ISSN 1749-3889 (print), 1749-3897 (online)
International Journal of Nonlinear Science
Vol. 33(2022) No.2/3, pp. 100-104

The Relationship between Economic Growth and Products Driven by Green Behavior

Min Fu, Xinyu Ye*
Energy Development and Environmental Protection Strategy Research Center, Jiangsu University, Zhenjiang, Jiangsu 212013, P.R. China
(Received February 8 2022, accepted May 15 2022)

Abstract: Carbon productivity is an important index to measure economic growth and low carbon emission reduction by combining economic indicators with carbon emission indicators. In order to study the change of carbon productivity in a certain region over a certain period, a new production technology function model was built, and the knowledge stock input of the production process was added. Combining the distance function based on energy input and the distance function based on knowledge stock input, the LMDI-PDA decomposition method is introduced to decompose the regional carbon productivity by four factors, and then three intensity indicators were further decomposed to investigate the driving force of change, and a new green factor decomposition model of the regional carbon productivity was established.

Keywords: Policy intervention; Endogenous growth; Draw; Budget constraint; Optimization

1 Introduction

The core idea of endogenous growth theory is that the national economy can achieve sustainable growth without external force.In the development of endogenous growth theory, there are many endogenous models that focus on different endogenous factors.In the Romer endogenous growth model of human capital accumulation, Bucci[1] reconsidered the impact of population growth on per capita income growth and the possibility that agents' investment in skills acquisition was affected by technological progress, and found that the growth rate and actual per capita wage level had nothing to do with population size. Chu et al. [2] developed an endogenous growth model characterized by environmental externalities, carbon reduction R&D and imperfect market, and compared the economic benefits under the three systems of public emission reduction, private emission reduction without tax and private emission reduction with tax. Yang et al. [3] based on the worry and debate about the replacement of labor by machines caused by the large-scale application of artificial intelligence, they built an artificial intelligence innovation model, divided skilled labor into three types: high, medium and low, and calculated that industrial intelligence can use the new job creation effect and production rate effect to promote poverty-stricken development. Davin et al. [4] explored the design of optimal policies by driving endogenous growth through human capital accumulation.Wan et al.(2018)[5] studied this Law from three aspects: production, family and government, took health and education as endogenous factors of production function, and divided human capital into health human capital and education human capital to explore the relationship between them, and then obtained the health risk effect and capital contribution constraint effect.

2 Model

Based on the research of Davoodi et al. [6], this chapter introduces carbon dioxide intensity and environmental quality into the endogenous growth model to build an economic model of environmental dynamic change. At the same time,

*__Corresponding author__. *E-mail address*:fumin@ujs.edu.cn

IJNS.2022.06.15

consider the impact of green and low-carbon behavior of products on environmental quality. Firstly, manufacturers of green low-carbon products adopt Cobb Douglas (C-D) function. The simplified production function is shown in (1):

$$Y = f(k, e, L, z) = Ak^{\alpha}e^{\beta}L^{\gamma}z \tag{1}$$

Where, A represents the technological progress rate, e represents the absorbed input of the product, z represents the carbon dioxide emission intensity, and L represents the labor input of the final product department of the product. Households choose a reasonable consumption path under certain budget constraints, and its utility maximization is expressed as:

$$U = \max \int_{0}^{\infty} u(C, N)e^{-\rho t}dt \tag{2}$$

Where $\rho > 0$ is the time preference rate, C is the consumption of representative families, N is the environmental quality, and $u(C, N)$ is the utility function of consumers:

$$u = \frac{(CN^{\eta})^{1-\sigma} - 1}{1-\sigma} - \theta\frac{T^{1+\omega} - 1}{1+\omega} \tag{3}$$

The budget constraints on consumers are as follows (4):

$$\dot{k} = (1-\tau)Y - C - e \tag{4}$$

where $p\,(t)$ is considered as the carbon dioxide emission reduced in the production process of the product:

$$p\,(t) = z^{\psi}Y \tag{5}$$

According to Zhang et al. [7], represents the reduced carbon dioxide emission level index.

2.1 The Share of Absorbed Input in Green Products with Different Absorbed Proportion

On the basis of Chu et al. [2], the carbon emission reductionin $p(t)$ the production process of products is negatively correlated with the total progress knowledge margin $H(t)$ of the technology department, and positively correlated with the green and low-carbon behavior absorption input $e(t)$. By equation (4):

$$e\,(t) = p\,(t)^{m}\,H\,(t) \tag{6}$$

$m > 0$ is the elasticity coefficient of carbon emission.Among them, assuming that the existing technical achievement $H(t)$ is used to replace the total progress knowledge margin, and $H(t)$ shows a certain exponential growth, then:

$$\dot{H}\,(t) = H\,(t)^{\xi} \tag{7}$$

Referring to Zhang et al. [8], in the third section, we divide green and low-carbon products according to different absorption proportions, so the total absorption investment of products is the sum of three different absorption proportions. So that the absorption input of high absorption products accounts for κ_1 of the total absorption input, the absorption input of medium absorption products accounts for κ_2 of the total absorption input, and the absorption input of low absorption products accounts for $1 - \kappa_1 - \kappa_2$ of the total absorption input. Then the formula (8-10) is obtained:

$$e_1\,(t) = \kappa_1 e\,(t) \tag{8}$$

$$e_2\,(t) = \kappa_2 e\,(t) \tag{9}$$

$$e_3\,(t) = (1 - \kappa_1 - \kappa_2\,)e(\,t) \tag{10}$$

From equation (6):

$$e_i\,(t) = p_i\,(t)^{m}\,D_i\,(t) \tag{11}$$

$e_i\,(t)$ represents the absorption input of green low-carbon absorption products with different absorption proportion. $p_i\,(t)$ refers to the carbon dioxide reduced in the process of producing green low-carbon products with different absorption ratios. Then according to equation (5):

$$p_i(t) = z^{\psi_i} Y \tag{12}$$

Where, ψ_i represents the carbon dioxide emission reduction level index of green low-carbon products with different absorption proportion. According to formula (8-10), the relationship between the proportion of absorption input of high, medium and low absorption products can be obtained:

$$\frac{e_2(t)}{e_1(t)} = \frac{\kappa_2}{\kappa_1} \tag{13}$$

$$\frac{e_3(t)}{e_2(t)} = \frac{1-\kappa_1-\kappa_2}{\kappa_2} \tag{14}$$

From equations (12) and (13):

$$\frac{\kappa_2}{\kappa_1} = \frac{D_2(t)}{D_1(t)} \cdot z^{m(\psi_2-\psi_1)} \tag{15}$$

From equations (14) and (12):

$$\frac{1-\kappa_1-\kappa_2}{\kappa_2} = \frac{D_3(t)}{D_2(t)} \cdot z^{m(\psi_3-\psi_2)} \tag{16}$$

It can be seen from equation (16) that the ratio of the total absorption investment of products to the investment share of green low-carbon absorption products with different absorption proportions theoretically depends on the technical knowledge surplus of green low-carbon products with different absorption proportions, and is positively correlated with the carbon dioxide emission level index reduced by green low-carbon absorption products with different absorption proportions. In other words, the higher the green degree, the higher the absorption investment of products. The total labor force of products includes the sum of the labor force for the production of green and low-carbon products and the labor force of carbon reduction R&D and scientific and technological progress departments, then: $L = L_H + \bar{L}$

2.2 Government Subsidies

In the process of carbon reduction, the government is also actively promoting carbon reduction research and development and scientific and technological progress. Since in the production function, each product of carbon reduction R&D and scientific and technological progress corresponds to the owner of a new technology, the connection between capital and green and low-carbon intermediate products can be established:

$$k = \int_0^H x(t)^\alpha \, dt \tag{17}$$

In green low-carbon products, w_H is set as the average salary of R&D personnel of green low-carbon products, then the overall remuneration of all R&D personnel involved in carbon reduction R&D of green products is $w_H L_H$,u is the price of intermediate products, and the total value obtained by intermediate producers of green low-carbon products is $u\dot{H}$,then the profit of intermediate producers engaged in carbon reduction R&D of green low-carbon products is:

$$u\dot{H} - w_H L_H \tag{18}$$

If the government supports new carbon reduction R&D and science and technology to a certain extent and invests certain subsidies to carbon reduction R&D, if the subsidy rate is set to v, the profit of the R&D Department of green and low-carbon products with the participation of the government is:

$$(1+v)u\dot{H} - w_H L_H \tag{19}$$

To achieve market equilibrium, it is necessary to meet:

$$(1+v)u\dot{H} = w_H L_H \tag{20}$$

At this time, in order to achieve the internal balance of the whole market economy, the monopoly profits obtained by the carbon reduction R&D and scientific and technological innovation departments under the monopoly competition must be used for carbon reduction R&D and scientific and technological innovation. The labor market should be balanced to meet $w_{\mathrm{H}} = w_Y$, so w_{H} is used here to replace the wages of all R&D personnel. Taking into account the labor income tax, the capital constraint at this time becomes:

$$\dot{k} = (1-\tau_Y)Y - (1+\tau_L)w_H L - C - e \tag{21}$$

The capital accumulation process of manufacturers is the income from the sale of final products, excluding the payment of production tax, the consumption of manufacturers, the absorption and investment of products, the remuneration of R&D personnel and the labor income tax of R&D personnel. The government subsidized carbon reduction R&D and scientific and technological progress departments. Drawing on Liu Yong et al. [50], the government collected production tax and labor income tax paid by enterprises.

$$\tau_L w_H L + \tau_Y Y = vu\dot{H} + w_H L_H + G \tag{22}$$

Here, $\tau_L L$ is the labor income tax accepted by the government,$\tau_Y Y$ is the production tax accepted by the government, $vu\dot{H}$ is the government's subsidy to carbon reduction R&D and technological innovation departments, and $w_H L_H$ is the remuneration for R&D personnel, which is the transfer payment of the government. Suppose that the government's transfer payment is a fixed proportion of the total income of enterprises. Order $G = n_g Y$:

$$\tau_L w_H L + (\tau_Y - n_g)Y = vu\dot{H} + w_H L_H \tag{23}$$

According to (20):

$$\tau_L w_H L + (\tau_Y - n_g)Y = vu\dot{H} + (1+v)u\dot{H} \tag{24}$$

According to formula (7):

$$\tau_L w_H L + (\tau_Y - n_g)Y = (2+v)uH^{\xi} \tag{25}$$

According to equation (25):

$$v = \frac{\tau_L w_H L + (\tau_Y - n_g)Y}{uH^{\xi}} - 2 \tag{26}$$

Equation (26) gives the theoretical subsidy rate of the government for the carbon reduction R&D and scientific and technological progress departments of green low-carbon products. It can be seen that it is jointly affected by the labor income tax, production tax, the price of carbon reduction technology and the total progress knowledge margin of carbon reduction R&D and scientific and technological progress accepted by the government.

2.3 Relationship between Product Input and Economic Growth

After exploring the proportion of product absorption investment in green and low-carbon products with different absorption proportion, we also need to explore the relationship between product absorption investment and economic growth under policy intervention, and confirm that product absorption investment can be used as the endogenous driving force of economic growth. Then, according to the production function, constraints and household utility function, and combining all the above factors, the general equilibrium solution of consumer decision-making is obtained by optimization as follows:

$$\begin{aligned} &\max \int_0^{\infty} [u(C,N)\exp(-\rho t)]dt \\ &s.t. \begin{cases} \dot{k} = (1-\tau)Y - C - e - (1+\tau_H)w_H L \\ \dot{N} = bN(1-N) - p(t) \\ \dot{H} = H^{\xi} \end{cases} \end{aligned} \tag{27}$$

Construct Hamilton function for equation (27):

$$J = u(C,N) + \lambda_1[(1-\tau)Y - C - e - (1+\tau_H)w_H L] + \lambda_2[bN(1-N) - p(t)] + \lambda_3 H^{\xi} \tag{28}$$

In equation (28), $\lambda_1\lambda_2\lambda_3$is a Hamilton multiplier. The first order condition of optimization is:

$$\frac{\partial J}{\partial C} = 0, \frac{\partial J}{\partial z} = 0, \dot{\lambda}_1 = \rho\lambda_1 - \frac{\partial J}{\partial k}, \dot{\lambda}_2 = \rho\lambda_2 - \frac{\partial J}{\partial N}, \dot{\lambda}_3 = \rho\lambda_3 - \frac{\partial J}{\partial H} \tag{29}$$

Combining equations (1), (3), (12) and (29), it is obtained that:

$$\frac{\dot{C}}{C} = \frac{1}{\sigma}\{\bar{\alpha}Ak^{\bar{\alpha}-1}e^{\beta}\bar{L}^{\gamma}z[1-\tau+\frac{1}{m}H^{\frac{1}{m}}z^{\frac{1}{m}}Y^{\frac{1-m}{m}} + (\frac{1-\tau}{\psi+1} - \frac{z^{\psi}Hp^{\frac{1-m}{m}}}{m})] - \rho\} \tag{30}$$

3 Conclusion

Given$\frac{\dot{C}}{C} = g$,it can be clearly seen from equation(30): since the greater and, the greater.The research shows that in the endogenous growth model driven by green low-carbon behavior under the background of carbon peak and carbon neutralization, absorbing input, as a new endogenous factor, can promote economic growth to a certain extent. At the same time, the government's theoretical subsidy rate to the carbon emission reduction R$\&D$ and scientific and technological progress departments of green low-carbon products is subject to the labor income tax, production tax, the price of carbon emission reduction technology and the total progress knowledge margin of carbon emission reduction R$\&D$ and scientific and technological progress recognized by the government.

Acknowledgments

This work was supported by National Natural Science Foundation of China (No. 51976085) and Social Science Foundation of Jiangsu Province (No. 18EYB020)

References

[1] A.Bucci. Population Growth in a Model of Economic Growth with Human Capital Accumulation and Horizontal R$\&D$. *Journal of Macroeconomics*, 30(3)(2008): 1124-1147.

[2] H.Chu, C.C.Lai. Abatement R$\&D$ Market Imperfections, and Environmental Policy in an Endogenous Growth Model. *Journal of Economic Dynamics* $\&$ *Control*, 41(4)(2014): 20-37.

[3] F.Yang, C.L.Fan. Is industrial intelligence conducive to China's Pro poor development? *Economic Research*, 632(05)(2020): 154-169.

[4] M.Davin, K.Gente, C.Nourry. Should a Country Invest More in Human or Physical Capital? A Two-Sector Endogenous Growth Approach. *Mathematical Social Sciences*, 76(2015): 44-52.

[5] B.Wan, L.X.Tian, N.Zhu, et al. A New Endogenous Growth Model for Green Low-carbon Behavior and Its Comprehensive Effects. Applied Energy. *Applied Energy*, 230(2018): 1332-1346.

[6] H.Davoodi, H.F.Zou. Fiscal Decentralization and Economic Growth: A Cross-Country Study. *Journal of Urban Economics*, 43(2)(1998):244-257.

[7] Z.Y.Zhang. Research on Environmental Quality under the Rich Endogenous Growth Model – Based on the Joint Perspective of Finance and Finance. *Scientific Decision*, (2021).

[8] X.J.Zhang, J.J.Liu, P.Xie. Whether Government Basic Research Contributes to Economic Growth – An Extension Based on the Theoretical Model of Endogenous Growth. *Inquiry into Economic Issues*, 1(2019): 1-10.