Learning for employment, innovating for growth

Falkinger, J; Zweimüller, J
Learning for employment, innovating for growth

Abstract

We present a model in which workers must be educated to get a good job and firms must innovate in order to increase productivity. Education as well as innovation and production require skilled labor as inputs. This, together with the fact that learning opportunities differ across workers, determine simultaneously the long-run level of skilled employment and the long-run rate of growth. We study the impact of changes in the factors which affect the education of workers and the incentives to innovate, and discuss the growth and employment effects of labor market policy measures.
Learning for Employment, Innovating for Growth

by

JOSEF FALKINGER AND JOSEF ZWEIMÜLLER *

We present a model in which workers must be educated to get a good job and firms must innovate in order to increase productivity. Education as well as innovation and production require skilled labor as inputs. This, together with the fact that learning opportunities differ across workers, determine simultaneously the long-run level of skilled employment and the long-run rate of growth. We study the impact of changes in the factors which affect the education of workers and the incentives to innovate, and discuss the growth and employment effects of labor market policy measures. (JEL: O 31, O 40, J 21, J 24)

1. Introduction

New growth theory offers explanations for the long-run rate of growth when the exogenously given labor force of an economy is fully employed. However, substantial and lasting unemployment can also be observed in growing economies. This suggests that the long-run level of employment cannot be assumed to be given by the labor potential. It is the purpose of this paper to present a model in which the level of employment is determined endogenously and simultaneously with the rate of growth. While growth is governed by the flow of innovations, employment is determined by a process of learning and education.

The object of the analysis is the long-run relationship between growth and employment, not the impact of growth on short-run fluctuations of employment as described by Okun's law. Whereas in the short run growth and employment are positively related to each other, no clear correlation can be observed in the long run (BEAN AND PISSARIDES [1993]). A negative relationship between the long-run rate of growth and the long-run level of employment is possible (see AGHION AND HOWITT [1992]). We are interested in the economic mechanism determining this relationship and do not consider institutional explanations of unemployment such as recent comparisons of US and European labor markets.

* We are grateful for valuable comments to J. K. Brunner, R. Föllmi, M. Summer, R. Winter-Ebmer, W. Vogt, and seminar participants at Linz, Regensburg, Berlin (Humboldt), Toulouse, Bern, and Munich. Moreover, we want to thank two anonymous referees for their constructive criticism.

Our analysis rests on the idea that the following four features are important for the long-run macroeconomic performance of modern economies: (i) Growth requires innovations and human capital. Both innovations and human capital can only be provided by skilled workers. Thus, skilled workers are a key factor for economic growth. (ii) Technologies, organizations, and the competitive environment in a modern economy are such that the employability of workers depends crucially on their skills. Thus, for employment as well, at least for good jobs, skills have become a key factor. (iii) The acquisition of skills requires resources. Education as well as training on the job is costly. An increase in these costs reduces the amount of skilled labor. (iv) Workers are different with respect to the opportunities to acquire skills. Thus, the costs of education and training differ across workers.

For a formal analysis of the features and their implications we take a Romer [1990]-type endogenous growth model and add endogenous human capital formation. There are two set-up activities. Firms must invest in R&D for generating innovations and workers must acquire education in order to be employable.\(^1\) In contrast to other models in which these costs are the income foregone as an unskilled worker (see, e.g., Grossmann and Helpman [1991, ch. 5], Cahuc and Michel [1996]), we assume that skill formation requires teaching and guidance by educated workers.\(^2\)

Unlike the literature on growth and employment which is based on matching models (Aghion and Howitt [1994]),\(^3\) our analysis considers a heterogeneous population. People differ in their education costs and only those whose costs are less than the life-time income of skilled labor acquire education.\(^4\) Since education costs and life-time labor income depend on the interest rate and on wage growth, the size of the educated work force is an endogenous function of the growth rate.\(^5\) On the other hand, the larger is the educated labor force, the higher will be the growth rate, since more innovations are possible if the resource base of the economy is larger. Workers who do not acquire education are either unemployed and get a subsistence income from a social net, or they can earn low incomes in some secondary economy. We assume that abilities are unimportant for these outside opportunities.\(^6\) In other words, only skill-based production is relevant for the process

---

\(^1\) For a discussion of the effectiveness of R&D policy, as opposed to measures for human capital accumulation in endogenous growth models, see Arnold [1998], [1999].

\(^2\) Also in Eicher [1996] not only research and innovation but also education requires skilled workers as an essential input.

\(^3\) For a discussion of the relevant literature see Pissarides [2000].

\(^4\) We assume perfect capital markets. Thus, the different education opportunities do not arise from borrowing constraints as in models focusing on the link between inequality and the accumulation of human capital (Galor and Zeira [1993], Torvik [1993], Benabou [1996]).

\(^5\) That interest rates are an important but neglected determinant of labor market outcomes has recently been emphasized by Atkinson [1997] and Phelps and Zoega [1997].

\(^6\) In contrast to models in which either a technology requiring skills or a technology operated by unskilled workers can be used for producing output (see, e.g., Eicher [1996]), there is no interaction in production between skilled and unskilled workers in our model.
of long-run growth and the long-run level of employment in our economy.\footnote{Several recent studies have emphasized the importance of complementarities between skills, innovations, and growth (see Redding [1996], Booth and Snower (eds.) [1996]).} This is not to deny that, in reality, low-skill production and low-wage jobs are important also in modern economies. However, this unproductive sector does not generate innovation. Moreover, as far as employment policy is concerned, the relevant question in our view is not the creation of poor jobs but how the level of employment in good jobs is determined in an economy.\footnote{See Voigt [1996] for a discussion of this argument in the context of European labor markets and macroeconomic policy.}

The paper is organized as follows: Section 2 describes the basic features of the economy. In section 3 we study how, for a given rate of growth, the employment level is determined. Section 4 describes an innovation-driven growth model, which determines, for a given level of employment, the steady-state rate of growth. In section 5 the simultaneous equilibrium of employment and growth is analyzed and the impacts of exogeneous parameters on the equilibrium are discussed. In section 6 we discuss applications, in particular, the role of increased skill requirements and the effect of labor market policies. Section 7 contains a summary of the results.

2. Population, Endowments, and Preferences

We consider a society of workers and firm-owners with no mobility between the two classes.

The population of workers is given by the following birth and death process: At each point of time $t$ a cohort of size $\theta L$ is born. Adopting a perpetual youth framework,\footnote{See section 3.3 in Blanchard and Fischer [1989] for a discussion of the framework.} we assume that the probability of death per unit of time is constant throughout life and equal to the birth rate $\theta$. Thus, the population of workers is always of size $L$. By assuming finite lifetimes for workers we are able to study a situation where human capital has to be continuously created.

Workers inherit no wealth. In order to be employable in the primary economy a worker has to incur set-up costs at the beginning of his or her life. Whereas different workers face different set-up costs, all who have incurred these set-up costs earn the same wage rate $w(t)$. A worker who has not incurred the costs gets an income $u(t) < w(t)$ either from outside earning opportunities or from the social net.

The firm-owners are represented by dynasties. They live forever, earn no labor income, and have wealth corresponding to the value of the inherited stock of firms. Assuming dynastic preferences for firm-owners ensures that in our model, in which firms do not die, the difference between the relevant rates of interest and time preference is equal for all individuals in the economy. The assumption of eternal life of firm-owners, as opposed to a finite life of workers, may appear arbitrary. Indeed, the assumption is mainly made for technical convenience. However,
we think that there is some sociological basis for the asymmetry. Dynastic behavior of firm-owners is familiar, whereas dynastic behavior of workers appears more far-fetched.

We assume that an individual’s lifetime utility can be represented by the function

\[ U(t) = \int_0^\infty \frac{c(t) e^{-\beta t}}{1-\sigma} d\tau, \]

with \( \beta = \rho \) for a capitalist and \( \bar{\beta} = \rho + \vartheta \) for a worker. \( c(t) \) is the level of consumption at age \( t \), \( 1/\sigma \) is the elasticity of intertemporal substitution, and \( \rho \) is the rate of time preference (which has to be adjusted by the probability of death for the workers).

There is a perfect capital market with interest rate \( r \). Only steady states will be considered. So \( r \) is constant over time. The budget constraint of a firm owner is:

\[ \dot{k}(t) = rk(t) - c(t), \]

where \( k(0) \) is the discounted value of profits of the inherited stock of firms.\(^{10}\) The flow budget constraint of a worker born at date 0 is:

\[ \dot{D}(t) = \tilde{w}(t) + (r + \vartheta) D(t) - c(t), \]

where for an educated worker employed in the primary economy \( \tilde{w}(t) \) is the wage rate \( w(t) \) and \( D(0) \) is the debt to be incurred for financing the worker’s set-up costs at the beginning of her or his life. If a worker has incurred no set-up costs, then \( D(0) = 0 \) and \( \tilde{w}(t) = u(t) \). A creditor who lends money to finance a worker’s set-up costs faces a risk that the worker may die and the debt not be repaid. This risk can be insured by charging an insurance premium equal to the death rate \( \vartheta \). Therefore, the relevant interest rate for the worker is \( r + \vartheta \).

Maximization of (1), subject to (2), and maximization of (1), subject to (3), lead for firm owners as well as workers to\(^{11}\)

\[ g = \frac{r - \rho}{\sigma}. \]

As a result, the rate of growth of consumption is the same for all individuals. However, the level of consumption varies due to differences in \( D \) for workers and differences in \( k \) for firm-owners.

\(^{10}\) As will be seen, we have profitable firms only in the production of intermediate inputs. The inherited wealth consists of the discounted stream of profits generated by the initial stock of firms \( n(0) \) in the intermediate goods sector.

\(^{11}\) Setting up the Hamiltonian with shadow price \( \lambda(t) \) we obtain the first-order conditions \( \dot{\lambda} = -\delta \) and \( \lambda(t) = c(t)^{1-\sigma} e^{-\beta t} \), where \( \delta = r \) for firm owners and \( \delta = r + \vartheta \) for workers, respectively. Combining the two first-order conditions we get (4). The transversality condition \( \lim_{t \to \infty} k(t) c(t)^{-\sigma} e^{(\alpha - \beta - \frac{\rho}{1-\sigma}) t} = 0 \) is fulfilled if \( \sigma > 1 - \rho/g \).
3. Human Capital and Employment

For becoming a productive worker a young individual has to incur a fixed cost. More precisely, the set-up requires $D$ units of labor so that the debt to be incurred at the beginning of life by a worker born at date $t$ is\footnote{For acquiring skills, services of skilled workers who work as teachers or consultants must be purchased. This goes beyond publicly provided formal education and implies private costs. Also mobility costs arise for closing the “distance” between the place where the individual is born and a potential work place.}

\begin{equation}
D(t) = w(t) \cdot D,
\end{equation}

where $w(t) = w(0) e^{\theta t}$ is growing with the steady-state rate of growth $\theta$. This debt has to be repaid during the worker’s life.

Labor productivity after investment of $D(t)$ is the same for all workers. While productivity is uniform, set-up costs differ. Acquiring skills is easy for some workers and less easy for others.\footnote{The assumption that workers have to incur set-up costs only at the beginning of their life is not essential. Instead of (5) we could have the following process of permanent set-up requirements: The set-up input $D$ at the beginning of a worker’s life depreciates so that an amount $De^{-\xi t}$ of the input has to be renewed in period $\tau$, provided that the worker is still alive. In this case the discounted value of lifetime set-up costs of a worker born at date $t$ would be}

\begin{equation}
\begin{aligned}
\hat{y}_H(t) &= w(t) \int_0^\infty e^{\theta (\tau-t)} e^{-r(\tau-t)} e^{-\theta (\tau-t)} d\tau \\
&= w(t) \frac{1}{\hat{r} - \hat{g}},
\end{aligned}
\end{equation}

with $\hat{r} = r + \theta$. The life-time wage income of an individual born at $t$ and remaining outside the primary economy is equal to $\hat{y}_L(t) = u(t) \frac{1}{\hat{r} - \hat{g}}$. It is assumed that both $w$ and $u$ grow at steady-state rate $g$.

If subsistence of the unemployed is guaranteed through transfers from employed workers, only some net-income $\hat{y}_B(t) < \hat{y}_H(t)$ is at the disposal of a skilled individual. The following analysis is conducted under the assumption...
that workers who have acquired no skills and are thus not employable in the primary economy get no transfers but live on earnings in an informal or secondary economy so that \( y_N(t) = y_H(t) \). The impact of transfers will be discussed at the end of section 6.

The size of the educated work force is determined by the following fact: Education only pays for those individuals whose income gains are at least as high as the set-up costs, that is, for whom \( D(t) \leq y_H(t) - y_L(t) \) holds. In view of (5), (6), and \( y_L(t) = u(t) \frac{1}{\bar{r} - g} \), this means that individuals with set-up costs \( D \) fulfilling the inequality,

\[
D \leq \frac{1 - \epsilon}{\bar{r} - g} = \frac{1 - \epsilon}{(\sigma - 1) g + \rho + \Theta},
\]

are employed in the primary economy, the others are not. (Use \( \bar{r} = r + \Theta \) and (4) for calculating \( \bar{r} - g \).) \( \epsilon = u/\bar{w} < 1 \) denotes the relative income of workers who stay outside the skill-based economy. Since it is assumed that outside income grows at the steady-state rate \( g \), this income differential is constant.

Denote by \( H \) the number of workers for whom education pays according to (7). This is the relevant labor force for our analysis of the interaction between education and employment on the one side and innovation and growth on the other side. Since \( D \) is distributed according to the distribution function \( F \), the share of \( H \) in total labor force \( L \) is given by \( F(\bar{D}) \), where \( \bar{D} \) is the threshold defined by the term on the right side of inequality (7). This threshold is a function of the exogenous rate of growth – determined in the next section – and of the exogenous parameters of the model. The following proposition summarizes the properties of the thus defined relationship between employment level \( H \) and growth rate \( g \).\textsuperscript{14}

**Proposition 1 (The \( H(g, \cdot) \)-curve):** Let \( F \) be the (differentiable) distribution function of set-up costs \( D \) and let \( \Theta < 1, \epsilon < 1, \sigma > 0, \rho > 0 \) be birth rate, relative outside income, and preference parameters, respectively. For any steady-state growth rate \( g \): (i) Employment \( H \) is given by

\[
H = LF(\bar{D}) = \frac{1 - \epsilon}{(\sigma - 1) g + \rho + \Theta}.
\]

(ii) For \( H < L \),

\[
\frac{\partial H}{\partial g} < (=, > 0) \quad \text{if} \quad \sigma > (=, <) 1.
\]

\textsuperscript{14} If permanent set-up costs were required as specified in the footnote to (5), then condition (7) would change to \( D \leq \left( 1 + \frac{\xi}{\bar{r} - g} \right) (1 - \epsilon) \). Thus, nothing would change in (9) and (10). An increase in the additional parameter \( \xi \) would have the same effect as a decrease in the death rate \( \Theta \), since a higher \( \xi \) means less renewal requirements.
\[ \frac{\partial H}{\partial \theta} > 0, \quad \frac{\partial H}{\partial \sigma} > 0, \quad \frac{\partial H}{\partial \rho} > 0, \quad \text{and} \quad \frac{\partial H}{\partial \theta} < 0. \]

**Proof:** (i) follows directly from (7). (ii) follows from the fact that \( F' > 0 \) for \( H < L \). \( Q.E.D. \)

For a given rate of growth, \( g \), employment level \( H \) does not depend on the wage level \( w(t) \). The reason is that higher wages lead at the same time to higher set-up costs, since the teachers' and consultants' wages also rise. However, of course the wage level of skilled workers plays a role in the process of innovation analyzed in the next section.

The set-up services necessary to make a worker employable in the skill-based economy require educated workers. According to (5) and (8), total labor input \( H_E \) for the education of the young workers is

\[ H_E(H; \theta) = \theta L \int_0^{D(H)} z f(z) dz, \]

with \( D(H) = F^{-1} \left( \frac{H}{L} \right) \). We have \( H_E(0, \cdot) = 0 \) and \( \partial H_E/\partial H = \theta D(H)^{-1} \). \(^{15}\) For the marginal worker the set-up costs are \( D(H) \), and \( \theta L \) workers are born. In any productive (viable) economy we must have \( H_E(H; \cdot) < H \). Moreover, since \( D(H) = \frac{1 - \epsilon}{r + \theta - g} \), according to (4) and (8), we have \( \partial H_E/\partial H < 1 \) as long as \( g < r \). The condition \( \partial H_E/\partial H < 1 \) is equivalent to \( D(H) < 1/\theta \). Thus, the amount \( D \) of teaching units required to educate the marginal worker is lower than the life-expectancy \( 1/\theta \) of the worker.

4. **Innovation and Production**

The educated labor force of the economy is \( H \), as determined in the preceding section. \( H_E(H; \theta) \) workers are used in the "education sector" so that \( H - H_E(H; \theta) \) workers are available for innovation and production. This labor force is allocated to two sectors: a sector which produces a homogenous final output good and an R&D sector, which uses labor to design new intermediate inputs. We describe first the technology in the various sectors and then derive the equilibrium allocation.

Final output is produced according to the production technology

\[ Y(t) = H_\gamma (t) \int_0^{n(t)} x(i,t)^{1-\alpha} di, \]

\(^{15}\) Note that \( dD/dH = \frac{1}{f(D(H))L} \).
where \( Y(t) \) denotes output at date \( t \), \( H_y(t) \) is the corresponding labor-input, \( n(t) \) is the measure of currently available intermediates, and \( x(i, t) \) denotes the amount of the intermediate \( i \) at date \( t \). \( \alpha \in (0, 1) \) is a constant technological parameter. The output of final goods has two uses. It can either be consumed or used as an input to produce intermediate goods. One unit of any intermediate good can be produced with an amount of \( \eta \) units of final output. No labor is required in the production of intermediate goods. Normalizing the price of the final output to one, we have for the cost function of producing intermediate goods

\[
C(x(i, t)) = \eta x(i, t).
\]

(13)

The only use of intermediates is as an input for final goods producers. Producers of intermediates have to perform R&D to be capable of producing such a new input.

After a successful innovation, the innovating firm has a monopoly position and can supply the good for an infinitely long period. The R&D technology is assumed to be linear. The only input is skilled labor where for a successful innovation at date \( t \),

\[
a(t) = \frac{G}{n(t)},
\]

(14)

units of labor have to be employed in the R&D sector. \( G > 0 \) is a technology parameter representing the level of the costs of innovation. \( n(t) \) is the number of existing intermediates invented up to date \( t \), which is a proxy for the stock of knowledge in the economy.

The production and innovation equilibrium is determined by profit maximization by competitive producers in the final output sector, monopolistic price setting in the intermediate goods sector, and free entry into the R&D sector.

We are interested in the allocation of the available labor force \( H - H_E \). As shown in the appendix, in a steady state the equilibrium level of employment in the final output sector is given by

\[
H_y = \frac{rG}{1 - \alpha}.
\]

(15)

Whereas no workers are employed in the production of intermediate inputs, the number of R&D workers \( H_y \) is, according to (14), equal to \( n(t) \ a(t) = G\eta(t) / n(t) \).

In a steady state, in which all rates of growth must be equal to the rate of consumption growth, we have \( n/n = \eta \). Thus,

\[
H_n = \eta G.
\]

(16)

The equilibrium condition for the allocation of the effective labor force is

\[
H_y + H_n = H - H_E(H; \delta).
\]

(17)

The size of the educated work force required in production and innovation must be equal to the number of workers available after the requirements \( H_E \) in the educa-
tion sector, for training the total effective work force \( H \), have been fulfilled. The equations (15)-(17) together with (4) determine the equilibrium rate of growth which is feasible with labor force \( H \). Proposition 2 summarizes the properties of this relationship between \( g \) and \( H \).

**Proposition 2 (The \( g(H,\cdot) \)-curve):** Let \( \theta, \sigma, \rho \) denote the same as in proposition 1. Let \( \alpha \in (0,1) \) and \( G > 0 \) be technological parameters characterizing the weight of labor in production and the costs of innovation, respectively. For any labor force \( H \), the steady-state rate of growth is given by

\[
(18) \quad g = \frac{H - H_E(H; \theta)}{G} \frac{1 - \alpha - \rho}{\sigma + (1 - \alpha)},
\]

with

\[
(19) \quad \frac{\partial g}{\partial H} > 0,
\]

and

\[
(20) \quad \frac{\partial g}{\partial z} > 0 \quad \text{for} \quad z = \sigma, \rho, \alpha, \theta, G.
\]

**Proof:** (i) Substitute (15) and (16) into (17), taking into account that \( r = g\sigma + \rho \) according to (4). This gives us the equation \([g\sigma + g(1 - \alpha)] G = (1 - \alpha) [H - H_E(H; \theta)]\) which is equivalent to (18). (ii) (19) follows from \( \partial H_E/\partial H = \partial D < 1 \) for \( g < r \). For the derivation of \( g \) with respect to \( \theta \) use (11). The signs of the other derivations follow immediately. \( Q.E.D. \)

5. The Steady-State Equilibrium

Equation (8) describes, for a given rate of growth \( g \), how many workers \( H \) can afford the set-up costs necessary to be employed in the primary economy. Equation (18) defines for each level of employment \( H \) the steady-state growth rate \( g \). Together these two equations determine equilibrium values \( H^*, g^* \) for long-run employment and growth. In general, no equilibrium or multiple equilibria may result. We discuss the sufficient conditions for and the properties of a unique equilibrium by representing the two equations in the \((H, g)\)-space.

According to (9), two cases must be distinguished. The figures concentrate on steady states when the elasticity of intertemporal substitution \((1/\sigma)\) is lower than one. This is the more plausible case from an empirical point of view (see Blanchard and Fischer [1989, 44]). The case of a high elasticity of intertemporal substitution \((1/\sigma > 1)\) will be briefly discussed at the end of this section.

The employment curve \( H \), which represents equation (8), is downward sloping if \( \sigma > 1 \). For \( \sigma = 1 \) the \( H \)-curve would be a vertical line. The reason behind the negative slope is: On the one hand, growth has a positive effect on employment since life-time income of workers rises, so that more people can afford the set-up
Figure 1
Impact of Increasing $G, \alpha$, when $\sigma > 1$

Figure 2
Impact of Increasing $\alpha, \rho, \vartheta$, when $\sigma > 1$
costs. On the other hand, higher growth leads to higher interest rates which makes it more difficult to finance education. With \( \sigma > 1 \) the latter effect dominates.\(^{16}\)

The innovation curve \( I \), representing equation (18), starts at \( g(0; \cdot) < 0 \) and is positively sloped, according to (19). The reason is that a larger educated work force makes higher growth rates feasible.

A sufficient condition for a unique equilibrium with \( g^* > 0 \) is that \( g(H_1; \cdot) \) is strictly positive, where \( H_1 \) is the employment level at which the \( H \)-curve cuts the horizontal axis. This is fulfilled if we make the assumption:\(^{17}\)

\[
(21) \quad \frac{\rho G}{1 - \alpha} < L \int_0^{\frac{1}{\rho + \theta}} (1 - \theta z) f(z) \, dz.
\]

\(^{16}\) Note that \( \tau - g = g (\sigma - 1) + \rho + \theta \), according to (4).

\(^{17}\) From (8) follows \( H_1 = LF \left( \frac{1 - \varepsilon}{\rho + \theta} \right) \). Substituting \( H_1 \) into (18), we get \( g(H_1; \cdot) > 0 \) if

\[
H_1 = H_1 \left( H_1; \theta \right) = \frac{\rho G}{1 - \alpha}. \tag{1-0}(\rho + \theta)
\]

According to (11), \( H_1(H_1; \theta) = \theta L \int_0^{\frac{1}{\rho + \theta}} z f(z) \, dz \). By definition

\[
H_1 = L \int_0^{\frac{1}{\rho + \theta}} f(z) \, dz. \tag{1-0}(\rho + \theta)
\]

Combining these facts, we have (21).
That means, for given $G, \alpha, \rho, \varepsilon, \text{ and } \partial$ the total labor force $L$ must be high enough to make growth feasible.

The following comparative steady-state results follow immediately from (10) and (20):

An increase in $G$ or in $\alpha$ has a negative effect on growth $g^*$, but a non-negative effect on employment $H^*$ (see figure 1). The reason is that the dampening effects of an increasing $G$ or $\alpha$ on growth leads to a decrease in the interest rate, which for $\sigma > 1$ outweighs the negative effect of growth on the workers’ income, so that more people can afford education.

An increase in $\sigma$ or $\rho$ has a negative effect on growth $g^*$ and skilled employment $H^*$. If people are more shortsighted, they discount future incomes more strongly and the reward to education decreases. At the same time, people invest less in innovative activities which decreases growth. The indirect effects arising from changes in the interest rate cannot change the direction of the direct impacts. Thus, in figure 2 the shift of the $H$-curve to the left dominates the downward shift of the $I$-curve and skilled employment decreases.\(^{18}\)

An increasing birth rate and death risk $\partial$ would also have a negative effect on growth (see figure 2). A younger work force requires a larger education sector so that a smaller work force remains for production and innovation. According to (20), the $I$-curve is shifted downwards. According to (10), the $H$-curve is shifted to the left, since life-time income is reduced ceteris paribus. The resulting effect on equilibrium employment is ambiguous.

Finally increasing outside opportunities $\varepsilon$ make education less attractive. According to (10), the $H$-curve is shifting downwards. As a result, both the equilibrium rate of growth and the equilibrium level of skilled employment decline (see figure 3).

In the case of $\sigma < 1$, which seems less relevant from an empirical point of view, nothing changes as far as the slope of the $I$-curve is concerned. The slope of the $H$-curve now becomes positive, according to (9). The negative effect on education of the growth-induced rise in the interest rate is outweighed by the positive effect of increased life-time worker income. For a unique equilibrium with $g^* > 0$ we must require, in addition to (21), that the $H$-curve is steeper than the $I$-curve. As far as comparative static results are concerned, we have now a parallel reaction of growth and employment to all shocks considered. If $G, \alpha, \rho, \varepsilon, \text{ or } \partial$ increases, both employment $H^*$ and the growth rate $g^*$ decrease. The reason is that for $\sigma < 1$ the interest rate effect never outweighs the growth effect in the workers’ set-up cost calculation.

\(^{18}\) According to (8) and (18),

\[
\partial H/\partial \sigma = -LF' \left[\frac{1-\varepsilon}{(\alpha-1)g+\rho+\partial}\right] g, \quad \partial H/\partial g = (\partial H/\partial \sigma) \frac{\sigma-1}{g},
\]

and $\partial g / \partial \sigma = \frac{-g}{\sigma+1-\alpha}$. Hence, $|\partial H/\partial \sigma| > |\partial H/\partial g|$ $\partial g / \partial \sigma$ is equivalent to $1 > \frac{\sigma-1}{\sigma+1-\alpha}$. Since $\alpha < 1$, this inequality is always fulfilled. An analogous argument can be applied for showing the negative impact of $\rho$ on $H$. 


6. Discussion

We first apply the comparative steady-state analysis presented above to discuss the growth and employment implication of changes in preferences and technical change. Then we turn to labor market policies. Obviously, the discussion shares the principal limitation of any comparative static argument. In reality, several exogenous factors may change at the same time so that the isolated discussion of the effects of single parameters cannot be taken for a complete description of real development. Nonetheless, the discussion leads to a better understanding of the concrete economic mechanisms operating.

6.1 Explaining Growth and Employment Problems by Behavioral and Technical Changes

The fundamentals determining the long-run equilibrium in our model are, on the one hand, the attitude of individuals towards the future and growth of consumption and, on the other hand, the requirements of innovation and skill-acquisition.

Changes in the “Desire to Growth.” In advanced countries, in the last three decades lower growth has been observed than in previous decades. Some people argue that the ambition to grow has diminished and this is why employment has come under pressure. A natural translation into our model would be that the rate of time preference \( \rho \) has increased or that the marginal utility of consumption decreases more rapidly than before. The latter means that its elasticity \( \sigma \) has increased. According to figure 2, saturation in this sense indeed implies a lower growth rate. Moreover, the net effect on employment is also negative. Thus, the predictions of our model fit well to the idea that a positive climate for growth is also good for employment, provided the positive growth climate means that people have a high preference for growth. The further discussion shows that this coincidence of positive growth climate and good employment opportunities is not guaranteed if changes in other determinants of the long-run equilibrium are considered.

Changes in Skill Requirements. There is a broad consensus that recent techniques of production and forms of organization are relying more heavily on knowledge and skills than in earlier periods. In our model, the hypothesis that economic conditions have been biased towards higher knowledge requirements can mean that the R&D requirements \( G \) for innovations have increased. It is intuitively clear that such a change has a negative effect on growth. Our analysis shows that the level of skilled employment is also affected. According to figure 1, for \( \sigma > 1 \) skilled employment rises, since higher innovation requirements make education relatively more attractive.\(^{19}\) Put the other way round, a decrease in R&D requirements leads

\(^{19}\) Enhancing innovations through lowering \( G \) would have an adverse effect on employment (see SAINT-PAUL [1996] for a similar effect).
to a higher growth rate but decreases the level of employment. Thus, the model predicts that "jobless growth" is possible if the increase in the long-run rate of growth results from a stimulation of innovations. As we saw above, an increase in both the steady-state growth rate and the long-run level of employment go hand in hand if the stimulus comes from changing attitudes towards growth. Moreover, like the changes in the education process discussed below, other exogenous changes may parallel the change in R&D requirements and either reinforce or offset the negative relationship between the long-run level of employment and the steady-state rate of growth.

Another interpretation of a bias towards increasing skill requirements is that the diffusion of modern techniques and forms of organization have led to a situation where workers have to be more qualified, more flexible or more reliable to be productive in the primary economy. This means that the set-up costs for workers increase. In our model, we can deal with this argument by considering a shift of \( F(D) \) to \( \tilde{F}(D) = F(D - d) \) for some \( d > 0 \). Then, for \( 0 < H < L, \tilde{F}(D) < F(D) \) in the neighborhood of \( \tilde{D} \). According to (8), this shifts the \( H \)-curve to the left, whereas the \( I \)-curve will be shifted downward, since more teachers are required to provide the higher qualifications. Thus, we have the situation represented in figure 2. The higher set-up costs have a negative effect on growth and, for \( \sigma > 1 \), an ambiguous effect on skilled employment. Whereas it might be expected that higher education requirements would depress the level of skilled employment, our model shows that the effect on skilled employment is ambiguous. The reason is that the higher set-up costs for workers also have an effect on the growth rate. This effect is unambiguously negative. As a consequence, the interest rate also declines. Thus, there are two opposing effects on employment in the primary economy. On the one side, higher investments in education are required to become a skilled worker. On the other side, with lower interest rates, it is easier to finance these higher investment costs.\(^20\)

In sum, higher skill requirements can indeed explain growth problems\(^21\) but they do not necessarily depress skilled employment.

6.2 Labor Market Policies

How can the steady-state equilibrium \( g^* \) and \( H^* \) be affected by policy? We discuss the following measures: subsidizing the costs of skill acquisition, paying unem-

\(^20\) A look at figure 2 shows that a change of renewal rate \( \vartheta \) has similar effects. An increase in \( \vartheta \) means that the education of workers has to be renewed more often. This would be the case if workers died early, or more realistically, if more older workers are fired, because of obsolescence of their skills, and substituted for by a larger inflow of young workers. But it is also the case if the acquired education depreciates rapidly. As mentioned in section 3, if the model is extended to include permanent set-up requirements of workers, an increase in \( \vartheta \) works like a decrease in \( \xi \), which means that the renewal costs to be incurred by the workers to remain employable in the primary economy rise.

\(^21\) This remains true for \( \sigma < 1 \). In this case also \( H \) would decline unambiguously.
ployment benefits, and improving the earning opportunities for unskilled workers. Before analyzing the effects of these measures we want to make a few caveats. In our model heterogeneity of agents is a central element. Therefore, the policies discussed involve distributional issues. So a normative judgement about what is a good or optimal policy can only be made by weighing the utility of different individuals according to a concrete social welfare function. Being aware of the deep problems of social choice, we present the policy effects on growth and employment without settling the question as to whether or not the implied redistribution between individuals is welfare-enhancing. We think this is more transparent than hiding value judgements behind some sum of utilities. There is a further principal problem. Policy measures which treat different individuals differently require the identification of the type of an individual. Thus, in principle, we would have to account for the asymmetric information problem when discussing how policy measures affect growth and employment. We ignore this problem and assume that the individual education costs \( D \) are observable.

**Subsidizing Skill Acquisition.** In the discussion about changing skill requirements in section 6.1, we considered the effects of a general shift in the set-up costs of workers. Instead of an overall change in these costs, one could think of redistributive measures which change the distribution of the costs. Suppose that income is redistributed from able individuals with set-up costs lower than \( D \) to less able individuals with set-up costs slightly higher than \( D \). This increases the life-time income of the marginal worker so that the \( H \)-curve is shifted to the right. The \( I \)-curve is not affected since the education technology remains unchanged. In sum, this kind of redistribution increases both \( g^* \) and \( H \) (see figure 3).

**Paying Unemployment Benefits.** Redistribution of incomes may have a different form. Suppose that individuals who do not acquire skills are not employed in a secondary economy but remain unemployed. Unemployed people receive a transfer of \( u(t) = b_0 \omega(t) \) financed by a tax on the wages of employed individuals. Net life-time income of an employed worker is then

\[
y_H^n(t) = y_H(t) - b_0 y_H(t) \frac{L - H}{H}.
\]

This net income must be compared with set-up costs plus life-time transfer income \( \frac{b(t)}{r - g} \). Thus, instead of (7), employment \( H \) is determined by the inequality

\[
D \leq \frac{1}{r - g} \left( 1 - b_0 \frac{L}{H} \right).
\]

---

\(^{22}\) We assume that lump-sum taxation of abilities is possible. Otherwise, efficiency losses due to tax distortions would have to be considered. Moreover, the tax imposed on an able individual must not be so high that they can no longer afford education.
Substituting this in (8), we see that with respect to the $H$-curve an increase in $b_0$ has the same effect as an increase in $\theta$. That means, the $H$-curve is shifted to the left. The $I$-curve remains unaffected. Thus, redistribution through the social net has the opposite effect to redistribution through set-up costs subsidization. Both growth and skilled employment decrease with the level of the unemployment benefit.

As pointed out at the beginning of this section, this does not mean that reducing unemployment benefits is a good policy in terms of welfare. After all, it means that those who remain unemployed despite the induced increase in employment, i.e., the poorest individuals, are at least in the short-run worse off than before.

*Improving the Earnings Opportunities for Unskilled Workers.* More generally, our analysis shows that any improvement which leads to a rise in the relative income outside the primary sector has a similar effect. The impact of a decreasing $\varepsilon$ is shown in figure 3. An increase in $\varepsilon$ has the opposite effect. Skill acquisition decreases because of more attractive outside opportunities. Thus, policies fostering the earnings opportunities in secondary labor markets have negative effects on skilled employment and long-run growth in our model.

7. Concluding Remarks

This paper has analyzed the relationship between employment and growth on the basis that employment requires education and growth is driven by innovations. Our approach has been that skills are the limiting factor in modern production. The analysis rests on the assumption that substitution between skilled and unskilled workers can be neglected. Unskilled workers are unemployed or obtain income in an informal or secondary sector.

We have studied how changes in the factors which affect human capital formation and innovation incentives influence the level of employment and the long-run growth rate of an economy. Higher innovation costs lead to a decrease in the growth rate but have an ambiguous effect on employment. On the one side, less growth and innovation lead to lower life-time income of workers so that less people can afford education. On the other side, less growth and innovation imply a lower interest rate which makes it easier to finance education. For the same reason, an increase in the costs of education caused by increasing skill requirements has a negative effect on growth but an ambiguous effect on the employment level. The effects of redistribution among workers depend on the form of redistribution. Growth as well as skilled employment can be increased by subsidizing education of less able individuals through taxes on more able people. Redistribution through the social net has a negative effect on both the level of skilled employment and the rate of economic growth, so that there is some conflict between growth and social concerns.
Appendix

Let $p(i, t)$ be the price charged for a unit of intermediate input $i$. Then the maximization problem in the final output sector is:

$$
(24) \quad \max_{x, H_i} \int_0^{n(i)} \left[ H_y(t)^{\alpha} x(i, t)^{1-\alpha} - p(i, t) x(i, t) \right] di - w(t) H_y(t).
$$

The first-order-conditions give us for the inverse demand curve for an intermediate input,

$$
(25) \quad p(i, t) = (1 - \alpha) H_y(t)^{\alpha} x(i, t)^{-\alpha},
$$

and for the inverse labor demand function in the final output sector:

$$
(26) \quad w(t) = \alpha H_y(t)^{\alpha - 1} \int_0^{n(i)} x(i, t)^{1-\alpha} di.
$$

Profit maximization of a monopolistic producer facing cost function (13) and demand curve (25) leads to

$$
(27) \quad p(i, t) = \frac{\eta}{1-\alpha}.
$$

Thus, prices and quantities are equal for all $i$, and prices remain constant over time. We write $p$ and $x(t)$ instead of $p(i, t)$ and $x(i, t)$, respectively.

Free entry into the R&D sector implies that the innovation equilibrium is determined by the zero-profit condition. This means that the discounted value of the flow of gross profits $\Pi(t) = (p - \eta) x(t)$ arising from the monopolistic provision of an intermediate input must be equal to the costs of the innovation which makes the monopolistic position possible. In a steady state, where $H_y(t) = H_y$ and thus, according to (25), $x(t) = x$ are constant, the present value of the profit flow resulting from an innovation is

$$
\int_0^{\infty} \left( p - \eta \right) x e^{-rt} dt = \left( p - \eta \right) \frac{x}{r}.
$$

The costs of an innovation are $w(t) G / n(t)$, according to (14). In a steady state both $w(t)$ and $n(t)$ grow at the same rate, so that these costs remain constant over time. Thus, the zero-profit condition in the innovation sector is given by the equation

$$
(28) \quad \left( p - \eta \right) \frac{x}{r} = \omega G,
$$

with $\omega = w(0) / n(0)$.

In a steady state, (26) reduces to $\omega = \alpha H_y^{\alpha - 1} x^{1-\alpha}$. Combining this with (28), we get

$$
\omega \alpha G = \frac{p - \eta}{r} H_y^{1-\alpha}.\]

Substituting this into (25), we obtain equation (15) in the main text.

Q.E.D.
References


Josef Falkinger
Department of Economics
University of Regensburg
Universitätsstraße 31
93053 Regensburg
Germany

Josef Zweimüller
Institute for Empirical Economic Research
University of Zürich
Blümlisalpstrasse 10
8006 Zürich
Switzerland