at a level of 0.536702 which is lower than the threshold around 2. Therefore, it can be concluded that the proposed model is suffering from an autocorrelation problem.

Balestra and Nerlove (1966), Fomby, Hill and Johnson (1984), Judge et al. (1985), Hsiao (1986), Anderson and Hsiao (1982), Nerlove (1971, 2003), and Baltagi (1995) also faced a similar kind of autocorrelation problem and by adding a lagged dependent variable to the model, the aforesaid studies overcome the autocorrelation.

Further, a solution was suggested by Wooldridge (2002) and Greene (2002) to overcome the autocorrelation of the problematic time series panel data, by running a Dynamic Panel Data Regression Model including the lag-dependent variables as the independent variable until the errors are minimised.

Based on the above literature and empirical studies, the panel regression model of this study was formulated as follows incorporating the lag dependent variable.

$$Y_{it} = Y_{it-1} + \alpha + \beta_1 (GNGA)_{it} + \beta_2 (NNNA)_{it} + \beta_3 (NNTA)_{it} + \beta_4 (LTA)_{it} + \beta_5 (PCR)_{it} + \beta_6 (GDP)_{it} + \beta_7 (IR)_{it} + \delta i + \gamma t + \varepsilon_{it}$$

[13] Durbin's Test *FD* = the *F* statistic for the joint significance of *P* lags of the residuals in the regression of the least squares residuals on [$\mathbf{x}_t$, $y_t-1, \ldots y_t-R$, $e_t-1, \ldots e_t-P$]. Reject *H*0 if $FD > F[P, T - K - P]$. This test examines the partial correlations between the residuals and the lagged residuals, controlling for the intervening effect of the independent variables and the lagged dependent variable (Greene, 2002).

Accordingly, the summarized results are given at Table 8 below.

According to Table 8 below, the Durbin-Watson test statistics for serial correlation was shown as 2.053966 in Model II where, there is no significant autocorrelation among the successive values of the variables in the model. Hence, Model II is considered the best fitted model for this study.

5. Interpretation of Results

This study comprehensively analyses the determinants of assets quality and its impact on bank profitability. According to the empirical results as depicted in Table 8, the highest R^2 of 0.638057 is represented in Model II analysis. Hence, compared to Model I, R2 of 0.638057 of Model II indicates a high existence of correlation among Y and GNGA, NNNA, NNTA, LTA, PCR, GDP and IR variables.

Table 8: Summary Results –Model II

Variable	Model II with Lag Y (-1) Coefficient	Probability
C	3.404789	0.0115
GNGA	-0.060678	0.2629
NNNA	-0.043906	0.5595
NNTA	-0.084542	0.3572
LTA	-0.004016	0.8145
PCR	0.006039	0.3127
GDP	-6.37E-06	0.0327
IR	-0.041854	0.2160
Y (-1)	0.719741	0.0000
R-squared	0.638057	
Adjusted R-squared	0.628437	
Durbin-Watson Statistics	**2.053966**	

Similarly, the co-efficient of determination value (R^2) of 0.638057 indicates that about 63 per cent of variation of Y can be explained by the combined influence of GNGA, NNNA, NNTA, LTA, PCR, GDP and IR variable. Hence, the null hypothesis of this study which predicted that "there is no relationship between the asset quality variables and bank's profitability" is rejected.

The Table 2 depicts the five internal determinants of a bank's assets quality that have been used in this study. However, the results show that three determinants, GNGA, NNNA and NNTA are negatively related to a bank's profitability at an insignificant level that contradicts the literature. According to the coefficients of GNGA, NNNA and NNTA, at 1% change in these variables, a bank's profitability may be affected by 0.06%, 0.04% and 0.08% respectively. Khalid (2012), Kosmidou (2008) and Festus Nzoka (2015) also found the same relationship for banks in India, Greece and Kenya respectively at different significant levels.

GNGA indicates a bank's aggressiveness in lending and the credit risk of the bank. NNNA and NNTA show the same trend as well as GNGA. Achou and Tenguh (2008) in their study found that the lower the ratio the better and these variables are important in determining the profitability of banks because if banks do not effectively manage these risk factors, such profits would be unstable. According to the empirical results of this study, the same negative relationships of GNGA, NNNA and NNTA are found and it suggests that high assets quality/effective credit risk management results in lower cost of recovery, low NPA provisioning, which is less threatening to liquidity and high profitability. These results are consistent with previous findings by Kosmidou (2008) and Festus Nzoka (2014).

The literature identifies that high loan growth often assumes lower profit due to high credit risk, but there is also a high return as the loans have a greater expected return than other assets, such as government securities (Hempel et al., 1994). This statement is further supported by Abata (2014), where his study showed a significant positive relationship between loans to asset ratio and bank profit. However, the empirical results of this study show a 0.004% negative impact on bank profitability at a 1% change in LTA at an insignificant level. This may be due to banks rapidly increasing their loan portfolio and having to pay a higher cost of funding and thereby, showing an inconsistency with the empirical findings of this study and the findings by Abata (2014).

Inflation is associated with higher costs and it could affect in two ways (Guru et al (2002), Jiang et al (2003) and Abreu and Mendes (2000). One would be to expect a negative relationship between inflation and bank profits since low inflation stabilizes the economy and it could improve the bank's profit due to low NPAs. Other would be to expect a positive relationship since in a high inflation scenario, banks might be encouraged to finance in property markets as an investment strategy that may lead to market losses.

Angela Roman (2003) and Abreu and Mendes (2000) found a strong negative relationship in Romania between IR and bank profit. Even though the said research showed a substantial effect on inflation in solvency of banks, a negative relationship between IR and a bank's profit was also evident at an insignificant level where 1% change in IR affects the bank's profit by only 0.04%.

In the Sri Lankan context, fluctuations in inflation affect the change in the bank's interest rates as well as profit margins. In such a situation, monetary policy involves stabilizing the economy that may result in a weak negative relationship between the variables.

Further, the empirical results illustrate that only one macroeconomic variable is significant in illuminating the bank profitability in Sri Lanka at 5% significant level. However, this study suggests a significant negative relationship between GDP and bank profitability where a 1% change in GDP has a 6.37E06% impact on profitability. The results differ from the similar researches conducted by, Demirguc-Kunt and Huizinga (2000), Michael et at (2006), Athanasoglou et al (2008) and Khalid (2012) that point out a positive relationship between GDP growth and bank profitability, as a general increase in economic growth leads to an increased demand for credit allowing banks to increase their charges thereby increasing profitability.

However, the coefficient may also be negative as countries with higher GDP are assumed to have a banking system that operates in a mature environment resulting in with a more competitive interest and profit margins (Goldberg and Rai, 1996). These data have been obtained from national statistics published in the IMF's International Financial Statistics.

Further, the Growth rate of GDP affects the supply and demand for loans and deposits of the banks. A bank's profitability may be driven by real GDP for a number of reasons. First, a bank's assets quality will depend on the position of economic cycles. In economic upturns, low NPAs and high bank profits can be expected than in economic downturns. Therefore, a bank's profitability will be positively correlated with GDP growth. Secondly, GDP can affect the market size. In an upturn, there will be a higher demand for bank loans than in a downturn. Hence, higher demand for loans will result in higher profits for banks.

However, as in the case of this study, the coefficient of GDP may also be negative in some situations due to less demand for loans even in an economic upturn where high interest cost is charged by the banks that may lead to high profits margins.

6. Conclusion

This paper attempts to estimate the impact of asset quality factors on bank profitability using two macroeconomic variables. A multiple regression model was used in estimating the coefficient of the model. Based on the results of estimations and robustness tests carried out, it can be concluded that there is a positive relationship between assets quality and a bank's profitability. Even though previous literature has showed a strong relationship between the assets quality variables and a bank's profitability, this research confirms that the relationship between assets quality and bank profitability is at an insignificant level. Limitation on sample and data mainly affected to weaken the significance level of the repressors of this study.

7. Policy Implications, Limitations and Future Research

From the policy maker's point of view, the regulator's recommendation to banks is to maintain quality assets in the bank balance sheet in order to ensure the operational efficiency of the bank in the short-term and enhance sustainability in long-run. Hence, findings of this study do not boost the outcome of other similar research findings conducted by Demirguc- Kunt and Huizinga (2000), Michael et at (2006), Athanasoglou et al (2008) and Khalid (2012).

Improper assets quality reduces bank profitability by increasing non-performing loans which may eventually lead to financial distress. As a result, banks need to make efforts to improve their financial soundness by following policy decisions;

a) Use collateral as security when granting loans to reduce further incidence of bad debts.

b) Implement better credit risk assessment indicators to overcome high credit risk that is involved in lending.

c) Ensure continuous post sanction risk monitoring over doubtful debts.

The scope of this study limited to 9 commercial banks and financial information only of 9 years due to the non availability of data. Therefore, further improvement can be made to this research by increasing the sample size, number of observations and incorporating macroeconomic variables such as interest rate and exchange rate fluctuations, thereby opening up avenues for future research in Sri Lanka for a better explanation for proxies in estimating the impact of assets quality.

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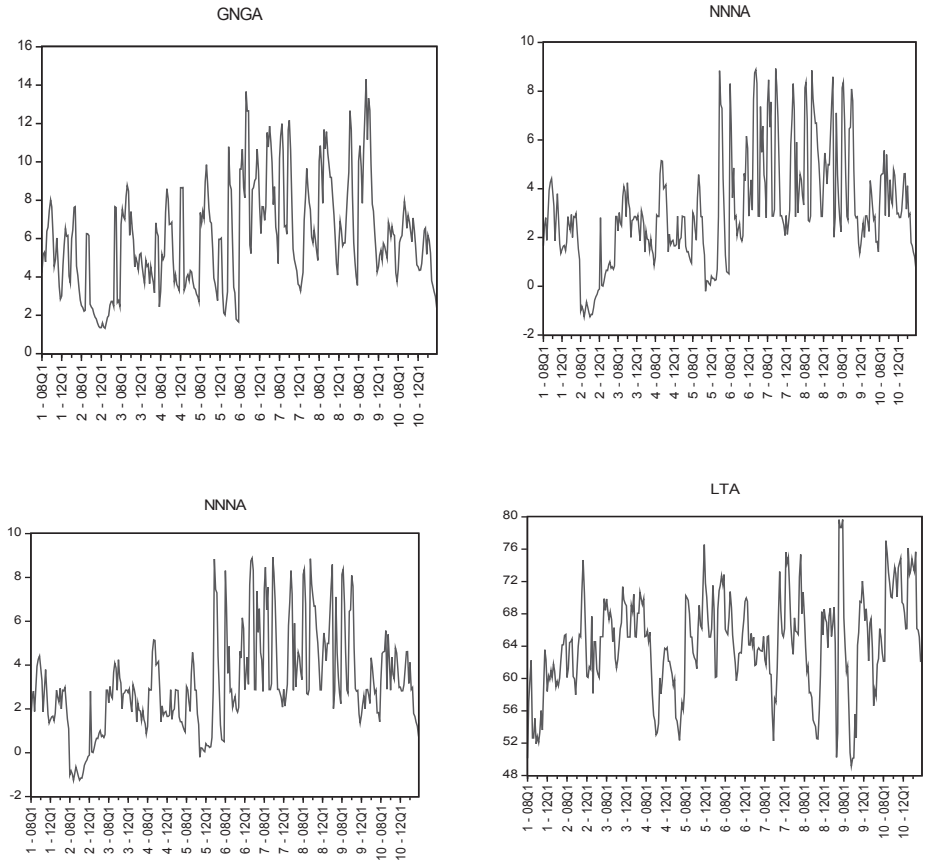
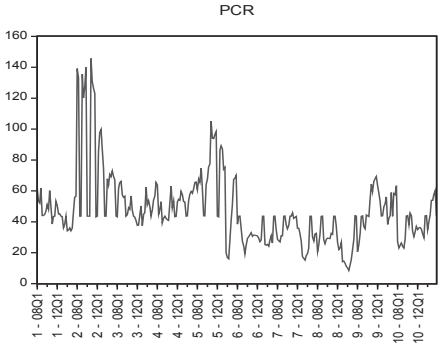
Appendices

A.1

Figure A1: Behaviour of Data

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160
140
120
100
80
60
40
20
0
1 - 08Q1
1 - 12Q1
2 - 08Q1
2 - 12Q1
3 - 08Q1
3 - 12Q1
4 - 08Q1
4 - 12Q1
5 - 08Q1
5 - 12Q1
6 - 08Q1
6 - 12Q1
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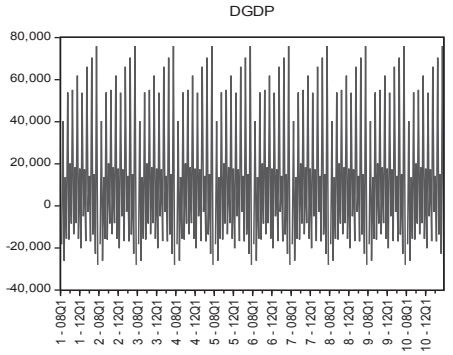
10 - 08Q1
10 - 12Q1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60,000
40,000
20,000
0
-20,000
-40,000
1 - 08Q1
1 - 12Q1
2 - 08Q1
2 - 12Q1
3 - 08Q1
3 - 12Q1
4 - 08Q1
4 - 12Q1
5 - 08Q1
5 - 12Q1
6 - 08Q1
6 - 12Q1
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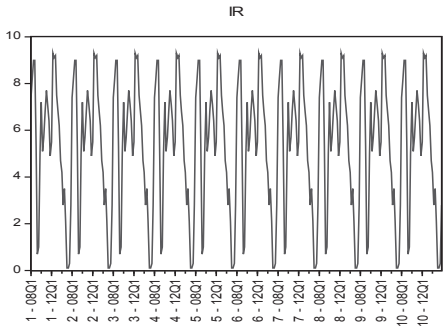
8 - 08Q1
8 - 12Q1
9 - 08Q1
9 - 12Q1
10 - 08Q1
10 - 12Q1


IR
10
8
6
4
2
0
1 - 08Q1
1 - 12Q1
2 - 08Q1
2 - 12Q1
3 - 08Q1
3 - 12Q1
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