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Optimal Policy for Secondary Education in Developing Countries

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Optimal Policy for Secondary Education in Developing Countries

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Abstract

This paper¹ shows that an accelerated increase in educational attainments in many East Asian countries derives from a dramatic augmentation of working population with vocational education relative to general education. This is consistent with the recent literature, which argues that the ratio of vocational-to-general education tends to be higher in middle-income countries. We explore an analytical approach to open up fresh insights into the composition of secondary education and prove the existence of optimal trajectory that ensures a positive expansion rate of secondary education at early stage of development. Also, we demonstrate that the actual path of vocational-to-general education in Taiwan is very similar to what can be defined by optimal policy for secondary education, which has resulted in a rapid increase in average years of schooling since 1978.

Key words: Employment · Economic growth · Education · Human Capital

JEL Classification: E24 · I20 · I25 · J24

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1. Introduction

There is an extensive body of literature on measuring the impact of human capital on economic growth through education, notably when it is measured by educational attainments. Numerous empirical studies show that the quantified relationships between average years of schooling and economic and social outcome variables across countries cannot be treated unambiguously. Particularly, Krueger and Lindahl (2001) found that education is positively and significantly associated with subsequent growth in developing countries with lowest years of schooling, but for middle-income and developed countries this relationship disappears with an educational progress.

However, other studies have argued that human capital should be specified appropriately as tied to productivity growth (Benhabib and Spiegel, 2003). The composition of human capital stock varies depending on the types of skills that are consistent with the demand of local labour markets, and which influence economic growth differently (Ramcharan, 2004). The formation of skills that presents a hierarchy from primary to tertiary education is modelled by a standard production function. As Su (2006) claims, the allocation of public funds across hierarchical education levels is often unbalanced in developing countries. In particular, as Patron and Vaillant (2012) show, the optimal allocation rule under maximizing the ratio of skilled-to-unskilled labour stocks requires relatively more funds to primary and secondary education in comparison to developed countries.

Vandenbussche et al. (2006) stress that the growth-enhancing effect of human capital expressed by the ratio of primary and secondary relative to tertiary educational attainment increases with closing a distance to the technology frontier. It implies that a larger number of more skilled workers with secondary education contributes to greater absorption of modern technologies from developed countries.

To prevent a global population growth, Cohen (2008) calls for making secondary education worldwide within 25 years. Secondary education affects a country's ability to implement existing frontier technologies. In almost all countries

primary education is compulsory, and thus, the completion of secondary education accounts for most improvements in average years of schooling (Barro and Lee, 2013). However, secondary education expansion policy often fails due to an unbalanced allocation of public funds across hierarchical education levels, parental preferences for general instead of vocational education, and high unemployment rates among youth cohorts. As a result, one cannot explain why some countries succeed in sizable educational attainment while others do not.

A few attempts have been made to manifest the link between the ratio of vocational-to-general education and economic development. Empirically analysing the data on secondary enrolments of UNESCO for 70 countries, Bennett (1967) showed that there exists a U-inverted curvilinear between the ratio of vocational-to-general education enrolments and GDP per capita. Later, Bertocchi and Spagat (2004) validate the hypothesis for 149 countries with data of 1950-1991 and show with a model that at early stages of economic development vocational education tends to expand, but at later stages general education tends to widen. Also, analysing the reason for slowed growth in 1980s Krueger and Kumar (2004) conclude that the Western European countries from 1960-1970 years have strengthened excessively vocational education and training compared to general education. A greater focus on general education guided by new technologies in a new era should be done to reduce the US-Europe growth gap. With a growth model of technology adoption the authors define that a country's optimal education policy in term of subsidies for general versus vocational education should depend on the growth rate of the technology frontier.

The paper contributes to the literature by providing fresh insights into the composition of secondary education. The role of human capital in technology adoption is specified by the ratio of vocational-to-general education instead of its measurement by average years of schooling. Specific skills, obtained through vocational education in line with technology adoption, explain the above specification that has many advantages. Firstly, the ratio of vocational to general enrolment is a good proxy only when the ratio of vocational-to-general education

increases that happens only for a developing country. Secondly, the composition of secondary education yields a richer set of dynamics than the overall stock of secondary education. Thirdly, there is a convergence between policies on expanding secondary education and evolving the ratio of vocational-to-general education in developing countries (Dosmagambet, 2008). Furthermore, the specification of human capital implies a finding of optimal trajectory that ensures an accelerated increase in educational attainment and therefore, can be viewed as optimal policy for secondary education.

The structure of the paper is organized as follows. The study focuses on composition of secondary education that enhances productivity growth while other issues are being set aside. Section 1 begins with the concept of feasible policy for secondary education and show that a rise of vocational relative to general education serves as a channel for widening secondary schooling. Moreover, we prove the existence of optimal trajectory in the composition of secondary education that ensures a positive increase in educational attainment at early stage of development. A sharp increase in the supply of vocational graduates would result in lower overall unemployment rate. Otherwise, graduates of general schools are likely to be often unemployed especially among those who do not continue to tertiary education. The empirical analysis in Section 2 shows that the actual path of vocational-to-general education in Taiwan is very similar to what is built by optimal policy for secondary education, which has resulted in a rapid rise in years of secondary schooling since 1978.

2. The Model in Discrete Time

Following Bertocchi and Spagat (2004), we present a model with discrete time, where Q_t - the output per worker is produced by using two inputs of labour, namely, V_t - the fraction of working population with skill-specific or vocational education and G_t - the fraction of working population with general education in total workforce at time t . It is assumed that a growth rate of total employment is constant and there is no unemployment². Then, the production function looks as follows

$$Q_t = A_t \cdot V_t^a \cdot G_t^{1-a} \quad (1.1)$$

The function (1.1) has a constraint such that $V_t + G_t < 1$. The parameter a belongs to the interval, $0 < a < 1$. Technological progress is assumed to be exogenously given by an increasing sequence $A_{t+1} = \gamma \cdot A_t$ with $\gamma > 1$.

From the first order conditions for (1.1) under the given constraint we conclude that the following expression holds for any time t

$$a \cdot \frac{Q_t}{V_t} = (1 - a) \cdot \frac{Q_t}{G_t}$$

After dividing both sides of the expression by output we finally get that the ratio of vocational-to-general education on balanced path growth is determined as a proportion of the factor shares

$$\frac{V_t}{G_t} = \frac{a}{1-a} \quad (1.2)$$

In order to describe the expansion of secondary education we consider that $\tan \beta_t = \left(\frac{V}{G}\right)_t < 1$, where β_t - angle of slope or β_t is inferior to $\frac{\pi}{4}$ at first stage. Certainly, the ratio of vocational-to-general education will be increasing over time so that $\left(\frac{V}{G}\right)_t > 1$ or β_t is superior to $\frac{\pi}{4}$ at second stage.

² Relevant statistical data are given in terms of vocational and general education and therefore, it can be subtracted from the types of working population correspondingly.

Below, we depict an initial point M with the coordinates G_t and V_t and its transformation into another point $E(G_{t+1}, V_{t+1})$ or make a shift $(V_t, G_t) \mapsto (V_{t+1}, G_{t+1})$.

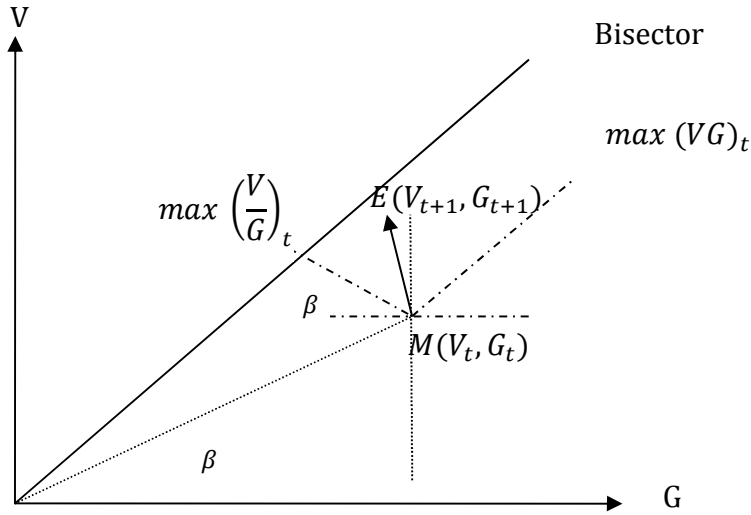


Figure 1.1 Trajectory of the ratio of vocational-to-general education

Then, the evolution of the ratio of vocational-to-general education will be governed by the equation³

$$\frac{V_{t+1}}{G_{t+1}} = \frac{V_t + \sin x}{G_t + \cos x} \quad (1.3)$$

where x – angle of shift, which varies within $[\pi; 0]$.

Education policy in developing country aims at increasing educational attainments through a widening of secondary education, defined as S_t – the sum of the shares of employed persons with vocational and general education. Then, by taking into account (1.3) dynamics of S_t can be expressed as follows

$$\frac{V_{t+1} + G_{t+1}}{V_t + G_t} = 1 + \frac{\sin x + \cos x}{V_t + G_t} \quad (1.4)$$

³For simplicity, we put that $\Delta V_t^2 + \Delta G_t^2 = 1$.

Similarly, the ratio $\left(\frac{V}{G}\right)_t$ is widely acknowledged as an important indicator for economic development and thus, its evolution can be specified in terms of growth rates as

$$\frac{V_{t+1}}{G_{t+1}} : \frac{V_t}{G_t} \equiv \frac{V_{t+1}}{V_t} : \frac{G_{t+1}}{G_t} = e^{\frac{\sin x}{V_t} - \frac{\cos x}{G_t}} \quad (1.5)$$

The expressions (1.4) and (1.5) will be used to formulate different policies for secondary education and prove its properties. Let consider first policy favours a relative rise of vocational to general education, which implies that the ratio $\left(\frac{V}{G}\right)_t$ will substantially increase. Second policy aims at expanding secondary education without raising the ratio of $\left(\frac{V}{G}\right)_t$. Yet, due to income inequality a relative rise of general to vocational education can be insurmountable at early stage of development.

Now, let define a policy as *feasible* if either S_t expansion or $\left(\frac{V}{G}\right)_t$ evolution rate is positive. However, being separately feasible these policies cannot be always simultaneously feasible. To exclude such cases a policy for secondary education is called *feasible* if both expanding S_t and evolving $\left(\frac{V}{G}\right)_t$ policies are jointly feasible.

Proposition 1 There exists such a segment $\left[\pi - \beta_t; \frac{\pi}{4} \right]$ in which any policy for secondary education is feasible.

Proof: Let take the first derivative of the expression (1.4) and solve the equation $\frac{\cos x - \sin x}{V_t + G_t} = 0$ implying that maximum growth rate of S_t is attainable only alongside the bisector. In other words, it is invariant on either angle of slope or angle of shift. Similarly, we find the first derivative of the expression (1.5) and solve the equation $\frac{\cos x}{V_t} + \frac{\sin x}{G_t} = 0$, which entails that $\sin x = \frac{V_t}{\sqrt{V_t^2 + G_t^2}}$. As the latter presents $\sin \beta_t$ by

definition, hence, the solution of the equation must be $x = \pi - \beta_t$. It means that the maximum growth rate of $\left(\frac{V}{G}\right)_t$ depends only on angle of slope β_t . In addition, it is easy to verify that the second derivatives of both equations are negative at the boundaries of the segment.

Then, policy on expanding S_t will be feasible, when the angle of shift defined in (1.4) moves from either π or zero to $\frac{\pi}{4}$. Inversely, policy on evolving $\left(\frac{V}{G}\right)_t$ will be feasible, when the angle of shift given in (1.5) changes from $\frac{\pi}{4}$ to $\pi - \beta_t$. As a result, the segment $\left[\pi - \beta_t; \frac{\pi}{4}\right]$, which is in fact the intersection of both areas, ensures feasible policy for secondary education by expanding S_t and evolving $\left(\frac{V}{G}\right)_t$ as well.

In accordance with the law of motion (1.3) any trajectory $\left\{\frac{V}{G}\right\}_{t=0}^T$ can be originated from the bottom right side to the top left side as shown in Figure 1.1. The area of feasible policy for secondary education will be squeezing with increasing the angle of slope β_t and therefore, any gap between S_t expansion and $\left(\frac{V}{G}\right)_t$ evolution rates will be decreasing over time.

Half-of-angle trajectory (HOA) presents an example of feasible policy for secondary education. It can be defined as the difference of two angles, which correspond to the left and right boundaries of the segment. As the term $\pi - \beta_t$ maximizes growth rate of $\left(\frac{V}{G}\right)_t$ while $\frac{\pi}{4}$ - growth rate of S_t , we take a half of the difference and add a quarter of π that looks as $\frac{\pi - \beta_t - \frac{\pi}{4}}{2} + \frac{\pi}{4}$. Hence, HOA trajectory is defined by the angle of shift equal to $\frac{5\pi - \beta_t}{2}$. Then, the law of motion (1.3) can be rewritten for HOA trajectory that looks as follows

$$\frac{V_{t+1}}{G_{t+1}} = \frac{V_t + \cos \frac{\frac{\pi}{4} - \beta_t}{2}}{G_t - \sin x \frac{\frac{\pi}{4} - \beta_t}{2}} \quad (1.6)$$

Importantly, HOA trajectory urges on the existence of optimal trajectory that contrasts to HOA by reason of its conjunction with production function (1.1). Certainly, optimal policy presents a feasible policy for secondary education.

Proposition 2 There exists optimal trajectory determined by the angle of shift, equal to $\{\frac{\pi}{2} + \beta_0\}$ and $\{\frac{\pi}{2} - \beta_0\}$ for first and second stages, respectively.

Proof: On balanced growth path the expression (1.2) holds for any t , which means that there exists t_0 so that $\beta_0 < \frac{\pi}{4}$. On the other hand, it is also true that $\frac{V_{t+1}}{G_{t+1}} = \frac{a}{1-a}$. Then, we replace the left side of the equation by (1.3) and rewrite as $\frac{V_t + \sin x}{G_t + \cos x} = \frac{a}{1-a}$. After manipulating by taking into account (1.2) again the latter can be reduced to the following form $(1-a) \cdot \sin x = a \cdot \cos x$ that provides two solutions such as $\cos x = \pm \frac{1-a}{\sqrt{a^2 + (1-a)^2}} = \pm \frac{G_0}{\sqrt{V_0^2 + G_0^2}} = \pm \cos \beta_0$. Hence, we get that the angle of shift is equal to $\frac{\pi}{2} + \beta_0$ for first and $\frac{\pi}{2} - \beta_0$ second stage, correspondingly.

Then, we reformulate the law of motion (1.3) for optimal trajectory, which will be generated by

$$\frac{V_{t+1}}{G_{t+1}} = \frac{V_t + \sin\left(\frac{\pi}{2} \pm \beta_0\right)}{G_t + \cos\left(\frac{\pi}{2} \pm \beta_0\right)} = \frac{V_t + \cos \beta_0}{G_t \mp \sin \beta_0} \quad (1.7)$$

As we see from (1.7), optimal trajectory, which looks as $\frac{V_t + \cos \beta_0}{G_t - \sin \beta_0}$, provides a large rise of $\left(\frac{V}{G}\right)_t$ by widening S_t as well at first stage. However, despite that the evolution of $\left(\frac{V}{G}\right)_t$, given by $\frac{V_t + \cos \beta_0}{G_t + \sin \beta_0}$, it slows down at second stage with expanding secondary education to some extent.

Let determine another feasible policy for secondary education that makes equal the growth rates of S_t expansion and $\left(\frac{V}{G}\right)_t$ evolution. Equal-growth-rate (EQR)

trajectory presents a borderline between two dynamics. Therefore, with regard to EGR one can verify whether policies on expanding S_t and evolving $\left(\frac{V}{G}\right)_t$ outweigh each other.

In order to identify EQR trajectory we equalize the right terms of (1.4) and (1.5) by taking into account that $e^{\frac{\sin x}{V_t} - \frac{\cos x}{G_t}} = 1 + \frac{\sin x}{V_t} - \frac{\cos x}{G_t}$. Then, after simplifying we get the following equation

$$\frac{\sin x + \cos x}{V_t + G_t} = \frac{\sin x}{V_t} - \frac{\cos x}{G_t} \quad (1.8)$$

After manipulating (1.8) we will have that $\sin x = \frac{K_t}{\sqrt{1+K_t^2}}$ within the segment $\left[\pi - \beta_t; \frac{\pi}{4}\right]$, where $K_t = \tan \beta_t \cdot [\tan \beta_t + 2]$. Then, the law of motion (1.3) can be rewritten for EQR trajectory as follows

$$\frac{V_{t+1}}{G_{t+1}} = \frac{V_t + \frac{K_t}{\sqrt{1+K_t^2}}}{G_t + \frac{1}{\sqrt{1+K_t^2}}} \quad (1.9)$$

Corollary 2.1 Optimal trajectory favours any policy on rising vocational relative to general education.

Proof: In order to check if EQR and optimal trajectories outweigh each other we compare the right and left terms of (1.8). Then, by putting $\frac{\pi}{2} + \beta_0$ as angle of shift after simplifying we see that $\frac{\cos \beta_0 - \sin \beta_0}{V_t + G_t} < \frac{\cos \beta_0}{V_t} - \frac{\sin \beta_0}{G_t}$. Thus, the left term, which presents the expansion of secondary education, is inferior to the right term that corresponds to the evolution of the ratio $\left(\frac{V}{G}\right)_t$ on optimal trajectory. It implies

that lying above EGR optimal trajectory favours any policy on evolving the ratio of $\left(\frac{V}{G}\right)_t$.

Yet, HOA, optimal and EQR trajectories while behaving differently can serve as policy instruments for analysing the expansion of S_t and evolution of $\left(\frac{V}{G}\right)_t$. HOA and EQR trajectories depend on the value of $\left(\frac{V}{G}\right)_t$ or the angle of slope β_t for each time, while optimal trajectory – only on the initial angle β_0 . Next, optimal trajectory lies above EGR curve and looks exactly as HOA on the bisector. Depending on the initial angle of shift HOA converges to optimal trajectory at first stage, but diverges from it at second stage and therefore, can serve as a proxy for optimal trajectory in empirical studies.

Thus, optimal trajectory ensures not only a rise of the of $\left(\frac{V}{G}\right)_t$ but also enlarges a widening of secondary education. However, to what extent the overall expansion rate of secondary education can be attained over time?

Proposition 3 Optimal trajectory ensures a positive expansion rate of secondary education only at first stage.

Proof: Let reformulate the expansion of secondary education (1.4) for optimal trajectory at first stage that looks after simplifying as follows

$$\frac{(V+G)_{t+1}}{(V+G)_t} = 1 + \frac{\cos \beta_0 - \sin \beta_0}{V_t + G_t} \quad (1.10)$$

We see that the numerator is always positive for any t and therefore, ensures the highest contribution to growth because $\tan \beta_0 < 1$ or $\cos \beta_0 - \sin \beta_0 > 1$ at first stage. Moreover, the lower is the initial angle of slope the higher is the expansion rate of secondary education on optimal trajectory. Similarly, the evolution of the ratio $\left(\frac{V}{G}\right)_t$ from (1.5) for optimal trajectory at first stage can be rewritten after

simplifying as $\frac{\left(\frac{V}{G}\right)_{t+1}}{\left(\frac{V}{G}\right)_t} = 1 + \frac{\cos \beta_0}{V_t} + \frac{\sin \beta_0}{G_t}$, which states that the evolution rate will be also high.

Following the concept of feasible policy for secondary education, only a rise of vocational relative to general education serves as a channel for widening secondary education. Any other attempts to expand S_t at early stage of development fail, because a threshold level in years of schooling is unlikely to be reached without evolving the ratio $\left(\frac{V}{G}\right)_t$. Therefore, optimal trajectory that ensures an accelerated increase in educational attainment can be viewed as optimal policy for secondary education.

Thus, there exists T such as $V_T = G_T$ that the overall expansion rate under optimal policy for secondary education will be maximum, which can be calculated for each period from (1.10) and finally expressed by

$$\max_T \frac{(V+G)_T}{(V+G)_0} = \prod_{i=0}^{T-1} \left[1 + \frac{B}{(V+G)_i} \right] \quad (1.11)$$

where $B = \cos \beta_0 - \sin \beta_0$ and it is constant for a given country.

3. Data for Taiwan

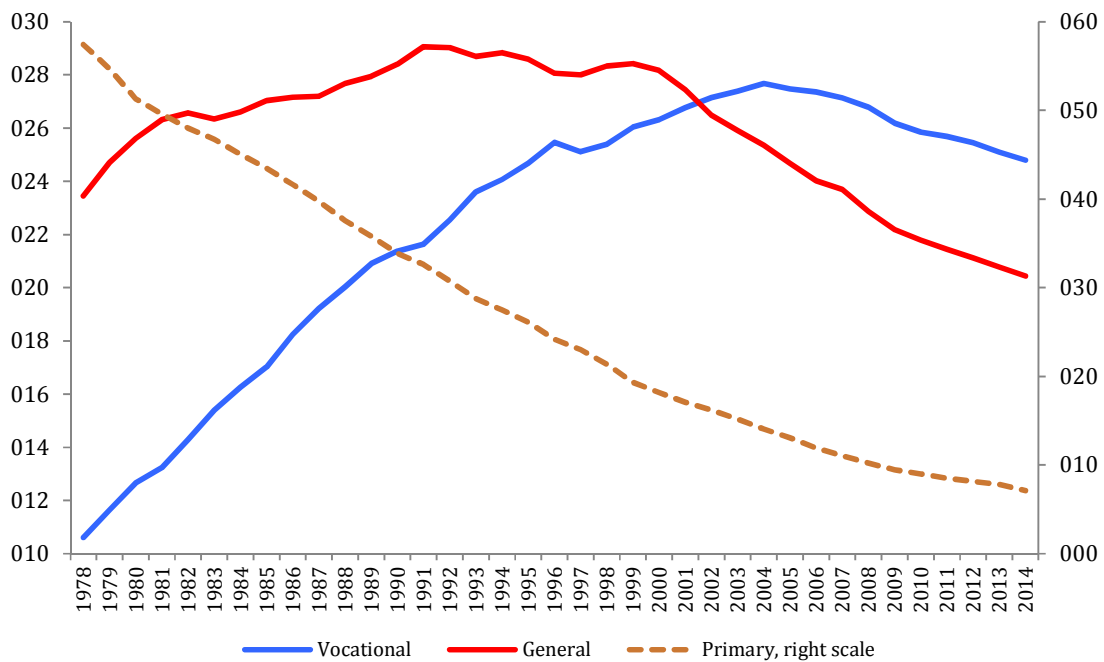
The composition of educational stock consists of the different levels of education. Let's suppose that working population has at least a primary education that covers at least 6 years and remains compulsory in most developing countries. At the upper level of secondary education students choose between two streams of secondary education: namely skill-specific or vocational and general education. Individuals endowed with specific knowledge and skills directly influence productivity growth. In turn, general education allows working with a wider spectrum of various knowledge and skills and therefore, opens a way to tertiary education.

Barro et al. (2013) point out that the average years of schooling among the overall population aged 15 years and above in developing countries increased significantly from 2.0 to 7.2 years. However, only rapidly growing economies in South East Asia, where the main source of productivity was technology adoption, have experienced a surprising increase in educational attainments for the period of 1960-1994. Moreover, South Korea and Taiwan reached the same level of industrial economies by average years of schooling in 1990s.

We use Taiwanese data over the period of 1978 – 2013 including annual measures of economic output, physical capital stock, labor input and educational stock compiled from Taiwan Statistical Data book 2013. Gross domestic product and gross fixed capital formation are considered as economic output and physical capital input, given in millions of New Taiwan Dollars (NT\$) at 2006 constant prices. Labor input is measured as the number of employed individuals who represent economically active population age 15 and over.

Human capital is measured as average years of education per person among those employed. It consists of the sum of primary, secondary and tertiary educational stock multiplied by 6, 12 and 16 years correspondingly, divided by total employed persons. The number of workers who previously studied at junior and senior high schools is taken as general educational stock, whilst the number of workers obtained vocational qualifications is considered as vocational educational stock. The number of workers graduated from junior college and universities is viewed as tertiary educational stock.

Figure 1.2 The shares of primary, vocational and general education, %



We overview the data on working population with two streams of secondary education and analyse its contribution to for economic development in Taiwan. As we see from Figure 1.2, the fraction of vocational education in total workforce sharply increases until 2004, while the share of general education – until 1992. Working population with primary education serves a source for expanding and tertiary secondary education. The share of secondary education rose from 34.06% in 1978 to 53.64% in 2002 (Figure 1.3). However, the share of secondary education slightly declined to 45% in 2014 due to an increase of working population with tertiary education. At the same time the ratio of vocational-to-general education constantly grows from 0.45 to 1.21 by the end of the period.

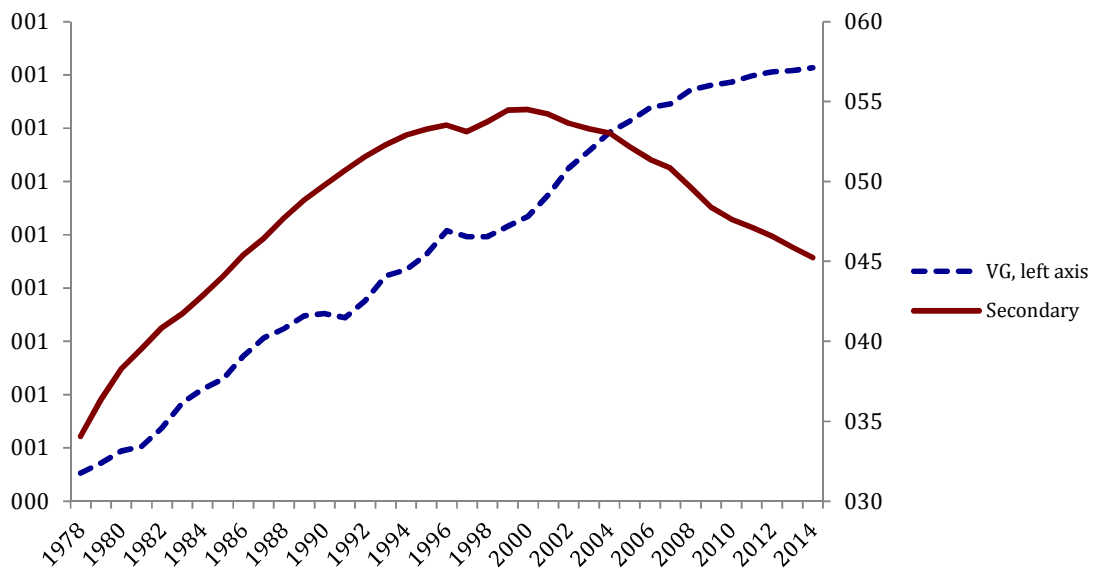
In order to construct an optimal trajectory for Taiwanese economy we test the link between GDP per worker (y) and gross fixed capital formation per worker (k), the fractions of working population with vocational (v) and general (g) education, respectively. The result of the assessment looks as

$$\log y = 8.0316 + 0.2159 * \log k + 0.5815 * \log v + 1.3536 * \log g \quad (1.12)$$

$$(7.716) \quad (3.371) \quad (7.488) \quad (1.997)$$

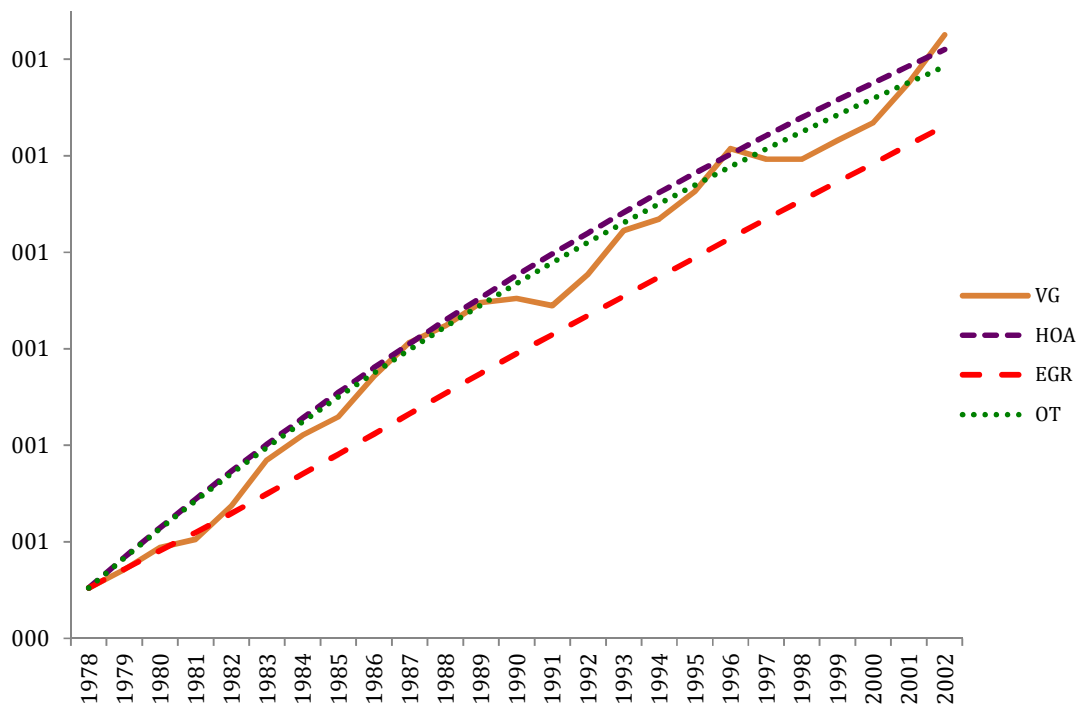
Then, following (1.2) we divide the coefficient of vocational education by that of general education from (1.12) and get that the ratio $\frac{v}{g}$ is equal to 0.4296, which is less than the value of the ratio of $\left(\frac{v}{g}\right)_t$ in 1978. The length of the period from 1981 to 1992 is defined by positive dynamics of vocational and general education.

Figure 1.3 The ratio of vocational-to-general and secondary education, %



We construct HOA, optimal and EQR trajectories in accordance with the laws of motion (1.6), (1.7) and (1.9) to analyse education policy in Taiwan. The Figure 1.4 shows that HOA and trajectories behave in a similar way, notable at the first stage of development. Therefore, in case of difficulties with data HOA trajectory can serve as a proxy for optimal trajectory in empirical studies. Next, we see that the actual and HOA and optimal dynamics lie above EQR trajectory by favouring a relative rise of vocational over general education. Finally, the actual path of vocational to general education in Taiwan is very similar to what the dynamic calculations yield.

Figure 1.4 Actual dynamics and EQR, HOA and optimal trajectories for Taiwan



Thus, optimal strategy for secondary education, applied by Taiwanese government, could ensure the accelerated expansion of secondary education by increasing educational attainment during a shorter period of time. Thus, the overall expansion rate of secondary education composes 1.58.

4. Conclusion

We have developed an analytical approach that opens up fresh insights into the composition of secondary education by specifying the ratio of vocational-to-general education as a measure of human capital in technology adoption. A surprising increase in educational attainments in East Asian economies demonstrates that specific skills, obtainable through vocational education in line with technology adoption, explain the above specification for developing countries.

The role of secondary education is very important in economic development for the reason that the completion of secondary education accounts for most

improvements in average years of schooling (Barro and Lee, 2013). A larger number of more skilled workers with secondary education contributes to greater absorption of modern technologies from developed countries that enhance productivity growth. Nevertheless, making secondary education universal within 25 years (Cohen, 2013) is unlikely to happen unless the mechanism of attaining this goal is widely explored.

The outcomes of education policy depend on the availability of resources, its allocation rule across all educational levels, market demands for skilled workforce, and other factors. Nevertheless, public funds were uncertainly allocated across two streams of secondary education. The cost of providing vocational education and training (VET) is higher than general education. Thus, the provision of VET has frequently been stigmatized over the past years as an anachronistic, dead-end path for students (Meer, 2007). By criticizing the World Bank position on VET at the expense of private funds, Bennell and Segerstrom (1998) argue that such prescription is seriously flawed both conceptually and in the relation to the proven experiences of developed and high-performing Asian economies. The topic is timely in light of a recent public policy shift that aims to dramatically expand VET (Newhouse and Suryadarma, 2011).

To conclude, the concept of feasible policy for secondary education presents a useful tool for evaluating the efficiency of decision-making in education sphere. In particular, we can check whether a rise of vocational relative to general education implies an extension of secondary education. Also, by verifying the rate of increase in years of secondary schooling we can judge if a policy for secondary education is optimal in a developing country. Further research can be dealt with finding a threshold in educational attainment.

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