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Impact of Health Capital on Total Factor Productivity in Singapore
(Impak Modal Kesihatan ke atas Jumlah Produktiviti Faktor di Singapura)

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ABSTRACT

The significance of health capital as a major determinant of economic growth and productivity was highlighted through the work by Jeremy Bentham (1780). In subsequent era, economists likewise acknowledged that individual and population health could be one of the important determinant of productivity and economic growth. This paper examines the impact of health capital on multi-factor productivity (hence TFP) in Singapore covering the period of 1980-2013. The finding from the Autoregressive Distributed Lag (ARDL) bound test shows that there is stable and long run co -integration between TFP, health capital, and education. The long run estimate shows that health capital and education makes a positive and substantial contribution to TFP. This indicates that the TFP of Singapore could be substantially improved if spending on health capital and education are increased accordingly.

Keywords: Health capital; health expenditure; total factor productivity; Autoregressive Distributed Lag; Singapore.

ABSTRAK

Tumpuan ke atas modal kesihatan sebagai faktor utama mempengaruhi pertumbuhan ekonomi dan produktiviti bermula pada awal tahun 1780 menerusi kajian Jeremy Bentham (1780). Kesedaran terhadap kepentingan kesihatan individu dan penduduk sebagai penentu produktiviti dan pertumbuhan ekonomi juga telah disokong oleh ramai ahli ekonomi. Kertas ini mengkaji kesan modal kesihatan terhadap jumlah faktor produktiviti di Singapura meliputi tempoh 1980-2013. Penemuan dari ujian sempadan 'Autoregressive Distributed Lag (ARDL)' menunjukkan bahawa terdapat kointegrasi jangka panjang yang stabil antara jumlah faktor produktiviti (TFP), modal kesihatan dan pendidikan. Model jangka panjang juga mendedahkan bahawa modal kesihatan dan pendidikan menyumbang secara positif dan signifikan ke atas TFP. Ini menunjukkan bahawa jumlah faktor produktiviti Singapura dapat ditingkatkan dengan ketara jika perbelanjaan ke atas modal kesihatan dan pendidikan ditingkatkan.

Kata Kunci: Modal kesihatan; perbelanjaan kesihatan; jumlah faktor produktiviti; Autoregressive Distributed Lagged; Singapura.

INTRODUCTION

Health as one of the causes of productivity and economic growth was highlighted in the seminal work by Jeremy Bentham in 1780 (Idowu et al. 2017). Bentham characterizes well-being (health) as the surface of pleasure, happiness over pain and, in addition, the contrast between health and ill health that he later associates with destitution, poverty, unhappiness, disease and hunger (Collard 2006; Idowu et al. 2017). Meanwhile, the World Health Organization (2000; 2002) defined health as a condition of complete physical, mental and social well-being. Therefore, since happiness is derived from pleasurable conditions, healthier conditions and lack of pain, policymakers need to ensure the happiness of society through a healthy life.

Basically, the speculative association between well-being and steady growth of the economy's productive capacity was first observed as the effect of disease on the efficiency of work (Bridbury 1973 ; Cohn 2007 ; Robbins 1928), alongside a review approach that draws the connection between health status and economic progress (Fogel 1986). Accordingly, economists have verified the importance of population health as an essential determinant of efficiency and steady development of the economy, and have concluded that individuals are investing in health to be endowed with productive time, which will allow them to gain income and revel in a longer lifetime. This implies that health well-being as a central component of human capital and crucial determinant of efficiency and economic sustainability. In view of this, the causes or determinants of economic growth and efficiency were a vital issue among economists, even ideally from the time of economic pioneers in the 18th and 19th centuries as well as among other classical economists. However, the extent to which health contributes to total productivity factor (TFP) or output growth has involved constant discussions.

The economic model of health capital, according to Arrow et al. (2014), emphasized strongly that health affects human well-being through three distinct channels: direct well-being, productivity, and longevity. Mankiw et al. (1992) were the first to consolidate well-being as a human capital feature in the economic growth model by expanding the Solow growth model due to the direct and indirect benefits that health improvements bring to individuals. The direct effect is in terms of longer and better lives, meanwhile, the indirect effect assumes that a healthier labor force tends to be more productive and efficient, which would eventually raise the national income (Chaudhry et al. 2013). Grossman (1972; 2000) initiated the concept of health capital and argues that human productivity can be raised by increasing the human's stock of knowledge and health. This implies that good health has a positive and significant impact on the aggregate productivity. He emphasized that health capital (a human capital component) can be viewed as both consumption and an investment good that can be demanded and produced. He argued that individuals choose their health and lifespan dimensions based on their initial endowment of a certain amount of health that depreciates over time, but can be replenished by investments in medical care, diet, exercise, etc. However, the health dimension relies heavily on the measurement of the resources allocated to health production by the individual (Nocera & Zweifel 1998).

Regardless of the fact that health capital has been recognized for quite some time as one of the components that could invigorate efficiency and economic development, nevertheless, to the best of our cognition, there is lack of study focusing on the effect of health capital on productivity, especially in the case of Singapore. Since its independence in 1965, in addition to producing consistent and high GDP growth rates, Singapore succeeded in providing better healthcare services and healthcare financing. Singapore's health care system has effectively gain ground throughout the nation's history (How & Fock 2014). Singapore has taken dynamic measures to gain top rankings in the provision of health care services given its successful economy, strong educational system, proper environmental sanitation facilities, good water drainage system and high influx of foreign direct investment (Haseltine 2013; Lim 1998). Like other countries, Singapore viewed that the three WHO healthcare elements (i.e., a sufficient range of health care services, appropriate quality and affordable to all citizens) are the basic privileges of the general population, as cherished in the Universal Declaration of Human Rights, (How & Fock 2014; Haseltine 2013). A major feature of Singapore's health care system transition is its strong healthcare infrastructure which is supported by a unique mixed-financing system, (Lim 2017). Similarly, the use of market-based mechanisms to promote competition and transparency, technological adoption to improve the delivery of health care services and the healthcare spending approximately 4% of the country's GDP are the key factors as well (Haseltine 2013).

Despite the fact that Singapore's healthcare expenditure is relatively less in terms of its share of GDP in comparison to other countries, its uniqueness have produced outstanding health outcomes and has received recognition and awards worldwide. For example, in 2000, the WHO ranked Singapore sixth out of 191 countries, based, on its health status, responsiveness, equity, and ranked first in 2014, second in 2018 by Bloomberg in efficiency in terms of overall performance in healthcare service maintenance. Given these health care achievements, it is reasonable to say that Singapore's health care service is considered among the best in the world (Lim 1998; WHO 2000; 2002). The infant mortality rate fell to 2.1 per 1000 by 2007 from 35 per 1,000 live births in 1960. This low rates recorded were only recorded in Luxembourg (1.8), Iceland (2.0), Sweden (2.5), Japan (2.6) and Finland (2.6). Some have commended this achievement, despite Singapore is having less health care expenditure (4 %) compared to Luxembourg (7.3%), Iceland (9.3%), Sweden (9.1%), Japan (8.1%) and Finland (8.2%) and the lowest compared to its Asian counterparts (Tilak 2002).

However, since health has been regarded by OECD as a major issue in terms of the future growth of any economy, one cannot assume that previous health gains in Singapore will continue (OECD 2004). This is because non-communicable diseases (NCDs) such as cancer, coronary heart diseases, strokes, pneumonia, diabetes, hypertension and injuries remains the major causes of death in the country (Low et al. 2015). Similarly, Singapore has the second highest rate of diabetes among the developed nations and the percentage of individuals aged 18–29 years suffering from diabetes doubled from 2004 to 2010 (Phan et al. 2014*)*. The most disturbing health awareness issue is that Singapore's teens are not active enough and this could lead to health problems in later stages, which may in turn affect the country's TFP and economic growth (Chia et al. 2013). Several scholars have highlighted that a healthy population is very much linked to increased productivity (Alexa et al. 2016; Bloom et al. 2004; Grossman 1972; Leibenstein 1957; Mitchell & Bates 2011; Piabuo & Tieguhonndg 2017). For instance, Leibenstein (1957) contended unequivocally that better nutrition is tied to individual health status, while healthy population is connected to an increase in productivity over the long haul. Similarly, Grossman (1972) supported this argument by presuming that human productivity can be raised in both market and non-market activities, as a result of an increase in human's stock of knowledge and health. This implies that good health has a positive and significant effect on the aggregate productivity. In corroboration, Lucas (1988) and Romer (1990) further extended this view by accentuating that that to increase earnings, productivity and economic growth, individuals must invest in health capital. This is because health conditions and lifestyle risk factors could contributes to workplace productivity loss (Mitchell & Bates 2011)

As mentioned earlier, Singapore enjoyed continuous high economic growth, regardless of the state of the world economy due to the fact that the country is globally connected and exports driven. However, Singapore productivity from 1960 to date has been pro-cyclical, in the sense that the contribution of two vital components of productivity, i.e. labor productivity and capital productivity (Figure 1) has not been consistent with upward and downward trends. Productivity refers to the efficiency in which productive inputs or factors are converted into outputs of goods and services (Asian Productivity Organization [APO] 2013). Figure 1 reveals an increasing trend in labor productivity and total factor productivity from 1980 to 2008 while capital productivity seems to be decreasing. This could be due to the convergence of polytechnic certificate holders and college or university graduates joining the labor force and the impacts of skills upgrading of the existing labor force. From 2009 to 2013 Singapore's TFP has been increasing owing to its higher capital and labour productivity growth and also due to the economic recovery in 2009 (Stat 2015).

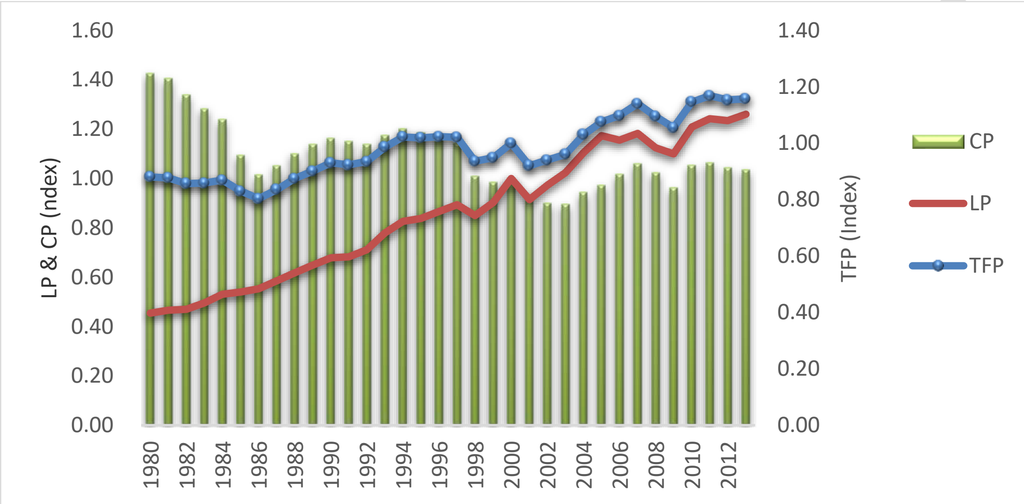


FIGURE 1. Singapore Total Factor Productivity, Labor Productivity and Capital Productivity (Index)
Sources: APO (2015), Productivity Data, Online Database

Literature has highlighted various determinants of productivity, however, there is less emphasis on the role of health capital (measured using healthcare expenditure) which is the focus of the present study. Figure 2 reveals that TFP and health expenditure showing an increasing trend, however the health care expenditure was relatively low in the 1980's before increasing significantly after 2001. During this period, TFP were generally high, especially in the 1990s. It is observed that TFP continues to increase in line with a surge in the healthcare expenditure from 2002 to 2013. Thus, this triggered our interest to study whether there is any empirical relationship between health expenditure and TFP in the case of Singapore. Theoretically, health capital has been regarded by most economists as a major issue in terms of the future growth of any economy. By global benchmarks, Singapore's state of health capital indicators has been hugely improved since 1965 (Lim 2017). This improvement has contributed positively to the education, living standards and the quality of healthcare services (MOH 2018). Moreover, Singapore is ranked as having the most efficient health care system in the world (Bloomberg 2014) which is also reflected in the improvements of various healthcare indicators. Nevertheless, it is unclear whether the significant improvement in the health outcomes has any influence on the total factor productivity. Thus it is crucial to empirically examine whether health capital has any role to play in explaining the increasing trend observed on Singapore's total factor productivity. This is particularly important in formulating appropriate policies to stimulate the contribution of health capital to the overall performance of the economy. There are several studies on the determinants of economic growth and TFP in Singapore (Maitra 2016; Osman-Gani 2004; Young 1994), however, most of these studies have related growth and TFP to other macroeconomic variables, except to the health capital. To the best of our knowledge, the only study that has examined the impact of health on productivity is by Cole and Neumayer (2006). Cole and Neumayer (2006) examined the direct impact of poor health on cross-country aggregate productivity levels. They estimated the TFP using production function and then estimate the determinants of TFP by focusing on three health indicators, namely: malnutrition, malaria and waterborne diseases). Hence, this study intends to fill the void by addressing the question on whether health capital has any short run and long run impact on Singapore's total factor productivity.

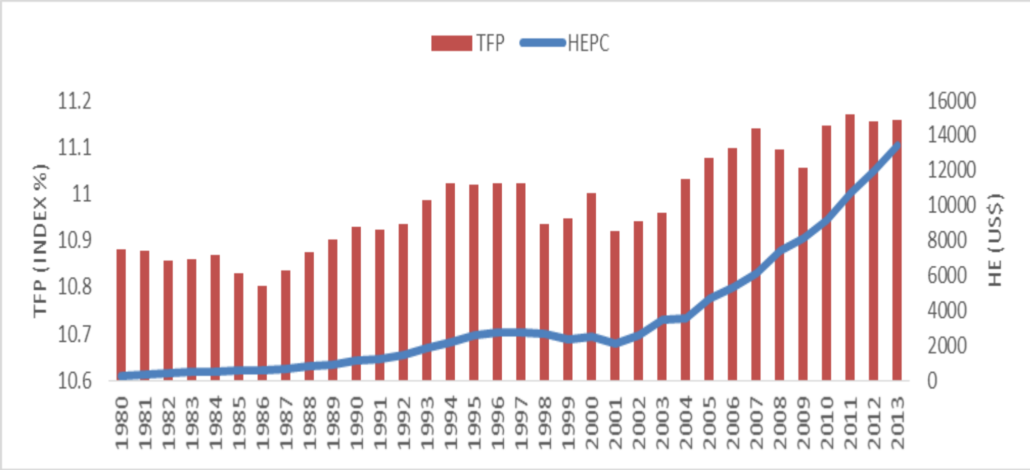


FIGURE 2. Singapore's Total Factor Productivity (Index) and Health Expenditure (Constant US)
Sources: *World Bank (2014), World Development Indicator, Online Database*

Even though, Singapore was able to register high GDP growth rate for past three decades (1980 to 2010) and widely recognized for its well-established and efficient health care system, however, it is not known whether these positive economic achievements has any significant impacts on the TFP. Theoretically, it is asserted there is positive link between health wellbeing and labour productivity. Nevertheless, there is no or less empirical studies that has been conducted to show whether the vast improvement in the country health care services has any impact on Singapore's TFP. An undisputed certainty in regards to Asian regional development was that from 1960 to 1990, the region encountered a strong and solid economic performance, and separated from China and Japan, the four Asian Tigers (Singapore, Taiwan, Hong Kong, and South Korea) recorded the most noteworthy economic growth. To numerous researchers, the four Asian tigers experienced exceptional growth through physical capital investment, trade openness, high saving rates, productive human capital development and viable macroeconomics policy (World Bank 1993). Singapore has been of particular interest in the present study because of its phenomenal economic growth coupled with its remarkable improvement in health care. Although, Singapore's economic growth can be ascribed to carefully planned policies, but the country's initial focus on preventive health and higher stock of other human capital can also be viewed as of the determinant of its TFP and economic growth.

Voluminous studies have been undertaken to examine the causes of economic growth or the variation in income among countries, but the findings are rather mixed up with different views regarding the most influential factors affecting economic growth. These includes trade openness, high saving rates, physical capital, human capital, productivity, technological advancement, gains from specialization and innovation (Collins & Bosworth 1996; Dahlman & Westphal 1981; Dahlman et al. 1987; Kim & Lau 1994; Lan 2001; Page 1994; Romer 1993; Sarel 1996; Sickles & Cigerli 2009;Young 1994), increased investments, higher life expectancy, female labor force participation and the decline in child and infant mortality rates (Bloom et al. 2009; Lee et al. 2000; Leipziger & Thomas 1993).

While most studies on human capital-economic growth nexus used education and skills as proxies for human capital, several studies have attempted to incorporate health as a noteworthy constituent of human capital (Arrow 1963; Bloom et al. 2004; Grossman 1972; Knowles & Owen 1995, 1997; Mushkin 1962; Schultz 1961). These studies have highlighted that investment in health positively affects economic development. Nevertheless, we find that most of the existing literature did not incorporate health capital as one of the determinants of total factor productivity or economic growth (Idowu et al. 2018). This is probably because health-related issues are more challenging and does not have a unified database (Bui et al. 2015). Although various research has been carried out in developed and developing countries, the case of Singapore remains extraordinary and has never been examined before. The overall reputation of Singapore in social policy frameworks and health funding, it's accomplishment of the WHO millennium goals in the 1980s and the well-recorded economic growth from 1970 to 1990, truly set off the research interest on the impact of health capital on TFP in Singapore.

The present study contributes in two way by complementing to the scarce empirical literature on the health capital-TFP nexus and also provide some insights on policy implications. As for the sample country used in the present study, many researchers have justified the role of non-health factors as the determinants of TFP, except the health or health capital despite the fact that Singapore is well known for its well established healthcare system and services. The present study enhances the existing theoretical framework of health-TFP nexus by examining the two human capital components, i.e. health capital and human capital. Moreover, we also used other determinant of TFP such as domestic investment. As for the policy implication, since the return on expenditure on healthcare services is in the future, frantic efforts need to be established to explicitly evaluate the returns to public health investment in monetary terms so that they can be more directly compared to alternative investment projects. Although, recent studies such as Tilak (2002), Osman-Gani (2004) and Maitra (2016) have addressed the issue of human capital stock on Singapore's economic growth or economic development, but there were no studies that have been undertaken to examine the potential role of health capital on the total productivity factor in Singapore. The remainder of this paper is organized as follows. The following subsection provides a brief overview on the performance of Singapore's healthcare services and total factor productivity. Section 2 provides a review of the related literature. Section 3 presents the methodology, including the empirical framework, model specification, and estimation methods and data sources. Section 4 discusses the empirical findings and the final section concludes with some policy recommendations.

LITERATURE REVIEW

Analyses on what causes economic growth has invariably been a noteworthy issue among economists (Acemoglu 2012). Economists generally agrees that the size of any nation's output and its TFP is governed by various determinants (Mussa 2000). This includes stock of knowledge, infrastructure, institutions, trade openness, competition, financial development, geographical factors, capital intensity or deepening, innovation or R&D, technology transfer via FDI, technology adoption, absorptive capacity and human capital (Isaksson 2007; Syverson 2011). Mankiw et al. (1992) was the first to suggest that health is a vital element of human capital in the determination of economic growth. Meanwhile, Bleakley (2010) stressed that although health is considered as both human capital and an input that could be used to produce other forms of human capital, health also has a significant impact on other non-health determinants of total factor productivity. For example, health impact education based on the fact that much of the physiological and cognitive development of a person passes off in childhood. This supports the economists ' view that health could affect the economic growth through total factor productivity (TFP).

Historical analyses of the association between health and productivity have existed for a while and it remains a subject of interest among economists which has been strongly advocated in various literatures (Bloom et al. 2018). Theoretically, there are views regarding the indirect effect of health capital on productivity and economic growth in general. However, there is no substantial literature or detail theoretical discussion on these effects especially the possible variables that could be used as the intervening variables. Some have mentioned (but not tested) on labour productivity, savings, demography and investments (Isaksson 2007). Meanwhile according to the envelope theorem an improvements in the health affect income by making human capital more productive, but not via more investment. Moreover, Cole and Neumayer (2003) argued that although other researchers have studied the effect of poor health on output growth, this effect is probably inaccurately measured because it is only indirect – it runs through its effects on the efficiency of labour and physical and human capital. Bloom et al. (2018) further argue that most empirical literature has highlighted that health indicators have an ambiguous effect on TFP. Existing theoretical and empirical studies have only considered indirect effects in the case of health- economic growth or human capital-economic growth nexus. To the best of our knowledge, we did have not find any empirical studies examining the indirect effect on the health capital-TFP nexus. This is probably due to lack or weak theoretical foundations on the indirect effect on this relationship. This section presents a review of the major findings in the previous studies on health capital and total factor productivity.

The theoretical basis for linking human capital and total factor productivity is the endogenous growth model which argues that improvement in the aggregate productivity of any economic system can be attributed to innovation and human capital investment (Barro & Sala-I-Martin 1995; Lucas 1988; Mankiw et al. 1992; Romer 1990). Nevertheless, the human capital in the model did not fuse health capital as one of the components of human capital. The justification of health as human capital and as an imperative determinant of TFP arises from Grossman (1972) work. His basic assumption is that good health will improve the aggregate productivity of labor, thus, individuals will invest in healthy wellbeing in order to be endowed with productive time. This in return gives more income in the labor market for household consumption and enjoy a longer life. Hence individual maximizes their utility with regards to their level of health and consumption subject to time and budget constraint.

Moreover, Tompa (2002) emphasized that the foundation of expectations for everyday comforts is the capacity of people to acquire wages and profits in order to purchase goods and services for utilization. This means that wages and profits reflects the value of the goods and services produced in an economy and the productivity of the inputs used to produce them. Since health is a key component of the individual's welfare and standard of living, thus, health capital has a direct effect on TFP as well as economic growth (Bloom & Canning 2000; Tompa 2002).

Although, numerous studies have explored on the causal relationship between health and growth, in which positive connection exists between them much of the time, there have been very few researches on the causal relationship between health capital and TFP. Studies by Grossman (1972) and Van Zon and Muysken (2001) highlighted health capital as a form of investment in human capital. Therefore, an increase in health expenditures will lead to higher labor supply and an increase in the TFP and the economic growth. Strauss (1986) and Barro and Sala-i-Martin (1995) found a positive link between health and TFP, particularly in developing countries.

Most studies on the relationship between health and productivity essentially centres around the negative effect of health, burden of disease, malaria, malnutrition and sanitation on productivity (Gallup & Sachs 2001; McCarthy et al. 2000; Murray & Lopez 1996). These studies argued that disease and poor health imposes adverse effect on individual productivity. Thus, there is a higher probability that poor health (as a result of malaria, sanitation and malnutrition) can unfavourably affect a country's productivity and economic growth. Based on this view, in less developed countries (LDCs), the impact of having a less productive labour is a lot more severe because most of its work force is engaged in manual labour than in the industrialized countries (Gallup & Sachs 2001; Murray & Lopez 1996).

Recent work by Saha (2013) confirms that better health improves TFP and there exist a unidirectional relationship from health to TFP. This implies that health positively affects TFP and for labor force to increase their productivity, they must be healthy. Similarly, Kumar and Kober (2012) examined the impact of health, education and urbanization on TFP and argued that access to good sanitation, better nutrition and health capital significantly affects TFP through labour supply. This implies that health influences economic growth indirectly through aggregate labour productivity, because it enhances their ability to work for a longer period and reduces absenteeism from work. Likewise, better health, induces people to save, which in turn leads to higher capital accumulation and further improves productivity. This is in line with Pocas (2014) who argued that health capital is vital in explaining the growth and convergence process among OECD countries and maintains that an improvement in health in most OECD countries leads to higher human accumulation, productivity and economic growth.

In sum, this section reviewed the relevant theoretical and empirical literature on health capital-total factor productivity nexus. Generally, studies have adopted different approaches and found mixed results on the relationship between these variables. Specifically, there is a positive relationship between health capital and TFP, implying that a healthy labor force is more productive because of their physical and mental capabilities, which eventually increases the total factor productivity. Similarly, a healthier worker may have longer life expectancy than unhealthy ones and consequently, induce higher investments in other stocks of human capital. (Amiri & Ventelou 2012; Bentham 1996; Bloom & Canning 2000; Bloom et al. 2004; Fogel 1986; Ganyaupfu 2014; Grossman 1972; Schultz 1961; Saha 2013; Tompa 2002). Nevertheless, the literature on the impact of health capital on TFP is relatively scarce and most of the literature was conducted in less developed countries and developed countries. Less attention has been paid to the health capital impact on Asian countries; especially the so called four Asian Tigers (e.g. Hong Kong, Singapore, South Korea and Taiwan) which have undergone rapid industrialization and registered significant growth in the 1990s. Most of the previous studies that have analysed the determinants of phenomenal growth registered by these Asian tigers largely focused on macroeconomics variables such as human capital, trade openness, FDI, productivity, etc. but not on the role of health capital. Therefore, this study intends to fill this gap, by analysing the impact of health capital on Singapore's TFP.

RESEARCH METHODOLOGY

EMPIRICAL MODEL

Total factor productivity basically refers to "the weighted average productivity of all inputs in the total production" (Dahal 2015). TFP is measured in terms of real GDP per unit of capital and labor. There are several channels through which health could affects productivity. Bloom and Canning (2000) specify four mechanisms, namely; the direct impact of health capital on labour quality, impact of health capital on education, health capital incentive for savings and capital investment and health capital demographic effects. This implies that higher survival rates for young children may reduce fertility, which eventually leads to an increase in the total population of working age and female labor force participation. To investigate the effect of health on productivity, one requires a measure of TFP. However, this is not required in the case of Singapore since there are available and reliable secondary data. Nevertheless, it remains of great importance to present the method of deriving TFP. Accordingly, the present study adopts the most commonly used methods to calculate TFP which was utilized in Hall and Jones, (1999), Miller and Upadhyay (2000) and Cole and Neumayer (2006). This study adopts the augmented Solow model (Cobb-Douglass production function) to estimate the impact of health capital on total factor productivity. Y is assumed to be a function of the stocks of physical capital (K) and human capital (H). Following Cole and Neumayer (2006), the Cobb-Douglas production function can be specified as

$$Y_t = AK_t^{\alpha} H_t^{1-\alpha} \tag{1}$$

Where α and (1- α) are the income share of capital and labor in total product, respectively. Y is output, A is TFP, K is the total physical capital stock, H = Lh, L is total number of workers, and h is human capital in each unit of labor force, which implies that the total quantity of human capital is equal to human capital per person h times the total labor force L (assuming all labor is identical). Basically in this equation, it is assumed that the Cobb-Douglas production function of equation (1) satisfies three conditions of diminishing marginal products, constant returns to scales, and the increasing returns to scale conditions and it ensures the importance of capital and labor for production. To obtain equation (2) in per worker form, we divide both sides by labor force.

$$Y/L = (AK/L)^{\alpha} \, (Lh/L)^{\beta}$$

Thus the equation will be written as;

$$y_t = Ak_t^{\alpha} h_t^{\beta} e_t \quad (2)$$

where h= H/L (H=Lh), and subscript (t) denotes a time trend. Expressing this equation in natural logarithms we arrive at;

$$\ln y_t = \ln A + \alpha \ln k_t + \beta \ln h_t + e_t \quad (3)$$

However, for empirical estimation, equation (3) leads directly to equation (4):

$$\ln y_t = \Omega + \alpha \ln k_t + \beta \ln h_t + e_t \quad (4)$$

Thus, total factor productivity is $(\Omega + e_t)$ which is equivalent to lnA in equation (3) is presented as below.

$$TFP_t = (\Omega + e_t) = \ln A \quad (5)$$

Thus, TFP can now be used as a dependent variable to investigate the impact of TFP determinant such as human capital (education and health) and investment, as specified by Hall & Jones (1999), Miller & Upadhyay (2000) and Cole & Neumayer (2006). The equation for the empirical estimation can now be written as:

$$\ln TFP_t = \beta_0 + \beta_1 \ln HEPC_t + \beta_2 \ln EDUC_t + \beta_3 \ln INV_t + e_t \quad (6)$$

Where, TFP_t is the total factor productivity, $HEPC_t$ is health capital proxied by health expenditure per capita, $EDUC_t$ is education proxied by government expenditure on education per capita, and INV_t is domestic investment proxied by gross fixed capital formation. The parameters to be estimated are β_1 to β_3, while β_0 is the constant term. The error term is captured by e_t and is assumed to be normally distributed with zero mean and constant variance, while *t* represents a time trend. Combining health and education supports past and recent empirical studies (Schultz 1961; United Nations Development Programme, UNDP 1998) that have emphasized that the concept of human development revolves around the notion that human welfare depends on a combination of various human capital variables. Therefore, including both education and health indicators are relatively better measures of human capital than using education or health indicators alone (United Nations Economic Commission for Europe, UNECE 2017). Moreover, human capital is depicted as the aggregate levels of education and health in a population that affect the rate at which technologies can be produced, adopted, and used to increase productivity.

VARIABLES DESCRIPTION AND DATA SOURCES

According to Syverson (2011), TFP is defined as "weighted average productivity of all inputs, where the weights to these inputs are their shares in total production cost". However, since the present study utilized TFP data from the Asian Productivity Organization (APO) (which is known as Tornqvist index), TFP is defined as the part of output growth that is not explained by the input growth. As for the health capital, there are two categories of health capital indicators, namely: health input indicators (i.e. expenditure on health and healthcare services and availability and quality of health facilities) and health output indicators (i.e. life expectancy, infant mortality rate adult survival rate and fertility rate). In this study, the input indicator, which is the total health expenditure per capita is used due to unavailability of data for most of the health output indicators.

Basically, there are substantial literature on health capital – TFP and health capital –growth nexus which have used different indicators for health capital. According to World Health Organization, there are direct and indirect measures of health. Direct measures of health are referred as biomedical measures, while the indirect measures implies the socio medical measures. Due to certain difficulty of using the direct measurement, several researchers have used the indirect measures of health that deals with inputs and processes indicators (i.e. health expenditure / financing, health workers density and distribution, hospital bed density and death and birth registration coverage), services access and availability indicators (i.e. service utilization, TB treatment success rate, core capacity index, etc.), health outcome indicators (birth attended by skilled workers, HIV care coverage, cervical cancer screening, etc.), and health status indicators (i.e. life expectancy at birth, mortality rate, morbidity, fertility rate, etc.) (WHO 2015). The present study used healthcare expenditure as the proxy for health capital rather than life expectancy because there is no significant changes in the life expectancy data over the past three decades. However in the case of healthcare expenditure (which is considered as the input indicators) has been increasing significantly since 2001. This prompts us to use healthcare expenditure. Although the link between health expenditures and outcomes is never automatic in any country, it is generally positive when expenditures are managed and executed efficiently (Filmer & Pritchett 1999; Keefer & Khemani 2005). This implies that increased in health expenditure coupled with good policies and good governance, can promote growth, reduce poverty, trigger declines in infant, child, and maternal mortality and improve productivity (Gupta & Mitra 2004).

Pritchett and Summers (1996) and Akram et al. (2008) have used infant mortality as the health capital indicator. Bhargava et al. (2001) used total fertility rate, while Barro (1990), Bloom et al. (2001), Bloom et al. (2004), Weil (2007), and Akram et al. (2008) have used life expectancy. Some have also used the probability of survival by age and gender as the proxy (e.g. Mayer 2001). For the purpose of this study, health expenditure is used as the proxy for health capital. This measure has been adopted in Mehrara and Musai (2011a; 2011b), and Amiri and Ventelou (2012).

Total health expenditure per capita is the sum of public and private health expenditures as a ratio of total population (expressed as a percentage of GDP). Data are presented in constant 2005 U.S. dollars. Most studies have found that poor health has a negative, but significant impact on TFP (e.g. Arcand 2001; Bhargava & Yu 1997; Bhargava et al. 2001; Bloom et al. 2004; Cole & Neumayer 2006; Gallup & Sachs 2001; McCarthy et al. 2000; Murray & Lopez 1996;). Meanwhile, Saha (2013) found a positive and significant relationship between health capital and TFP. Therefore the expected sign is positive and significant.

Education (EDUC) as the second component of human capital is measured by total government expenditure on education per capita. Education has been empirically proven to be a positive determinant of TFP. For instance, Nelson and Phelps (1966) argue that education affects TFP growth by facilitating the adoption and implementation of new technology. Similarly, Romer (1990) and Aghion and Howitt (1992) argue that education affects TFP positively by promoting the domestic production through technological innovations. This is support by Benhabib and Spiegel (1994) study which found a positive and significant impact of education on TFP. Therefore, the expected sign of the coefficient of education is positive and significant.

In this study, domestic investment (INV) is measured by gross fixed capital formation (US$). It refers to the net increase in physical assets (investment minus disposals) within a period and does not account for the consumption (depreciation) of fixed capital and land purchases. According to both neo-classical and endogenous growth model, investment (capital formation) is one of the most fundamental determinants of productivity. Study by Sothan (2014) have confirmed the positive and significant relationship between domestic investment (INV) and TFP due to the fact that the accumulation of the capital is supposed to favour the economic growth because the efficiency of the labor force and the other factors of production depend upon the amount and quality of physical capital investment they have. The summary of the variables and theoretically expected signs are presented in Table 1. Data for TFP value (index (2000=1.0), health expenditure, government expenditure on education, domestic investment from 1980 to 2013 and are taken from the World Bank (World Development Indicators; 2014), Department of Statistics Singapore (2015; www.singstat.gov.sg/), Government Data Singapore (2015; http://data.gov.sg/) and Asian Productivity Organization (APO database).

TABLE 1. Summary Descriptions of Explanatory Variables

Variables	Description	Expected Results
Health Capital (HEPC)	Health expenditure per capita as a share of GDP (US$ millions)	Positive
Education (EDUPC)	Government expenditure on education as a share of GDP (US$ millions))	Positive
Domestic Investment (INV)	Gross fixed capital formation as a share of GDP (US$ millions))	Positive
Total Factor Productivity (TFP)	TFP Index	

EMPIRICAL METHODOLOGY

ARDL MODEL AND COINTEGRATION ANALYSIS

This section discusses the methodology used in estimating the empirical model as specified in equation (4). An ARDL approach is applied to time series data to estimate the bound test as well as the long-run and short run relationship between health capital, education, domestic investment and total factor productivity. Although this study adopts the ARDL cointegration approaches to examine the long-run relationship between TFP and three other independent variables, in time series analysis, stationary test is employed to determine whether the variables are I(0) or I(1). ARDL cointegration is suitable to be used for short sample size which has combination of I(1) and I(0) series (Pesaran et al. 2001). Firstly, the ADF and

Phillips–Perron (PP) unit root test are employed to check for variables stationarity and to ensure that none of the series are I(2). The augmented Dickey–Fuller (ADF) model is determined as:

$$\Delta Y_t = \beta_0 + \varphi Y_{t-1} + \sum_{i-1}^{k} \beta i \Delta Y_{t-i} + \mu_t \text{ (Intercept only)} \quad (7)$$

$$\Delta Y_t = \beta_0 + \beta_1 T + \varphi ln Y_{t-1} + \sum_{i=1}^{k} \beta i \Delta Y_{t-i} + \mu_t \text{ (Intercept and Trend)} \quad (8)$$

The parameter of interest in the ADF model is φ and the null and alternative hypotheses to be tested are H_0: φ = 0 (not stationary) and H_1 : φ ≠ 0 (stationary). Next the long- and short-run coefficients are estimated by selecting the appropriate values for the maximum lags using one or more information criteria (i.e. AIC, SC (BIC) and HQ). This is followed by testing for the Lagrange multiplier (LM) test and other diagnostic tests to check if the model is the best fit. Then the bounds test is performed for the absence of a long-run equilibrium relationship between the variables. To test the presence of cointegration relationship between the variables, Wald Test (F-statistics) is conducted to determine the joint significance of the coefficients of lagged variables. The computed F-statistics then is compared with the lower and upper bound critical values provided by Narayan (2005) at given significant level. Narayan (2005) critical values table is suitable for small number of observations (30 to 80) compared to the critical values table proposed by Pesaran et al. (2001) which recommended for a larger sample size. The lower bound implies that the variables have integrated order of I(0) while upper bound implies the integrated order of I(1). If the computed F-statistics exceed the upper bound critical value provided by Narayan (2005), we reject the null hypothesis and conclude that there is cointegration relationship between the variables. However, if the computed F-statistics falls below the lower bound, we fail to reject the null hypothesis, indicating that there is no long run relationship between the variables. In case the computed F-statistic is in-between the lower bound and the upper bound critical values, the result of the bound test is said to be inconclusive. Once cointegration is established, the conditional ARDL long run model is estimated. Finally, the short run and error correction coefficients (to estimate short run elasticities of the independent variables for the model) are estimated. Following Pesaran et al. (2001) general model, ARDL model for total factor productivity and its determinants can be specified as:

$$\Delta \ln TFP_t = \beta_0 + \beta_1 lnTFP_{t-1} + \beta_2 lnHEPC_{t-1} + \beta_3 \ln INV_{t-1} + \ln EDUC_{t-1} + \sum_{i=1}^{p} \theta_1 \Delta lnTFP_{t-i} + \sum_{i=0}^{p} \theta_2 \Delta lnHEPC_{t-i} + \sum_{i=0}^{p} \theta_3 \Delta \ln INV_{t-i} + \sum_{i=0}^{p} \theta_4 \Delta EDUC_{t-i} + u_{t,} \quad (9)$$

where β_1 and β_4 are long-run parameters and θ_1 to θ_4 are short-run parameters. u_t is an error term and denotes lag length of the auto regressive process and t is the time trend of the model. The null hypothesis and the alternative hypothesis are: $H_0 : \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0$ (There is no long run relationship among the variables), and the alternative hypothesis is: $H_1 : \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq 0$ (There is a long run relationship among the variables).

FINDINGS AND DISCUSSION

This section discusses the findings of the estimations on health capital-TFP nexus which includes the descriptive statistics, correlation matrix, regression analysis and diagnostic tests. Table 2 presents the descriptive statistics of the variables included in the analysis of health capital – TFP nexus which includes mean, standard deviation, minimum, maximum; observation, skewness and kurtosis. Four variables were used with annual data for Singapore over a period of 34 years. The statistics show that data for all the variables are complete. It is observed that the domestic investment (INV) have the highest volatility recorded by the standard deviation. According to the maximum and minimum, it is indicated that all the data are in the positive range. Two of the variables are positively skewed; while domestic investment (INV) and education expenditure (EDUPC) are negatively skewed.

TABLE 2. Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max	Obs.	Skewness	Kurtosis
TFP	4.578	0.108	4.386	4.761	34	0.143	1.939
HEPC	6.474	0.537	5.527	7.442	34	0.084	2.041
EDUPC	6.567	0.399	5.539	7.041	34	-1.001	3.260
INV	10.501	0.662	9.232	11.561	34	-0.246	1.867

Table 3 shows the correlation matrix which reveals that all explanatory variables are positively correlated with the total factor productivity. Although all the variables are highly correlated and implying the existence of multicollinearity or significant amount of correlation among variables of non-stationary series, however, ARDL-ECM model is considered a robust and a dynamic method that is designed specifically to manage multicollinearity cases successfully because the model able to reduces problems of multicollinearity, but increase the reliability and stability of t-ratios in testing for statistical significance (Thomas 1997).

TABLE 3. Correlation Matrix

	TFP	INV	HEPC	EDUPC
TFP	1.000000			
INV	0.900997	1.000000		
HEPC	0.914365	0.937045	1.000000	
EDUPC	0.807250	0.921198	0.914942	1.000000

UNIT ROOT TEST RESULT

The unit root test result (Table 4) shows that respective variables can be assumed to be stationary given that they are stationary in either level or first difference. For instance, total factor productivity (TFP), health capital (HEPC) and domestic investment (INV), are considered to be I (1) stationary at the first difference. On the other hand, education (EDUC) is stationary at level (based on intercept and intercept with the trend) at the 10% significance level for the ADF test and in both intercept and intercept and trend in PP test. In sum, the stationarity test results justify the use of the ARDL bound test developed by Pesaran et al. (2001).

TABLE 4. Unit Root Test (level)

	ADF		PP	
Levels	Constant	Constant & Trend	Constant	Constant & Trend
lnTFP	-0.60(0)	-3.55(0)*	-0.60(0)	-2.74(1)
lnHEPC	-0.33(0)	-2.80(0)	-0.33(1)	-2.55(2)
lnEDUPC	-2.74(0)*	-2.23(0)	-5.59(10)***	-3.58(11)**
lnINV	-0.58(1)	-3.04(7)	-1.10(2)	-2.20(2)
		First Difference		
	ADF		PP	
First Difference	Constant	Constant & Trend	Constant	Constant & Trend
lnTFP	-5.28(0)***	-5.23(0)***	-5.28(1)***	-5.23(1)***
lnHEPC	-6.62(0)***	--6.51(0)***	-6.23(0)***	-6.12(0)***
lnEDUPC	-5.42(0)***	-5.34(0)***	-5.23(0)***	-5.15(0)***
lnINV	-3.19(4)**	-3.17(4)**	-3.01(4)**	-3.90(4)**

Notes: The rejection of the null hypothesis is based on MacKinnon's (1996) critical values. AIC is used to determine the lag length while testing the stationarity of all variables. ***, ** and * indicate rejection of the null hypothesis of non-stationary at the 1%, 5% and 10% significance level, respectively, and the value in parentheses represent automatic lag length.

ARDL BOUND TEST

In this subsection, the result of the estimated ARDL bound test is presented as on the basis of the ARDL model estimation using AIC with a maximum lag order of 3. The results of the bound test are presented in Table 5 and confirm a long-run association (cointegration) among the estimated variables. The computed F-statistics is greater than the upper critical bound (9.644*** > 5.61) at the 1% significance level. This also confirms a long-run association among the variables in model 1, implying that the null hypothesis $H_0 : \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0$ (no long-run relationship) against its alternative ($H_1 : \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq 0$) (long-run relationship is rejected at the 1% significance level and concluded the existence of cointegration among the estimated variables.

TABLE 5. Results for the ARDL bounds testing approach to co-integration with optimal lag (1.1.0.1) K (3)

F-statistics	Lag	Sig. Level	Bound	Critical Value
			I(0)	I(1)
9.644 K(4)	2	1%	4.29	5.61
		5%	3.23	4.35
		10%	2.72	3.77

Note: *, ** and *** denote significance at the 1%, 5% and 10% levels, respectively.

ARDL LONG-RUN AND SHORT RUN COEFFICIENTS ESTIMATION RESULTS

After confirming the ARDL bounds testing approach as the best fit in the present study, the next step is the ARDL model testing, which examine the existence of a long-run relationship among the estimated variables (i.e. TFP, education, health capital and domestic investment). The long-run equilibrium shows the relationship between the variables without any short-run shock while the short-run coefficients estimates show the dynamic adjustment of all variables. The estimated results are reported in Table 6 and 7. In general health capital (HEPC) is positive and significant in both long run and short run, whereas domestic investment (INV) and human capital (EDUPC) is only significant in the long run and short run, respectively. It is observed that the estimated coefficients of health capital (HEPC), education (EDUC), and domestic investment (INV) have the hypothesized signs. The estimated coefficient of health capital (HEPC) and education (EDUC) is statistically significant, while that of domestic investment (INV) is positive but statistically insignificant.

TABLE 6. Estimated long-run coefficients using ARDL with optimal lag (1.1.0.1), using AIC

Dependent Variable: lnTFP				
Regressors	Coefficient	S.E	T-Ratio	Prob
lnHEPC	0.1538***	0.0424	3.628	0.0012
lnEDUPC	0.0511**	0.0653	0.7824	0.0410
lnINV	0.0194	0.0453	0.4277	0.6724
Constant	3.0136	0.1527	19.741	0.0000

Note: *, ** and *** denote significance at the 1%, 5% and 10% level, respectively.

Since the specified TFP model is in a log-linear form, the coefficient of the independent variables can be interpreted as elasticity with respect to TFP. The coefficient of HEPC is 0.1538, which implies that in the long-term, keeping other things constant, a 1% change in health expenditure brings about a 0.1538% change in TFP. This finding is in line with the endogenous growth theory developed by Lucas (1988) and Romer (1990) and empirical studies undertaken by Tompa (2002), Bloom et al. (2004), Cole and Neumayer (2006), Ajani and Ugwu (2008), Saha (2013) and Huq et al. (2014). Therefore, it is appropriate to conclude that improving health conditions is imperative in boosting TFP in Singapore (since the benefits include impacts on economic productivity and technological advances both in short run and long run). Similarly, EDUPC has a significant long-term impact on Singapore's TFP, where a 1% increase in government expenditure on education results in a 0.051% change in TFP. This legitimized the fact that greater spending on human capital in education would accelerate TFP and can also be seen as a good domestic policy measure. Moreover, it also means that investment in schooling will have a true long-term effect on productivity at both person and domestic level. Previous studies have shown that government expenditure on education has a significant and positive effect on TFP (such as Bose et al. 2007; Mekdad et al. 2014; Omojimite 2010). In addition, domestic investment (INV) is found to be insignificant in the long run. This could probably implies that the accumulation of the physical is more important in the short run because the efficiency of the labor force and the other factors of production depend upon the amount and quality of physical capital invested.

The next step is to model the short-term dynamics and the results of short-term coefficients; the error correction model (ECM) is presented in Table 7. The findings reveal that HEPC and domestic INV are statistically significant at 1% level. However, human capital (EDUPC) is found to be insignificant in the short-term. This is probably due to the three stages of Singapore's academic development since its independence, namely; the survival-driven phase in the late 1960s, the efficiency-driven phase in the late 1970s, instructional changes in the mid-1980s, and the skill-driven stages that began in 1997, have beneficial but insignificant consequences for Singapore's short-term productivity growth. More so, because education investment has more effect on long-term productivity growth than on short-term. The error correction coefficient (-0.68221) is highly significant with correct negative sign. The result implies that 68.22% of the variations in productivity in the short-run are explained by the variables presented in the model and it takes approximately (1/0.6822= 1.47), one year five month to converges back to the long-run equilibrium in the current year.

TABLE 7. Estimated short-run coefficients and error correction model (ECM) based on ARDL (1, 1, 0, 1)

Variables	Coefficient	Std. Error	T- stats	Prob
D(lnINV)	0.26349***	0.06984	3.77257	0.0008
D(lnHEPC)	0.10490***	0.02793	3.75570	0.0009
D(lnEDUPC)	0.10081	0.07388	1.36449	0.1841
CointEq(-1)	-0.68221***	0.16087	-4.24067	0.0002

Note: *, ** and *** denote significance at the 1%, 5% and 10% level, respectively.

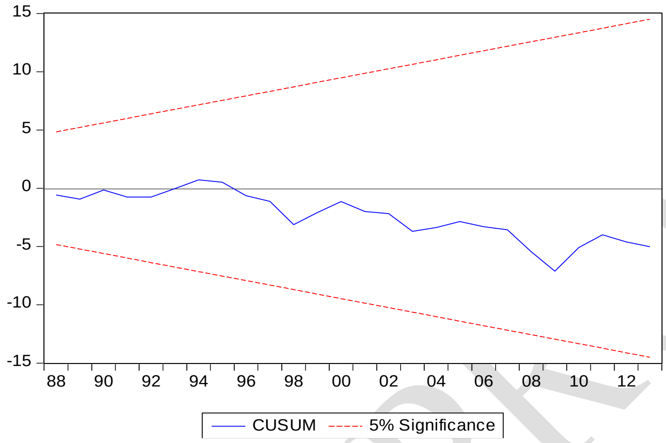
DIAGNOSTIC TESTS FOR ARDL REGRESSION

The results of the estimated diagnostic tests for the ARDL regression reflect a fairly high level of goodness of fit. The Breusch–Godfrey serial correlation LM test, Breusch–Pagan–Godfrey heteroskedasticity test, Jarque–Bera normality test and Ramsey RESET specification test shows that the estimated model is free of serial correlations, functional-form misspecifications, non-normal errors and heteroskedasticity at the five percent level (see Table 8). Therefore, all diagnostic checks for the model reject the null hypothesis that the theoretical account is not the best fit. In addition, in consideration of Pesaran and Shin (1999) recommendation, Figure 3 and 4 presents the stability test for the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) in the short and long run. According to the graphical representation, CUSUM and CUSUMSQ reveal a satisfactory plot of the recursive residuals at the 95 percent significance level, which implies that none of the parameters falls outside of the critically dotted lines. This empirically dismisses any trace of inconsistent parameter estimates and further enhances the standard significance of the conventional test statistics without a trace of nuisance parameters.

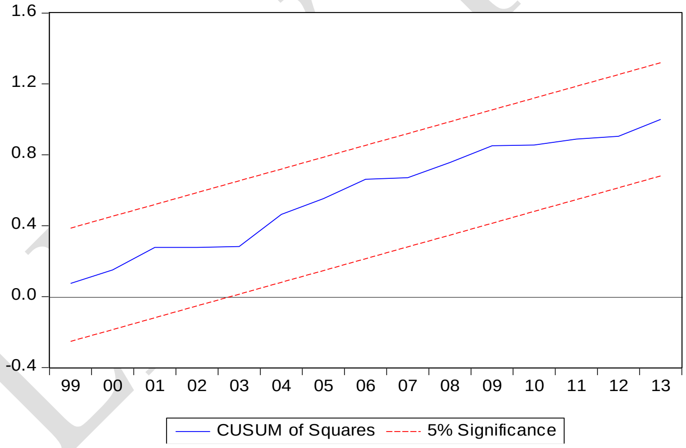
TABLE 8. Diagnostic test for ARDL Regression

Diagnostic tests	Value
J–B Normality Test	0.852 (0.653)
B–G LM Test	3.299 (0.1922)
Ramsey Reset Test	0.0002 (0.9872)
Heteroskedasticity Test (BPG)	7.324 (0.2919)
F-Statistic	0.000068

Note: The values in the parentheses represent the probability values.



Note: The straight lines represent critical bounds at 5% significance level
FIGURE 3. Plot of cumulative sum of recursive residuals



Note: The straight lines represent critical bounds at 5% significance level
FIGURE 4. Plot of cumulative sum of recursive residuals

CONCLUSIONS

The main objective of this study is to analyze the impact of health capital on TFP in Singapore from 1980 to 2013 using ARDL approach to co-integration. The results reveal that TFP in Singapore can be significantly improved when health capital (measured by health expenditure) and human capital (measured by expenditure in education) are increased in the long run. Meanwhile in the short run, human capital and domestic investment appears to be significant in affecting the TFP. These findings have some important policy implications. Given the existing policies on public expenditure in Singapore, we believe that TFP could be improved substantially if health capital, human capital and investments are increased accordingly. Firstly, as mentioned earlier Singapore's healthcare system has been praised for achieving remarkable population health outcomes by just spending a modest 4–5 per cent of GDP per capita on national health expenditure. For this, Singapore has been awarded as the healthiest country in the world by Bloomberg Media (2012) and was also described as the second most efficient health care system in the world by the Economist Intelligence Unit (Lim 2017). Thus, it is clear that that healthcare has always been a priority in Singapore. However, a higher awareness of the health of the people is necessary if an increased and sustainable economic and productivity growth is to be pursued. In addition, despite the transformation of Singapore into a vibrant city-state with one of the world's highest per capita gross domestic product (GDP), productivity has declined in recent years. Therefore, in order to reform drastically into an innovation-driven economy and maintain its economic standards, urgent attention must be given to health capital in order to increase the level of productivity in the country.

Moreover, Singapore is also well recognized for its high-quality education system. Since independence, the country has regarded education as the key to achieve high and sustainable economic development. For this, Singapore has established and implement a high-quality system in terms of educational retention, quality and efficiency and has ensure that the investment in education as the central priority (OECD 2010). Thus by ensuring higher quality education, the total factor productivity could be further improved. In terms of investment, it is widely known that Singapore is the largest recipient of foreign direct investment in the Southeast Asia. In 2017, Singapore was the fifth largest recipient of FDI inflows in the world (UNCTAD 2018). Thus, Singapore has a conducive and robust investment climate and tax regime which attracts both foreign and domestic investments. These investments are crucial for the economy as a whole as there are numerous positive spill over effects such job creations, income generation, higher productivity, etc.Therefore, it is crucial for the Singaporean government to give importance on healthcare, education and investment as some of the macroeconomic policy tools to further increase the TFP. The government also needs to ensure there is continuous increase on the healthcare and education services in the national budget allocation. This is to sustain the overall economic and productivity growth. This study also has a major limitation despite its contributions. The main problem is data limitation, such as complementary and alternative healthcare and non-communicable diseases (NCD) expenditure that is yet to be codified. Thus, limiting such important data enforces severe study-level restrictions and will likely led to major variables being ignored. Similarly, since this study is significant in explaining the impact of health capital on TFP in Singapore and indicates a framework for future empirical investigation of extending the study to examine indirect effects and using a panel data estimation approach to explore the relationship between health capital, economic growth and TFP among Asian countries.

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