A Circular Economy Approach for Sustainable Economic Growth

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Abstract

This paper focuses on the circular economy model for sustainable development in the frame work of endogenous economic growth structure. Paper differentiates products and their consumptions, and also highlights the recycling of waste that reduces pressure of natural resource extractions and pollution generation. Recycling economic activities also contributes in the economic growth without degrading environment.

***Key* Words**: Circular Economy, Consumption, Economic Growth, Environmental Externality, Production, Sustainable Development, Recycle of Waste, Natural Resource, .

JEL *Classification Number*: Q53, Q43, O44, O41, O13

1. Introduction

Industrialization is the driving force of economic growth since the 19th century. Adopting successful industrial strategy several nations become rich and improve their standard of living or/and social welfare. However, rapid industrialization generates huge waste and pollution that degrades environment. Truly, industrialization reduces the intrinsic functional capacity of nature and its living system, which allows resources to return to the environment through certain cycles and/or flows. Nature accommodates everything including industrial wastes with certain limitations. Industrialisation, truly, adopts a principle of '*take- make- dispose*' which generates huge amount of waste along with high economic growth rate, and rising industrial demand for resources (which are limited in this planet) that becomes unsustainable. What is the solution? How do we restore sustainability? What is the alternative development mechanism for sustainable economic growth? One possible solution is to adopt recycling resources. In this context, this paper focuses on the circular economy model, which solves this resource problem and suggests one simple solution of converting wastes to resources and creating market for wastes. Recently the concept of the circular economy emerges (MacAthur foundation 2015, Andersen 2007; Geng et al. 2012; George et al. 2015; Korhonen et al. 2018, Heshmati 2018, Yuan, Bi and Moriguichi 2006, McDonough et al. 2003). The circular economy model optimally uses resources over the entire life of a product cycle – from '*take*' stage to *product's end life*. The objective of this circular economy is to take least resources and utilizes fully all products, components and materials through their life cycle.

Traditionally industrialised countries follow a linear economy, which is based on the principle of '*take-make-dispose*'; or, linear processes of '*extract, produce, consume and* *trash*'. Value of products is important in market, and disposes valueless wastes that damage the environment. Since this linear economy model of '*take-make-dispose*' is unsustainable, alternatively the circular economy model is based on a principle of *reduce, reuse, and recycle*. In the circular economy model the waste becomes a value producing resources (McDonough et al. 2003), and waste resource might turn to be one contributor of economic growth in a restrictive model (George et al. 2015). Relaxing the restrictions, this paper highlights on the economic growth rate of the circular economy model and compares that of with the linear economy. Circular economic principle also spurs innovations, which improves resource productivity and reduces ecological impact, and creates jobs.

Recently development economists and other social scientists introduce the concept of circular economy model (MacAthur foundation 2015, Andersen 2007; Geng et al. 2012; George, Lin and Chen 2015; Yuan, Bi and Moriguichi 2006). The concept of circular economy drives optimal resource efficiency utilizing through the product's life cycle or/and closed loop material flows. Truly, the circular economy model aims to solve industrial waste management problems, internalizing the environmental externalities, minimising waste, and moves toward sustainability. The circular economy represents a fundamental alternative to the dominant linear economic model based on a '*take- make-consume- through away*' pattern (Reichel, De Schoenmakere and Gillabel 2016). We take, make and dispose materials in the linear economy model that relies on large quantities of cheap, easily accessible materials and energy (MacAthur foundation 2015). In the context of discussion about the linear economy model, Braungart and McDonough

(2002) rightly point out that resources are extracted, shaped into products, sold and eventually disposed of in a '*grave*' of some kind, usually landfill.

The notion of circularity idea is deep rooted historical origin. Boulding (1966) is the pioneer to motivate for the idea of circular economy in his *spaceship economy*. '*Limits to growth*' of Club of Rome has highlighted the finiteness of the Earth in 1972. Daly (1991) points out a sinking boat while Arrows et al. (1995) indicate the carrying capacity of an economy. Anderson (2007) highlights environmental economics of the circular economy, while George et al. (2015) analyse environmental quality in a theoretical model with restricted conditions. Recently, several countries (like Australia, China, Finland, Germany, Japan, and the Netherlands) have adopted certain development strategies incorporating circular economy model (Yuan et al. 2006, Geng et al. 2012).

Earlier studies ignore a relevant dynamics of accumulation of waste resources, which may trigger to move towards sustainable development. Traditional economic growth theory (Solow 1956, Romer 1986, and Lucas 1988) analysed unidirectional concept of production and consumption. Following George et al. (2015) this paper aims to incorporate the concept of circular economy in the economic growth theory, and deals with this issue by combining the accumulation of stock of waste and pollution along with physical capital. George et al. (2015) consider recyclable and polluting resources, and ignore physical capital. This paper provides more clarity on modifying the circular economy and its sustainable growth strategy for long run. This paper considers that waste generates within as well as out of the circular economy system which differ from George et al. (2015) model. This paper mainly internalizes environmental externalities in terms of waste and pollution stock in the framework of endogenous growth model.

The paper is organised as the follows: Section 2 describes the model setup for this study. Section 3 analyses the model and its properties, and finally the paper concludes with remarks.

2. Model Setup

Consider a closed economy where population is fixed or unchanged. For simplicity consider a single individual who produces and consumes goods. His/her production and consumption activities generate wastes. (S)he uses the polluting factors (or resources) as input in his/her production process. Pollution is generated for using the polluting resources.

2.1 Production

The representative firm traditionally produces output, *y*, using composite capital (i.e., manmade capital or combination of physical and human capital), *k,* and resources, *m,* which are the sources of all pollutions and/or wastes generation. Truly, *m* is polluting resource. A well-defined production function is

$$y = f(k, m), \qquad (1)$$

$$f_k > 0, \, , \; f_m > 0, \; f_{kk} < 0, \;\; f_{mm} < 0, \; f(k, 0) = f(0, m) = 0 .$$

Traditional output, y, is used for both consumption and capital accumulation for further production. Pollution and waste are generated as the by-products in this production process. Let pollution, *P*, and waste, *S*, both are the function of output, *y*. Consider composite capital, *k,* is non-polluting factor of production. Now, more specifically both pollution and waste depend on use of polluting resources, *m*, hence, $p = \gamma(y), \Rightarrow p = \gamma(m)$, where $\gamma_m > 0$, $\gamma_{mm} \leq 0$ and partly pollution is reduced due to absorption capacity of nature; while $S = l(y), \Rightarrow S = l(m)$. Truly, traditional economy generates waste and accumulates over time and turns to be a stock. This waste stock grows exponentially, it can be expressed as *l(m)* with $l_m > 0$ and $l_{mm} > 0$ properties. In this context this waste stock can be converted to productive resource and the circular economy starts to operate to control waste related problems. Let us try to understand the economic development mechanism of the circular economy.

The Circular Economy

2.2 Recycling Production function

Now, consider the situation where individual produce *q* product using recyclable waste which reduce the pressure on environment and natural resources. The representative firm produces recyclable output, *q*, using composite capital, *k;* polluting resources, *m*, and recyclable waste, *x*. The recyclable output is potential for both consumable and further recyclable. The recyclable output function is also well-defined as

$$q = h(k, x, m), \qquad (2)$$

$h_k > 0,\ h_x > 0,\ h_m > 0,\ h_{kk} < 0,\ h_{xx} < 0,\ h_{mm} < 0,\ h(k, m, 0) = 0$, $h(k, 0, x) > 0$, and $h(0, x, m) > 0$.

Now, one traditional good is produced in the linear economy model while another new good is created in the circular economy model, which might be operated at micro and meso (middle layer economy or in-between macro and micro) levels. The Circular Economy is based on the '3R' principles: ***Reduce, Reuse, and Recycle***. Truly, the circular economy reuses waste and reduces resource extractions. Stock of waste accumulation is essential for reusing and recycling resources. Output or production depends on available stock of recyclable resources in the circular economy. Available waste stock becomes the constraint in the circular economy. Consider the circular economy which is self-sufficient with proper economic incentives for all possible productive resources and activities. This newly produced good of the circular economy (i.e., the recyclable output) is used for consumption, *c*; payment for input requirements, θm, and the rest $h(k,x,m)-c-\theta m$ is the profit, which is measured in terms of output. This is potentially recyclable waste which is used as investment in the circular economy model for further production. Let *S* be the stock of waste and recyclable rate is ϕ. Production activity continues with waste stock accumulation in the circular economy just like capital formation in the traditional economy which also creates stock of waste that depends on polluting resource, *m,* i.e., *l(m).*

2.3 Stocks Dynamics

Waste is generated through any production processes using polluting resources and is also used as input in the circular economy.

Waste accumulation dynamic equation is

$$\dot{S} = h(k,x,m) - c - \theta m + l(m) \tag{3}$$

Where *l(m)* is waste generating function (with $l_m > 0$ and $l_{mm} > 0$ properties) and exogenous source of stock of waste that is similar to polluting resource, *m*. Recycling waste stock *x* amount is used to convert it to produce one unit output *q*. Reuse and recycling fully control waste stock dynamic in the circular *economy*. Substituting $x = \phi S$ in equation (3) yields the stock of waste accumulation and its dynamic equation in the circular *economy* turns to be

$$\dot{S} = h(k,\phi S,m) - c - \theta m + l(m) \tag{4}$$

Pollution is generated due to unused waste stock of last year, i.e., $(1-\phi)S$ and polluting resource used in production process, i.e., $\gamma(m)$. However, nature absorb certain pollution, i.e., $\delta_p > 0$.

Pollution accumulation dynamic equation is

$$\dot{P} = (1-\phi)S + \gamma(m) - \delta_p P \quad (5)$$

Where $\gamma_m > 0$ and $\gamma_{mm} > 0$

Objective of all these activities is the consumption or need satisfying wants that lead to improvement of wellbeing or welfare of the society.

2.4 Welfare function

For simplicity, this study considers that the household consumes only recyclable output, *q*, and satisfies his/her utility. The representative household maximizes her (his) instantaneous utility through consumption (*c*) at each moment, and accumulation of all instantaneous utility discounted by *ρ* (>0) is his/ her welfare for his/ her entire life span [0, ∞]. So, the traditional objective of the household is

$$\underset{c}{Max} \int_0^\infty U(c) e^{-\rho t} dt \quad (6)$$

Where marginal utility of consumption is positive (i.e., $u_c > 0$) and change of marginal utility of consumption is negative (i.e., $u_{cc} < 0$).

So, basic objective of the society is to maximise eq (6) subject to constraints i.e., eq (4) and eq (5) in the circular economy[1].

[1] This economy does not focus on traditional capital accumulation. Here, capital accumulation is replaced by waste accumulation.

3. Results and Analysis

3.1 Optimization and economic growth

The Hamiltonian function is

$$H = u(c) + \mu[h(k,m,x) - c - \theta m + l(m)] + \eta[(1-\phi)S + \gamma(m) - \delta_p P] \qquad (7)$$

FOCs

$$u_c - \mu = 0 \;\; => \;\; u_c = \mu \qquad (8)$$

$$\mu(h_m - \theta + l_m) + \eta\gamma_m = 0 => \; \eta = \mu(\theta - h_m - l_m)/\gamma_m \qquad (9)$$

Economic growth rate in this Circular Economy is

$$\frac{\dot{c}}{c} = (1/\sigma)[\phi h_x - \{(1-\phi)/\gamma_m\}h_m + (\theta(1-\phi)/\gamma_m) - \rho)] \qquad (10)$$

The rate of economic growth in the circular economy depends directly on marginal productivity of recyclable resources (h_x) and the rate of recycle of waste (ϕ), and growth rate is reduced due to marginal productivity of polluting resources, h_m . Crucially economic growth of the circular economy depends on net effect of difference of marginal productivity of recyclable resources (h_x) and that of polluting resources, h_m . Economic growth rate also as usually affected by the intertemporal consumption elasticity (σ), the discount rate (ρ). Interestingly θ, ϕ *and* γ also influence the economic growth rate.

3.2 Stability Conditions

Now we examine the economic growth saddle path and its stability conditions in the domain of the control and state variables[2]. A stable economic growth saddle path exists in

[2] For details of stability conditions see the appendix.

the C - P space under the condition of positive economic growth rate ($\frac{\dot{c}}{c} > 0$); while it is unstable in the C - S space.

4 Conclusion

This study highlights the circular economic approach for sustainable economic growth strategy. The paper incorporates the concept of reuse and recyclable resources for sustainable development in endogenous economic growth framework. Paper differentiates products and their consumptions, and highlights the recycling of waste that also contributes in the economic growth with least impact on environment. The paper shows that economic growth path is stable in the circular economy and suggests continuing economic activities for long time.

The paper suggests a policy strategy which is required to redesign the economic activities incorporating the circular economy model for ensuring sustainable economic growth and development. The circular economy requires a system change with parallel actions for produced goods as well as waste resources along the value chain of production and consumption. In a circular economy, value creation is decoupled from consumption of finite resources. Circular economy model should distinguish between technical and biological cycles[3], which rely on distinct infrastructure building strategies. Adoption of circular economy will be successful under the condition of technological innovation and social change. So, there is a need to change the institution, technology, culture and stable

[3] Technological cycles recover and restore products, components and materials through strategies like repair, reuse, remanufacture and recycling; while in biological cycles, nutrients are metabolized and life process regenerate living system, such as soil, plants, or animals, that give rise to materials and other resources.

regulatory body for moving towards circular economy. This study has several limitations in terms of assumptions. Empirical validity is required to check.

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Appendix

1a.

$$\begin{vmatrix} \frac{\partial \dot{C}}{\partial C} & \frac{\partial \dot{C}}{\partial P} \\ \frac{\partial \dot{P}}{\partial C} & \frac{\partial \dot{P}}{\partial P} \end{vmatrix} = \begin{vmatrix} (1/\sigma)[\phi h_x - \{(1-\phi)/\gamma\}h_m + (\theta(1-\phi)/\gamma) - \rho)] & 0 \\ 0 & -\delta_p \end{vmatrix} < 0 \text{ , } iff \ \frac{\partial \dot{C}}{\partial C} > 0$$

1b.

$$\begin{vmatrix} \frac{\partial \dot{C}}{\partial C} & \frac{\partial \dot{C}}{\partial S} \\ \frac{\partial \dot{S}}{\partial C} & \frac{\partial \dot{S}}{\partial S} \end{vmatrix} = \begin{vmatrix} (1/\sigma)[\phi h_x - \{(1-\phi)/\gamma\}h_m + (\theta(1-\phi)/\gamma) - \rho)] & \phi^2 h_{xx} \\ -1 & \phi h_x \end{vmatrix} < 0, \ iff \ \frac{\partial \dot{C}}{\partial C} < -\frac{\phi h_{xx}}{h_x}$$