R&D and its impact on the growth of the transportation sector in selected developing countries

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Abstract
Today, R&D is the key to competition and access to modern technologies in the world and plays a major role in innovation, increasing productivity and improving economic growth. The transportation sector, as a prerequisite and infrastructure for development, has a fundamental and efficient role in the fertility of the potential facilities and talents of communities. Therefore, it is necessary to study and identify the factors affecting the growth of this sector. This study examines the effects of R&D expenditures on the growth of the transportation sector in selected developing countries using the data panel model for the period 2007-2018. The results show that the increase in research and development expenditures has a positive and significant effect on the growth of the transportation sector in the countries under study. Trade index and employment variable also have a positive and significant effect on the growth of the transportation sector. Of course, the variable of inflation has a negative impact on the growth of the transportation sector, so that with its increase, the growth rate of the transportation sector decreases.

Keywords: R&D, Growth, Transportation, Developing Countries, Panel Data
JEL Classification: C23, O30, L91.

1. Introduction

One of the most important strategies that make firms sustainable is to strengthen the power of innovation to create and use advanced technology to produce products and do more effective work to meet the needs of society. Economists believe that science and technology, as an effective and powerful tool, can play a key role in the development process. In today's world, developed countries are considered to have a high level of science and technology. Therefore, many products, methods, tools and advanced technologies are due to the development and progress of these countries in science and technology (Bazdar, 1390: 115). The high standard of living, advanced means of transportation by land, sea, air and health conditions in developed countries are the direct results of increasing research and development costs in these countries; So that industrialized countries devote a significant share of their income and labor force to R&D activities. The transportation sector, as a prerequisite and foundation of development, has a fundamental and efficient role in the fertility of facilities and potential talents of communities, which provides an inseparable link between various factors of growth and development through the movement of cargo and passengers.

This issue will strengthen the various economic, social and cultural sectors of the countries as soon as possible and expand. Thus, it shows its role and importance as one of the most effective indicators of growth and development. Paying attention to the optimal use of the capacities of this sector and determining policies to increase its efficiency is of great importance (Heidzadeh and Sokhanvar, 2016: 13). In proportion to the development of communities, the need for fast, safe and cheap transportation is growing day by day. So that today's transportation industry is an increase in gradual evolution and fundamental changes in human life and fundamental changes in production, distribution, consumption and technical advances and causes the establishment of various economic, social and It becomes the culture of countries (Mahmoudi, 1997: 3). In fact, transportation is one of the basic sectors of the economy, which has become the basis of trade exchanges and the key to economic and social development by influencing the process of economic development. In today's situation, transportation is considered as one of the important components of the national economy and due to its infrastructure role, it has a great impact on the country's economic growth process. This section includes activities that are widely used in all fields of production, distribution and consumption of goods and services and has an undeniable role in the set of economic activities. Transportation connects different sectors of society towards sustainable development and is a mediator between agricultural, industrial, commercial and service activities at the national and international levels. Transportation also plays an important role in income distribution and reducing economic and social inequalities and reducing the effects of poverty and income disparities between villagers and urban dwellers. Without the transportation network, facilities and ancillary equipment and the desired fleet, it seems impossible to imagine the general growth and development of the country. The role of transportation systems in optimizing costs, travel time, speed of movement, safety and level of services provided in the growth and development of the world economy and trade at the present time and its expansion cannot be denied. Macro-level studies show that investment in transport increases the economic growth of countries and by investing in social returns in private investment leads to investment in transport infrastructure. Meanwhile, R&D expenditures in the transportation sector are considered as one of the influential and important factors in the development of economic science and technology in that sector, and efficient and correct management of R&D activities can accelerate the growth of the transportation sector (Bazdar, 1390: 116).

Therefore, the present study seeks to examine the effects of R&D expenditures on the growth of the transportation sector in Iran and selected developing countries in the period 2005 to 2018. In the following, first the theoretical foundations of the research topic are discussed and then the study records are examined. Then the research methodology and the results obtained from the model estimation will be discussed and in the last part the conclusions will be discussed and suggestions will be presented.

2. Theoretical foundations

R&D is the main factor of innovation and technical changes in the production process and therefore have a significant role in increasing the productivity of society or the economic growth of that society. Therefore, to show this role in the transportation sector, a nonlinear model of the production function is used, which is based on the theoretical form of the Cobb-Douglas function. In these models, the technological process results from research and innovation, and the discovery of new technologies increases productivity, and such discoveries are ultimately the source of long-term growth. The main equations of these models are as follows:

$$Y = K^{\alpha}(AL_y)^{\beta} \quad (1)$$

$$\frac{\dot{A}}{A} = \delta L_A \quad (2)$$

In the above relations, Y is product, A is productivity or knowledge, and K is human capital. Labor is used in both product production (L_y) and research for innovation (L_A). Thus, the total workforce (L) consists of the following two components:

$$L_Y + L_A = L \quad (3)$$

In these models, the R&D workforce (L_A) is related to the growth rate of technical knowledge ($\frac{\dot{A}}{A}$). Romer (1990) assumes that the size of the labor force is constant, so the economy is in a state of equilibrium, and they follow the path of equilibrium growth when the share of labor in the R&D sector is constant. In this direction of growth, per capita product and the ratio of capital to labor grow at the same rate, and these growth rates are equal to the growth rate of total factor productivity (Bazdar, 1390: 120).

R&D-related endogenous growth patterns have been proposed by economists such as Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992), and Jones (1995). Romer's model is based on three logical hypotheses:

- Technological change is at the core of economic growth.
- A large part of technological change is due to the voluntary performance of people and economic agents, which is also motivated by market motivation and profit. So technological change is endogenous.
- Knowledge is fundamentally different from other economic goods because if we bear the cost of creating and creating a set of knowledge once, we can use that knowledge many times without any other cost. In other words, creating new knowledge requires only a fixed initial cost.

In this model, it is assumed that in any economy, there are 3 sectors. The first part is the R&D part, which uses human capital and the existing volume of knowledge to produce new knowledge; In particular, in this section, plans are presented for the production of new durable goods. The second part is the intermediate goods sector, which uses the designs of the R&D sector and unused production to produce a large number of new durable goods that can be used in the production of final goods. The third part is the production of final goods that use labor, human capital and a set of durable goods to produce final goods that can also be consumed or saved as new capital.

Simple assumptions such as population stability, labor supply, and market capitalization; The use of R&D sector only human capital and the volume of knowledge and lack of depreciation are among the hypotheses of this model. The production function in the final goods section of this model is considered as the following equation:

$$Y(H_Y, L, x) = H_Y^{\alpha} L^{\beta} \sum_{i=1}^{\infty} x_i^{1-\alpha-\beta} = H_Y^{\alpha} L^{\beta} \sum_{i=1}^{A} x_i^{1-\alpha-\beta} \quad (4)$$

So that L, H_Y and $x_{(i)}$ are labor, human capital and capital goods used in the production of final goods, respectively. As can be seen, this production function is homogeneous of degree 1. The difference between this production function and the conventional production function is that in this production function, the production technology has entered the production function indirectly through physical capital. Also, unlike the conventional production function, physical capital is made up of an unlimited variety of durable goods. Roemer states that due to the symmetry in the model, all capital goods are offered at the same level, and therefore shows the production function of the final goods as equation (5):

$$Y = H_Y^{\alpha} L^{\beta} A \bar{x}^{\,1-\alpha-\beta} \quad (5)$$

Where $\bar{x}$ represents the capital goods used to produce the final goods. Each durable product is produced by a manufacturer who has a monopoly on the intermediate goods sector. The sole proprietorship produces a unit of durable goods by purchasing a plan for the production of durable goods from the R&D sector and using λ units of final goods. If firm i produces $x_{(i)}$ units of durable goods I, it will lease them to firms producing final goods at price P (i). Due to the lack of depreciation in the model, the value of a unit of durable goods I is also equal to the present value of the rental income that the goods can generate in an indefinite period of time. Since firm i is the sole seller of capital goods I, we are faced with a downward demand curve for that commodity, which is derived from maximizing the profits of firms in the final commodities sector. In this model, total capital is represented by Equation (6):

$$\dot{K}(t) = Y(t) - C(t) \quad (6)$$

Where C (t) and $\dot{K}(t)$ represent the total consumption at time and the changes in capital stock at time t, respectively. Because the λ consumption unit is omitted to produce one unit of any durable goods, the size K can be related to the durable goods actually used in production. So, we can write:

$$K = \lambda \sum_{i=1}^{\infty} x_i = \lambda \sum_{i=1}^{A} x_i \quad (7)$$

As can be seen, unlike L and H, which are assumed to be constant, K grows based on neglected consumption. The process of accumulating new designs (A (t)) also depends on the amount of human capital allocated to the R&D department and the availability of available knowledge. So, the following relation can be written for the R&D department:

$$\dot{A} = \delta H_A A \quad (8)$$

Where H_A is the total human capital employed in the R&D sector, A is the available knowledge of the economy and δ is the efficiency parameter. As shown in Equation (8), the production of new designs is a linear function of the human capital employed in the R&D sector and the amount of knowledge available. The linearity of relation (5) with respect to A indicates the infinite growth of knowledge. Also, relation (8) has two implications: one is that the use of more human capital in the R&D sector leads to an increase in the production rate of new projects and the other is that the greater the volume of existing knowledge, increases the productivity of human capital in the R&D sector. (MotafakerAzad et al., 2011: 171).

After producing a design and offering purchase offers by suppliers, the design is sold to the firm that offered the highest price. According to Romer, price is derived from Equation (9):

$$P_A = \frac{\alpha+\beta}{r}(1-\alpha-\beta)H_Y^{\alpha}L^{\beta}\bar{x}^{1-\alpha-\beta} \quad (9)$$

According to Equation (9), households also decide on consumption and savings at a given interest rate to achieve maximum utility. At the general level, H_A and H_Y are related by $H = H_A + H_Y$, which indicates that households provide a fixed amount of human capital.

Romer believes that long-run equilibrium occurs when variables A, K, Y, and C grow at the same constant rate. Romer also states that in the long run, the payoff for human capital will be equal in both R&D and the production of finished goods. So, in the long-run equilibrium state, equation (10) can be considered:

$$W_A = W_Y \Rightarrow P_A \delta A = \alpha H_Y^{\alpha-1} L^{\beta} A \bar{x}^{1-\alpha-\beta} \quad (10)$$

Where P_A represents the price of the plan purchased by the monopolist, the value of which is obtained from Equation (9). By placing P_A from Equation (9) to Equation (10) we have:

$$H_Y = \frac{\alpha}{\delta(1-\alpha-\beta)(\alpha+\beta)} r \quad (11)$$

As can be seen, in the long-run equilibrium, H_Y is constant. Given $H = H_A + H_Y$, we can say that in the long run, H_A is also constant. Therefore, considering Equation (8), it grows in the long-run equilibrium state A at a constant rate δH_A. Roemer also shows that in the long-run equilibrium state, K, Y, and C also grow at a constant δH_A rate. Therefore, in the long-run equilibrium, the equilibrium growth rate can be considered as follows:

$$g = \frac{\dot{C}}{C} = \frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{A}}{A} = \delta H_A \quad (12)$$

Considering Equation (11) and the limit $H = H_A + H_Y$, we can also write the equilibrium growth rate in terms of interest rate (r):

$$g = \frac{\dot{C}}{C} = \frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{A}}{A} = \delta H_A = \delta H - \frac{\alpha}{(1-\alpha-\beta)(\alpha+\beta)} r \quad (13)$$

Romer presents the following results with respect to Equation (13):

In the long run, as the human capital employed in the R&D sector (H_A) increases, the growth rate of the economy increases, thus creating a strong correlation between the allocation of resources in the R&D sector and the economic growth rate.

The opportunity cost of human capital working in the R&D sector is equivalent to the income that can be earned in the production of final goods. The return on human capital employed in the R&D sector is also equal to the present value of the net income that a project will generate in the future.

So, if the interest rate is higher, the present value of net income will be lower, and then less human capital will be allocated to the R&D sector, which in turn will lead to a reduction in the equilibrium growth rate (Romer, 1990: 78-93). Grossman and Helpman (1991) and Aghion and Howitt (1992) in their endogenous growth models also predict a strong and strong relationship between R&D investment and economic growth. Also, in Jones' (1995) model, he argues that higher R&D costs only lead to higher production levels and do not meet faster long-term growth.

3. Research background

Lin and Raza (2020) have examined the impact of energy substitution in Pakistan's transportation sector from 1991 to 2018 using the VAR model. The results show that by increasing capital and energy technologies, maximum production can be achieved. By allocating maximum capital to the transportation industry, energy-saving technologies, energy-to-capital substitution, and capital-to-capital substitution technologies can enhance environmental protection.

Heidarzadeh and Sakhnour (2016) in a study have studied the economic effects of transportation infrastructure costs in developing countries using the GMM method in the period 2000 to 2014. The results show that the impact of government spending on transportation infrastructure (rail and air) on economic growth is significant.

Bazdar (2015) has investigated the effect of investment on the economic growth of Iran's road transportation sector using the neoclassical growth model in the period 1353 to 1389 using the VAR method. According to the research findings, a one percent increase in the ratio of investments made in the road transportation sector to the GDP of that sector will increase the value-added growth rate of this sector by 0.213 percent and increase the growth rate by one percent. The labor force working in the road transportation sector will increase the value-added growth of this sector by 0.389 percent.

Ketabforoush et al. (2013) in a study have examined the effects of R&D on the growth of the transportation sector in 9 selected developing countries in the period 2000 to 2007. The results show that R&D has a positive and significant effect on the growth of the transportation sector.

Pradhan and Bagchi (2012) in a study of the effects of transportation infrastructure on India's economic growth using the VECM model in the period 1970 to 2010. The results show that there is a two-way causality between road transportation and economic growth.

Bazdar (2011) in a study has analyzed the role of R&D on the growth of the transportation sector in Iran using endogenous and exogenous growth patterns in the period 1347-86. The results show that the index of the degree of openness of the economy, changes in the price index of goods and services and the size of government have a positive and significant role on the growth of this sector. Virtual variables for the war period and the time of the revolution also have a negative effect on economic growth.

Goo (2011) examines the effects of R&D costs on the transportation sector using an endogenous growth model. The results show that R&D costs in the transportation sector have a positive and significant effect on the growth of this sector.

Tseng (2007) in a study examined the effect of R&D on value added and production of 219 Taiwanese electronics companies in the period 1990-2003. The results show that R&D has a positive and significant effect on sales and value added of the companies under study.

Akkoyunlu et al. (2006) investigated the effect of R&D and imports on the production and labor productivity of the 12 sectors of Turkish production in the period 1994-2001 using panel data model. The results show that R&D and import costs have a positive and significant effect on labor production and productivity.

4. The Model of Estimation

4.1. Introducing models and variables

The statistical population of this study includes 15 developing countries: Argentina, Brazil, Chile, China, Colombia, India, Malaysia, Iran, Mexico, Honduras, Tajikistan, Kazakhstan, Kyrgyzstan, Turkmenistan and Turkey. The time period used is 2005 to 2017. The time series data of these countries has been collected from WDI2021.

The model introduced in this research, inspired by the Bazadar (2011) is as follows:

$$LTRANS_i = \beta_0 + \beta_1 L(R\&D_i) + \beta_2 L(TRADE_i) + \beta_3 L(P_i) + \beta_4 L(EMP_i) \quad (14)$$

$LTRANS_i$= Logarithm of the amount of investment in the transportation sector for country i in dollars

$LR\&D_i$= R&D logarithm for country i in dollars

$LTRADE_i$= Trade index logarithm (ratio of total exports and imports to GDP) as a percentage of GDP for country i

LP_i= Logarithm CPI of country i

$LEMP_i$ = Employment logarithm of country i in terms of the ratio of active population over 15 years to total population

4.2. Estimation method

The econometric model used in this research is based on panel data. In the panel data model, the data are time-series and cross-sectional, i.e., the data is measured over time between sections. According to the principles and foundations of econometrics, the model is estimated by the ordinary least squares (OLS) method and the coefficients of β are obtained.

4.2.1. F-Lymer test

According to the econometric literature of panel data, in order to homogenize the data and as a result of using the panel data estimation method, F-Lymer statistic is tested. The results of F-test statistics indicate that it is significant to use the panel data method instead of the aggregated least squares method.

4.2.2. Hausman test

The Hausman test is used to determine which method (fixed effects and random effects) is suitable for estimating data panel models. In the component regression of the error, a very important assumption is that $E(U_{it}/X_{it}) = 0$. In other words, the error sentence, which includes individual effects, is independent of the explanatory variables. In the random effect model, iμs are independent of X_{it}. Because iμs are in the error sentence, it can be assumed in the random effect model that E (U_{it} / X_{it}) =0, but in the fixed effect model this assumption is no longer valid; Because μ_is are correlated with X_{it}. Since he made decisive judgments about the choice of the random effect or fixed effect model. Hausmann provides a test to correctly identify a model that is a fixed effect or a random effect.

If the effect model is not random then E (U_{it} / X_{it}) will be the opposite of zero. Therefore, if the hypothesis H_0 is tested and the value of the statistic χ^2 is examined and its probability value is less than the significant level of α, the hypothesis H_0 is rejected and the hypothesis opposite H_1 which expresses the same fixed effect is accepted. The model is accepted with a fixed effect (Ashrafzadeh and Mehregan, 2010: 135).

5. Research findings

5.1. Unit root test results

In this research, Levine, Lin and Chou (LLC) test, which is one of the most important unit root tests in panel data, has been used. The test results are presented in Table 1.

Table (1): The results of LLC unit root test for model variables

Variables	T-stat	Prob	Condition
LTrans	-1.6878	0.0457	Stationary
LR&D	-8.7546	0.0000	Stationary
LTrade	-6.1125	0.0000	Stationary
LP	-3.7776	0.0001	Stationary
LEMP	-7.1903	0.0000	Stationary

Source: Research findings

As can be seen from the results in Table (1), All the variables in the model are stationary. After the unit root test of the studied variables, the next tests of the data panel method will be reported.

5.2. Results of F-Lemmer and Hausman tests

According to Table 2, the probability value of the F-test statistic indicates that the use of the fixed effects method would be more appropriate. Also, Hausman test statistic indicates the appropriateness of using the fixed effects method to estimate the model.

Table 2: Results of F and Hausman tests to estimate the model

Test	F lymer test	Housman Test
Statistics	3.8483	15.2508
Prob	0.0011	0.0042

Source: Research findings

5.3. Estimation results

Accordingly, the results of estimating the model introduced to determine the pattern of the effect of R&D on investment growth in the transportation sector using the fixed effects method of data panel are presented in Table 2. It should be noted that due to the logarithmic nature of the model under study, the coefficients of the variables represent the elasticity.

Table 2: Results of estimating the effect of R&D on investment growth in the transportation sector

Variables	Coefficient	T-stat	Prob
LR&D	0.3812	2.6320	0.0092
LTRADE	0.4912	3.3622	0.0009
LP	-0.5361	-3.9771	0.0001
LEMP	0/1647	0.7230	0.4704
R^2= 0.8732	R^{2bar}= 0.8136	D-W= 1.71	

Source: Research findings

As the results show, the elasticity of investment growth in the transportation sector compared to R&D is equal to 0.38. This means that, one percent increase (decrease) in R&D, investment in the transportation sector increases (decreases) by 0.38 percent, which is a sign that agrees with economic theories and is also statistically significant. It can be concluded that R&D is effective on investment in the transportation sector.

In addition, it can be concluded from Table (2) that trade has a positive and significant effect on investment in the transportation sector equal to 0.49. That is, with a 1 percent increase in trade, the transportation sector will grow by 0.49 percent.

The elasticity of inflation to investment in the transportation sector is -0.53, which indicates an inverse relationship between inflation and investment in the transportation sector.

The estimated elasticity related to the employment variable is equal to 0.16 and positive. This means that with an increase (decrease) of one percent in the employment rate, investment in the transportation sector increases (decreases) by 0.16 percent. Of course, this variable is not statistically significant.

R^2 estimated by the model is equal to 0.81. This indicates the high explanatory power of the independent variables and indicates the high percentage of reliability of the results. There is no correlation in the estimated model itself, and Watson 1.71 confirms this.

6. Conclusion

The transportation sector has a significant impact on economic, social and cultural activities and the basis of economic development of any country. Transportation is one of the important indicators of development and plays an important role in development.

This sector, in the short, medium and long term, affects the main variables of the country's economy such as total production, production in economic sectors, total employment, employment in economic sectors, prices in different economic sectors and the cost-of-living index. Short-term effects include effects on the increase or decrease in the cost of living directly through the transportation costs of each household and indirectly through the impact on the prices of other goods and services affected by transportation prices.

The medium-term effects include the effect of transportation prices on the consumption of alternative services such as communications, and the long-term effects are related to the change in the basis of economic calculations of production and development plans. In general, the composition of production activities in each region and, consequently, the composition of the production context, employment composition, production volume, per capita income volume and other economic variables can be affected by changes in the price of transportation services.

Today, R&D expenditures are very important in the process of development and progress of different societies. The transportation sector, as a prerequisite and infrastructure for development, has a fundamental and efficient role in the fertility of the facilities and potential talents of communities. Identifying the factors affecting the growth of this sector will lead to the optimal use of the capacities of the transportation sector and determine policies to increase efficiency.

In this study, the effects of R&D expenditures on the investment growth of the transportation sector for 15 developing countries were investigated using the data panel model for the period 2007-2018. The results showed that R&D expenditures have a positive and significant effect on the growth of investment in the transportation sector. The trade index also had a positive and direct effect on the growth of investment in the transportation sector. Meanwhile, inflation had a negative effect on the growth of investment in the transportation sector, so that with the increase in inflation, the growth rate of investment in the transportation sector decreased. The results also showed that employment has a direct relationship with the growth of investment in the transportation sector, although this variable was not statistically significant.

The following suggestions are also made to increase the role of R&D on the growth of the transportation sector:

1- Increasing the growth rate of R&D expenditures by providing more credits in research affairs;

2- Increasing the share of specialized labor force in the transportation sector;

3- Increasing government support for investment in the R&D sector;

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