中央研究院經濟所學術研討論文

IEAS Working Paper

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IEAS Working Paper No. 04-A006

February, 2004

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Taipei 115, TAIWAN
http://www.sinica.edu.tw/econ/

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May 2003

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Working Hours Reduction and Endogenous Growth

[Abstract] This paper formulates an endogenous growth model and uses it to inquire into the *long-run* impact of work-sharing arrangements on economic growth. We show that the styles of wage contract, namely salary-style and hourly-style contracts, are a key factor in determining the long-run growth effects of working time reduction. If the labor market is overwhelmingly salaried arrangement, then the extent of wage flexibility is relatively low; as a consequence, a policy of reducing working hours will deteriorate economic growth. On the contrary, if hourly pay predominates, then the wage system tends to increase the degree of wage flexibility. Thus, a cut in working time may favor the economy's growth rate.

Key Words: Working hours reduction; Endogenous growth

JEL Codes: J22, J23, O41

Working Hours Reduction and Endogenous Growth

1. Introduction

In Western Europe there has been a prevalent phenomenon of the low-growth and high-unemployment phase of economic development since the mid-seventies (Layard, Nickell, and Jackman (1991, ch. 1), Bastian (1994, p. 2), and Daveri and Tabellini (2000)). Lately, the economy in many Asian countries, for example Japan and Taiwan, is also in a similar phase. To combat this problem, economists have propounded many distinctive arrangements. The *work-sharing* arrangement, which is linked to a reduction in working hours, is one of the most popular and also the most controversial policy issue. Advocators recommend that a reduction in employees' standard working hours will provide benefits to the unemployed through the provision of new jobs, while improving the workers' quality of life. The opponents argue that shorter working hours increase firms' labor costs; this consequently cuts back their demand for labor in the short run and even deteriorates economic growth in the long run.

In the economic literature, work sharing as a means of reducing unemployment has a long history. Many theoretical and empirical studies (e.g., Hart (1984), Calmfors (1985), Hoel (1986), Booth and Schiantarelli (1987), and Hunt (1999)) point out the effect is usually ambiguous due to different wage arrangements, the type of production and unemployment, and the government's policy in different countries.[1] Surprisingly, to our knowledge there does not exist a formal model making a further investigation into the relationship between working hour reductions and economic growth, however. To fill this gap in the existing literature, the present study therefore formulates an endogenous growth model and uses it to inquire into the *long-run* impact of work-sharing arrangements on economic growth.

Ever since Romer (1986) and Lucas (1988) published their pioneering papers, there has been a substantial amount of literature focusing on the issue of endogenous growth on both

[1] See Drèze (1986) and Hart (1987) for detailed and completed discussions of work sharing.

theoretical and empirical grounds.[2] It is widely recognized that endogenous growth has emerged as a branch of mainstream research in macroeconomic theory. The familiar feature of endogenous growth is that the source of growth comes from the model itself rather than from exogenous population growth or technical process. Accordingly, in an endogenous growth model the endogenous growth rate can be influenced by policy makers through designing different policies and arrangements.[3] By virtue of this, an endogenous growth model allows us to explore the long-run effect of working time reduction on the equilibrium growth rate.

This paper shows that the styles of wage contract, namely salaried and hourly contracts, are a key factor in determining the long-run growth effects of working time reduction. In some countries, such as Japan and Taiwan, the labor market is dominated by salary arrangements, for instance, weekly or monthly compensation contracts.[4] Given the fact that the wage payment is independent of working hours, the extent of wage flexibility is relatively low. Within such a wage regime, a reduction in working hours implies an increase of firms' labor costs when workers' salaries are fixed by contract. As a consequence, a policy of reducing working hours will deteriorate economic growth. However, if countries have a predominance of hourly arrangements, such as America, then the wage system tends to increase the degree of wage flexibility.[5] Once workers' wage payment is accounted by their working hours, reducing hours of work will accomplish a reduction in employer costs. Thus, a cut in working time may favor the economy's balanced growth rate.

In static frameworks (e.g., Hart (1984) and Hunt (1999)), the decision of working time is

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[2] See, for example, Barro (1990), Rebelo (1991), Jones, Manuelli, and Rossi (1993), and Jones (1995).

[3] Most papers on endogenous growth focus on the effects of fiscal or monetary policy on long-run economic growth. For the literature on fiscal policy and endogenous growth, see, e.g., Barro (1990), Rebelo (1991), and Barro and Sala-i-Martin (1992). The literature concerning monetary policy and endogenous growth includes Wang and Yip (1992), Van der Ploeg and Alogoskoufis (1994), Chang and Lai (2000), etc.

[4] See Hashimoto and Raisian (1988) and Contensou and Vranceanu (2000, ch. 2) for cross-nation comparisons concerning wages structures.

[5] According to the Scarpetta et al. (2000) report, in many OECD countries there is an increasing trend of part-time employment. For instance, in the Netherlands almost half of employment's growth in 1993-1997 was in the form of part-time employment, and almost two-thirds of women are part-time workers. Because wage payment of part-time jobs is usually accounted by workers' working hours, the use of part-time working will promote the flexibility of wages in an economy. See Hart (1987) and Hashimoto and Raisian (1988) for relevant illustrations and practical observations.

often brought into the issue of work sharing to examine the employment effect of shorter working hours. Going beyond the static model, we extend our endogenous growth model with overtime work. It is found that if overtime work is allowed, due to the substitution between working time and worker, then shorter standard working hours will push firms to substitute more working hours for fewer workers. Such an adjustment will reduce the accumulation of employment, and hence further deter economic growth.

The remainder of this paper is organized as follows. Section 2 first sets up the analytical framework, and then discusses the effect of shorter working hours on the economic growth rate. Section 3 extends the model with overtime work and examines the same analysis. Section 4 presents concluding remarks.

2. The model

Consider an economy where many identical competitive firms engage in production and investment. Each firm has the same production function such that:

$$Y = AK^{\alpha}[E(h)N]^{1-\alpha}, \qquad A > 0, 0 < \alpha < 1, E' > 0, E'' < 0, \tag{1}$$

where Y is output, A is a fixed technological parameter, K is the stock of capital, h is working hours per worker, N is the stock of employees, and $E(h)N$ is the amount of labor services. The function $E(h)$ represents the relationship between per-worker productivity and working time in the production of labor services.[6]

In this section we first assume that an individual firm's working time is exogenous while the case of endogenous working time will be discussed in next section. The exogenous working hours might be determined by law or through collective bargaining between trade unions and employer federations. In addition, each firm incurs quadratic costs $\Phi(I, K)$ and $\Psi(L, N)$ in adjusting investment and labor. These two adjustment cost functions are given by:

[6] See Calmfors and Hoel (1988), Booth and Ravallion (1993), and Hart and Moutos (1995, p. 23) for a similar setting.

$$\Phi(I,K)=\frac{bI^2}{2K}, \tag{2}$$

$$\Psi(L,N)=\frac{aL^2}{2N}, \tag{3}$$

where I is investment, L is the number of newly-hired workers, and both exogenous parameters a and b denote the sensitivity of adjusting investment and labor to the costs, respectively.

Equation (2) is an application of the familiar Hayashi (1982) cost of adjustment (installation) framework. In line with Turnovsky (1996, 1999) and Hoon (1998), the adjustment cost is specified to be proportional to the *rate* of investment per unit of installed capital rather than its level. As pointed out by Turnovsky (1996b), it is necessary that the adjustment cost function Φ is homogeneous of degree one in I and K if a steady-state equilibrium having ongoing growth is to be sustained.[7] Similarly, in equation (3) we also assume that the labor's adjustment (training) cost is proportional to the *rate* of newly-hired workers per unit of employed worker (rather than the level of newly-hired workers).[8]

The representative firm that maximizes the discounted value of its life-time profit stream faces the following intertemporal optimization problem:

$$\max_{L,I,N,K}\int_0^{\infty}\{Y-wh^{\beta}N-\Psi-I-\Phi\}e^{-rt}dt, \tag{4}$$

$$s.t.\quad \dot{K}=I, \tag{5}$$

$$\dot{N}=L-\theta N, \tag{6}$$

where w and r denote the wage and the interest rate, respectively. The coefficient β is an index parameter. If $\beta=0$, then the firm faces a salary arrangement (w is the weekly wage); if $\beta=1$, then the firm faces an hourly wage regime (w is the hourly wage). Equation (5)

[7] Generally, adjustment costs are specified in terms of the level of investment. Hayashi (1982) provides some empirical evidence supporting that the adjustment cost function Φ is homogeneous of degree one in I and K.
[8] In the existing literature (e.g., König and Pohlmerier (1988) and Georges (1995)), costs of adjusting labor are formulated in terms of the level of newly-hired workers. In order to obtain the balanced-growth equilibrium, the setting of labor's adjustment costs is similar to that of investment's adjustment cost. An intuitive rationale for this setting is that the accumulation of labor's training experience may reduce the cost of training new workers. Accordingly, the relationship between adjustment costs and the number of employee is negative.

indicates that the stock of capital will change over time with the status of investment.[9] Equation (6) defines the change in a firm's employees is equal to the difference between the inflow of newly-hired workers and the outflow of quitting workers. The term θ is an exogenous separation rate of workers. From equations (1)-(6), the current-value Hamiltonian function H can be expressed as:

$$H = AK^{\alpha}[E(h)N]^{1-\alpha} - wh^{\beta}N - (\frac{aL}{2N})L - I(1+\frac{bI}{2K}) + qI + \lambda(L-\theta N)\,, \tag{7}$$

where q and λ are the co-state variables that can be interpreted as the shadow value of capital and employees, respectively. The corresponding optimum conditions are:

$$\frac{aL}{N} = \lambda\,, \tag{8}$$

$$1+\frac{bI}{K} = q\,, \tag{9}$$

$$(1-\alpha)AE^{1-\alpha}(\frac{K}{N})^{\alpha} - wh^{\beta} + \frac{aL^2}{2N^2} - \lambda\theta = -\dot{\lambda} + r\lambda\,, \tag{10}$$

$$\alpha AE^{1-\alpha}(\frac{K}{N})^{\alpha-1} + \frac{bI^2}{2K^2} = -\dot{q} + rq\,. \tag{11}$$

The transversality conditions of K and N are:

$$\lim_{t\to\infty} qK\exp(-rt) = 0, \qquad \lim_{t\to\infty} \lambda N\exp(-rt) = 0\,. \tag{12}$$

Equation (8) states that the representative firm equalizes the cost of a newly-hired worker to the shadow value of employment, while equation (9) asserts that the cost of investment equals the shadow value of capital.[10] Differentiating equation (8) with respect to time and using equation (10) we obtain:

$$\frac{\dot{L}}{L} - \frac{\dot{N}}{N} = \frac{\dot{\lambda}}{\lambda} = r + \theta - \frac{L}{2N} + \frac{wh^{\beta}}{a(L/N)} - \frac{(1-\alpha)AE^{1-\alpha}(K/N)^{\alpha}}{a(L/N)}\,. \tag{13}$$

According to equations (5), (6), and (9), the accumulation of physical capital and the firm's employees are:

$$\frac{\dot{K}}{K} = \frac{I}{K} = \frac{q-1}{b}\,, \tag{14}$$

[9] Without loss of generality, we assume that physical capital is without depreciation for simplification.
[10] In equation (9) the shadow value of capital q is called "Tobin's q" in the literature.

$$\frac{\dot{N}}{N}=\frac{L}{N}-\theta . \tag{15}$$

We now turn to deal with the household's behavior. There are many identical and infinite-lived workers who consume output and lend capital to the firms (financial markets are kept implicit). Households provide labor services but have no right to determine their working hours. This specification is consistent with practical observations; for example, Stewart and Swaffield (1997) find that in UK workers are usually constrained in the hours of their work.[11] Consequently, in our model the standard working hours are set by government and the overtime (see Section 3) is determined by the firm. Assume that the household has an intertemporal iso-elastic utility $\int_0^\infty [(C^{1-\sigma}-1)/(1-\sigma)]e^{-\rho t}dt$, where C is consumption, ρ is time preference, and $1/\sigma$ is the intertemporal elasticity of substitution. We have the following growth rate of consumption, known as the Keynes-Ramsey rule:

$$\frac{\dot{C}}{C}=\frac{1}{\sigma}(r-\rho), \tag{16}$$ [12]

The aggregate resource constraint of the economy indicates that total output equals the sum of consumption, investment, and the adjustment costs of investment and newly-hired workers, i.e.:

$$\dot{K}=Y-\frac{aL^2}{2N}-\frac{bI^2}{2K}-C . \tag{17}$$

Dividing equation (17) by K and substituting equation (14) into equation (17), the accumulation of physical capital can also be described by:

$$\frac{\dot{K}}{K}=\frac{Y}{K}-\frac{aL^2}{2NK}-\frac{(q-1)^2}{2b}-\frac{C}{K} . \tag{17a}$$

Following Barro and Sala-i-Martin (1995), we define the following transformed variables:

$$x\equiv\frac{L}{N},\quad z\equiv\frac{K}{N},\ \text{and}\quad m\equiv\frac{C}{K}$$

since L, N, K, and C will grow at the same rate along the balanced growth path. Due to

[11] Manning (2001) points out that the model in which individuals have flexibility of their hours seems inappropriate.
[12] Postet-Vinay (1998) and Pissarides (2000) have quoted this equation to analyze economic growth related issues in their literature.

$\dot{C}/C = \dot{K}/K$ in the equilibrium, from equations (14) and (16) we obtain

$$\frac{1}{\sigma}(r-\rho) = \frac{q-1}{b}. \qquad (18)$$

Using equation (18), we can solve the interest rate as

$$r = \rho + \frac{\sigma(q-1)}{b}. \qquad (19)$$

Consequentially, on the basis of equations (13)-(16), (17a) and (19), we can derive a dynamic system in terms of the transformed variables x, z, and m as follows:

$$\frac{\dot{x}}{x} \equiv \frac{\dot{L}}{L} - \frac{\dot{N}}{N} = \rho + \frac{\sigma(q-1)}{b} + \theta - \frac{x}{2} + \frac{wh^{\beta}}{ax} - \frac{(1-\alpha)AE^{1-\alpha}z^{\alpha}}{ax}, \qquad (20)$$

$$\frac{\dot{z}}{z} \equiv \frac{\dot{K}}{K} - \frac{\dot{N}}{N} = \frac{q-1}{b} - x + \theta, \qquad (21)$$

$$\frac{\dot{m}}{m} \equiv \frac{\dot{C}}{C} - \frac{\dot{K}}{K} = \frac{q-1}{b} - Az^{\alpha-1}E^{1-\alpha} + \frac{ax^2}{2z} + \frac{(q-1)^2}{2b} + m. \qquad (22)$$

In addition, equation (11) can be rewritten as:

$$\alpha AE^{1-\alpha}z^{\alpha-1} = [\rho + \frac{\sigma(q-1)}{b}]q - \frac{(q-1)^2}{2b} - \dot{q}. \qquad (23)$$

Equation (23) is an expression of the user cost theory of capital in the investment literature. It states that the marginal contribution of capital $\alpha AE^{1-\alpha}z^{\alpha-1}$ is equal to user's cost of capital $[\rho + \sigma(q-1)/b]q - (q-1)^2/2b - \dot{q}$. The user's cost is broken up into three components. The first is the interest costs $[\rho + \sigma(q-1)/b]q$. The second is the installation benefit $(q-1)^2/2b$, stemming from the fact that additional capital stock will reduce the installation costs of new investment. The third is the benefit of capital price changes $\dot{q}$.

The economy's dynamic behavior can be described by differential equations (20)-(23). At the steady-growth equilibrium, the economy is characterized by $\dot{x} = \dot{z} = \dot{m} = \dot{q} = 0$, and x, z, m, and q are at their stationary values, namely x^*, z^*, m^*, and q^*, respectively. As a result, along the balanced growth path, hiring new labor, employment, physical capital, and consumption all grow at the common rate γ^*, that is,

$$\frac{\dot{L}}{L} = \frac{\dot{N}}{N} = \frac{\dot{K}}{K} = \frac{\dot{C}}{C} = \gamma^*.\text{[13]} \qquad (24)$$

[13] This implies that at the steady-state equilibrium, workers and capital are complements in the production process.

From equations (14) and (15), we learn that the steady-state growth rate γ^* is:

$$\gamma^* = \frac{q^* - 1}{b} = x^* - \theta \, . \tag{25}$$

To trace out the effect of shorter working hours on the economy's steady-state growth rate γ^*, we should first calculate the effect of shorter working hours on x^*. According to equation (25), we obtain:

$$\frac{\partial \gamma^*}{\partial h} = \frac{\partial x^*}{\partial h} \, . \tag{26}$$

From equations (20)-(23) with $\dot{x} = \dot{z} = \dot{m} = \dot{q} = 0$, using Cramer's rule, we have:

$$\frac{\partial x^*}{\partial h} = \frac{\alpha(1-\alpha)AE^{1-\alpha}}{-\Omega ab} z^{\alpha-2}[(1-\alpha)Az^{\alpha}E^{-\alpha}E' - \beta wh^{\beta-1}] \gtreqless 0$$

$$if \quad (1-\alpha)Az^{\alpha}E^{-\alpha}E' \gtreqless \beta wh^{\beta-1}, \tag{27}$$

where $\Omega = -\alpha(1-\alpha)Az^{\alpha-2}E^{1-\alpha}\{(\sigma x + r + \theta - x)/b + z[r - (q-1)/b + \sigma q/b]/a\} < 0$ due to the transversality condition.[14]

Equation (27) indicates that the linkage between x^* and h is ambiguous, depending upon the relative magnitude of $(1-\alpha)Az^{\alpha}E^{-\alpha}E'$ and $\beta wh^{\beta-1}$. The former denotes the change of working time in the marginal productivity of labor due to shorter working hours,[15] while the latter denotes the change of working time in the marginal cost of labor due to shorter working hours. Given that the extent of $\beta wh^{\beta-1}$ is closely related to whether the firm faces a salary regime ($\beta = 0$) or an hourly wage regime ($\beta = 1$), in what follows we discuss these two regimes in turn.

We first consider the salary-style wage regime. From equations (26) and (27) with $\beta = 0$, we obtain:

$$\frac{\partial \gamma^*}{\partial h} = \frac{\partial x^*}{\partial h} = \frac{\alpha(1-\alpha)}{-\Omega ab} Az^{\alpha-2}E^{1-\alpha}[(1-\alpha)Az^{\alpha}E^{-\alpha}E'] > 0 \, . \tag{26a}$$

Hence, when firms increase the number of workers on the one hand, they must increase the amount of capital as well on the other hand.

[14] The restrictions $r + \theta - x > 0$ and $br + 1 - q > 0$ are imposed to satisfy the transversality condition.

[15] The total effect of changing working time can be decomposed as:

$$\frac{d(\partial Y/\partial N)}{dh} = \frac{\partial(\partial Y/\partial N)}{\partial h} - \frac{\partial(\partial Y/\partial N)}{\partial K}\frac{\partial K}{\partial(\partial Y/\partial K)}\frac{\partial(\partial Y/\partial K)}{\partial h} = (1-\alpha)Az^{\alpha}E^{-\alpha}E' \, .$$

The above equation reveals that a reduction of working hours will decrease the balanced growth rate, and the intuition behind the result is obvious. Within a salary arrangement, wage payment is independent of working hours. This implies that the reduction of working hours will increase the firm's labor cost if workers' salaries are fixed by contract. As a result, shorter working hours lower the marginal productivity of labor, but leaves the marginal cost of labor unchanged. Thus, firms are likely to hire fewer workers in response. This leads to a reduction in accumulating employment, and hence the economy is characterized by a lower growth rate.

We next consider the case where firms face a more flexible wage contract — the hourly wage regime. From equations (26) and (27) with $\beta = 1$, we have:

$$\frac{\partial \gamma^*}{\partial h} = \frac{\partial x^*}{\partial h} = \frac{\alpha(1-\alpha)AE^{1-\alpha}}{-\Omega ab} z^{\alpha-2}[(1-\alpha)Az^{\alpha}E^{-\alpha}E' - w] \gtreqless 0$$

$$if \quad (1-\alpha)Az^{\alpha}E^{-\alpha}E' \gtreqless w. \tag{26b}$$

Equation (26b) expresses that a cut in working time has an ambiguous effect on the economic growth rate. It is evident that the hourly-style contract tends to increase the degree of wage flexibility. Thus, shorter working hours reduce not only the marginal productivity of employees $(1-\alpha)Az^{\alpha}E^{-\alpha}E'$, but also the marginal cost w. When employees' marginal productivity falls by more than the marginal cost in response to a cut in working time (i.e., $(1-\alpha)Az^{\alpha}E^{-\alpha}E' < w$), it is beneficial for firms to hire more workers. This tends to increase the accumulation of employment, and hence favors the economy's balanced growth rate.[16] On the contrary, if shorter working hours decrease marginal productivity more than the marginal cost of workers, then firms are inclined to hire fewer workers. Such an adjustment will lower employment and the economy will then suffer from a lower growth rate.

3. Endogenous working time and economic growth

[16] From equation (19), we can confirm the positive relationship between employment growth and economic growth. Empirical studies, in effect, also support such a relationship. See Padalion and Vivarelli (1997) and Plantenga and Hansen (1999).

For analytical convenience, working time h is treated as an exogenous parameter in the previous section. This section extends the analysis by way of introducing overtime work and endogenizing working time. Assume that actual working hours are decided endogenously by firms. Let $\bar{h}$ and h denote the standard and actual working hours, respectively. Hence, $h-\bar{h}$ is the overtime work.[17] Moreover, let $\phi > 0$ denote the exogenously-determined overtime premium.[18] In order to distinguish different overtime premiums under a salary regime ($\beta = 0$) and an hourly wage regime ($\beta = 1$), we specify that

$$\phi = \begin{cases} \phi_0 & for\ \beta = 0 \\ \phi_1 & for\ \beta = 1. \end{cases}$$

When the decision of overtime work is taken into account, equation (4) is changed to:

$$\max_{L,I,h,N,K} \int_0^\infty \{Y - wh^\beta N - \phi wN(h-\bar{h}) - (\frac{aL}{2N})L - I(1+\frac{bI}{2K})\}e^{-rt}dt\,. \tag{28}$$

With the same accumulation functions of capital and employment described by equations (5) and (6), the current-value Hamiltonian function H can be expressed as:

$$H = AK^\alpha [E(h)N]^{1-\alpha} - wh^\beta N - \phi wN(h-\bar{h}) - (\frac{aL}{2N})L - I(1+\frac{bI}{2K}) + qI$$
$$+\lambda(L-\theta N)\,. \tag{29}$$

The optimum conditions necessary for the representative firm are:

$$(1-\alpha)AK^\alpha N^{1-\alpha}E^{-\alpha}E' = \beta wh^{\beta-1}N + \phi wN\,, \tag{30}$$

$$(1-\alpha)AE^{1-\alpha}(\frac{K}{N})^\alpha - wh^\beta - \phi w(h-\bar{h}) + \frac{aL^2}{2N^2} - \lambda\theta = -\dot{\lambda} + r\lambda\,, \tag{31}$$

together with equations (8), (9), and (11). Equation (30) reveals the optimal choice for the representative firm to decide the actual working time per worker.

The growth of consumption and the aggregate resource constraint of the economy remain specified as in equation (16) and (17), respectively. Along the balanced growth path, L, N, K, and C will grow at the same rate. We similarly define three transformed variables

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[17] In what follows, in line with relevant research, we only discuss the situation where $h-\bar{h} > 0$.

[18] Erbas and Sayers (1999) claim that "[t]ypically, the wage paid for overtime hours is a legally determined multiple of the wage paid for regular hours." Therefore, the overtime premium parameter ϕ here is exogenously determined. See Hart (1984, 1989), and Hunt (1999) for a similar specification.

$x \equiv L/N$, $z \equiv K/N$, and $m \equiv C/K$. From equation (30), we can first solve working time as

$$h = h(z), \quad h_z = \frac{\partial h}{\partial z} = \frac{-\alpha E^{-\alpha} E'}{[E^{-\alpha} E'' - \alpha E^{-\alpha-1} (E')^2] z} > 0 . \tag{32}$$

Differentiating equation (8) with respect to time and using equations (19), (31) and (32), we obtain:

$$\frac{\dot{x}}{x} \equiv \frac{\dot{L}}{L} - \frac{\dot{N}}{N} = \rho + \frac{\sigma(q-1)}{b} + \theta - \frac{x}{2} + \frac{\phi w[h(z) - \bar{h}]}{ax} + \frac{wh(z)^{\beta}}{ax}$$
$$- \frac{(1-\alpha) AE[h(z)]^{1-\alpha} z^{\alpha}}{ax} . \tag{33}$$

Exploiting equation (32), equations (22) and (23) can then be alternatively written, respectively, as:

$$\frac{\dot{m}}{m} \equiv \frac{\dot{C}}{C} - \frac{\dot{K}}{K} = \frac{q-1}{b} - Az^{\alpha-1} E[h(z)]^{1-\alpha} + \frac{ax^2}{2z} + \frac{(q-1)^2}{2b} + m , \tag{34}$$

$$\dot{q} = [\rho + \frac{\sigma(q-1)}{b}]q - \frac{(q-1)^2}{2b} - \alpha Az^{\alpha-1} E[h(z)]^{1-\alpha} . \tag{35}$$

Accordingly, the economy's dynamic behavior can be described by equations (21) and (33)-(35). Let x^*, z^*, m^*, and q^* denote the stationary values of x, z, m, and q at the steady-growth equilibrium. From equation (25), we learn that the linkage between the balanced growth rate γ^* and shorter standard working time $\bar{h}$ completely depends upon the impact of shorter standard working time $\bar{h}$ on x^*. By Cramer's rule, from equations (21) and (33)-(35) with $\dot{x} = \dot{z} = \dot{m} = \dot{q} = 0$, we have:

$$\frac{\partial \gamma^*}{\partial \bar{h}} = \frac{\partial x^*}{\partial \bar{h}} = \frac{-\alpha(1-\alpha)\phi w A z^{\alpha-2} E^{1-2\alpha} E''}{\Delta ab[E^{-\alpha} E'' - \alpha E^{-\alpha-1} (E')^2]} > 0 , \tag{36}$$

$$\frac{\partial h^*}{\partial \bar{h}} = \frac{\phi w}{\Delta a} (r + \frac{1 - q + \sigma q}{b}) h_z < 0 , \tag{37}$$

where

$\Delta = -\alpha(1-\alpha) Az^{\alpha-2} E^{-\alpha} (E - zh_z E')(r + \theta - x + \sigma x)/b + (rb + 1 - q + \sigma q)\{[\phi w + \beta wh^{\beta-1} - (1-\alpha)^2$

$Az^{\alpha} E^{-\alpha} E'] h_z - \alpha(1-\alpha) Az^{\alpha-1} E^{1-\alpha}\}/ab < 0$.[19] Note that $\phi = \phi_0$ under the salary system and

[19] In order to have a unique stable adjustment for this system, the determinant of the matrix of coefficients must be negative with three positive (unstable) and one negative (stable) eigenvalues. Since x, m and q can jump

$\phi = \phi_1$ under the hourly wage system.

Equation (36) states that a reduction of standard working time leads to a decrease in the balanced growth rate in both a salary regime ($\beta = 0$) and an hourly wage regime ($\beta = 1$). Equation (37) expresses that actual working hours increase through a rise in overtime work when the standard working time decreases. These results can be interpreted as follows. Shorter standard working hours lead to a higher marginal cost of workers, but leaves the worker's marginal productivity unchanged, thereby the firm is inclined to reduce its hiring of workers. Given that both the number of workers and working time exhibit a substitution relationship, firms are more likely to replace workers with more working hours in response to a reduction in standard working time. With fewer new hirings, the growth rate of employment falls and so does the economy's balanced growth rate.

More importantly, we find that if overtime work is taken into account, then economic growth definitely deteriorates with a cut in the standard working time no matter what the styles of wage contract (salary or hourly wage) are. The reason is that, as indicated in equations (30) and (31), regardless of the wage payment being paid weekly or hourly, a reduction of standard working hours ($\bar{h}$) does not affect the optimal condition of actual working hours, but raises the marginal cost of hiring workers. With this adjustment, the firm tends to lower its hiring of workers. Given the fact that both workers and working time are substitutes, the firm will then ask its workers to provide more working hours (reported by equation (37)) and decrease the labor demand. Given that the firm hires fewer workers, the accumulation of employment falls, and hence the economy exhibits a lower growth rate.

4. Concluding remarks

In this paper we have formulated an endogenous growth model with adjustment cost in both investment and labor. It is shown that, in the absence of overtime work, the styles of wage

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instantaneously, whereas z is constrained to adjustment continuously, the number of unstable roots to this system equal the number of jump variables to ensure that the economy is on the stable path.

contract play an important role in determining the relationship between shorter working time and economic growth. To be specific, if the firm faces a salary-style arrangement, then shorter working hours cause a decline in the economy's growth rate unambiguously. However, if hourly-style wage contracts are widespread in the labor market, then the effect of reducing working time on the economic growth rate is ambiguous. The consequence depends on the relative magnitude between the change of working time on labors' marginal productivity and marginal cost.

If overtime work is allowed, due to the substitution between working time and worker, then shorter standard working hours will push firms to substitute more working hours for fewer workers. No matter what styles of contract are in the labor market, such an adjustment will reduce the accumulation of employment, and hence deters economic growth.

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