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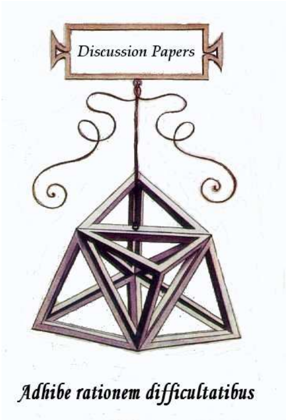

Luciano Fanti and Luca Gori

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Luciano Fanti
Department of Economics, University of Pisa
Via Cosimo Ridolfi, 10, I–56124 Pisa (PI), Italy
e-mail address: lfanti@ec.unipi.it
tel.: +39 050 22 16 369
fax: +39 050 22 16 384

Luca Gori
Department of Economics, University of Pisa
Via Cosimo Ridolfi, 10, I–56124 Pisa (PI), Italy
e-mail address: luca.gori@ec.unipi.it
tel.: +39 050 22 16 212
fax: +39 050 22 16 384

'Backyard' technology and regulated wages in a neoclassical OLG growth model

Luciano Fanti*[*] and Luca Gori[**]

Abstract This paper formally explores the joint roles played, on the one side, by the regulation of wages and, on the other side, by the existence of a "backyard" (or home) technology exploited by the unemployed people, in a standard neoclassical OLG growth model. The main findings are the following: 1) the introduction of a "binding" regulated wage fosters the capital accumulation and lead to a higher long term capital stock (and thus to higher output and welfare as well) in comparison with a competitive wage economy, provided that both the labour productivity at "home" and the capital weight in the firms technology are sufficiently high; 2) however, if the regulated wage is set at a too high level, the capital accumulation will be inferior to that of the competitive wage economy. These results, so far escaped closer scrutiny by economic growth literature, shed a new light on the effects of the regulation of wages and may have interesting policy implications.

Keywords: Regulated wage; Unemployment; Home production; OLG model

JEL classification: D13; E24; J22; O41

[*] Department of Economics, University of Pisa, Via Cosimo Ridolfi, 10, I–56124 Pisa (PI), Italy; e-mail address: lfanti@ec.unipi.it; tel.: +39 050 22 16 369; fax: +39 050 22 16 384.

[**] Corresponding author. Department of Economics, University of Pisa, Via Cosimo Ridolfi, 10, I–56124 Pisa (PI), Italy; e-mail address: luca.gori@ec.unipi.it; tel.: +39 050 22 16 212; fax: +39 050 22 16 384.

1. Introduction

The debate on the macroeconomic effects of the regulation of wages is long lasting. Conventional wisdom, dating back to Stigler (1946), holds that it may be harmful, mainly because they tend to reduce output, employment and welfare. However, the necessity of higher wages for non-specialised workers and benefits for the unemployed is often advocated mainly for equity reasons. Although some recent literature[1] had relaxed the efficiency-equity trade-off showing that in some cases a minimum wage could even be welfare improving regardless of its negative effect on the unemployment rate, we note that, however, these models neither are concerned on the possible economic values of the leisure associated to the unemployment nor are framed in the basic dynamic OLG model used in this paper. Moreover it is of interest to consider a possible link between regulated wages (with the corresponding unemployment) and two economic facts which are evidenced in the literature, as stated by Benhabib et al. (1991), p. 1167: "home production is an empirically significant entity at the aggregate level";[2] 2) "the individuals employed in the market sector spend much less time working in the home than unemployed individuals". Therefore to our knowledge there is no literature that formally explores the joint roles played, on the one side, by the regulation of wages and, on the other side, by the existence of a "backyard" (or home) technology exploited by the unemployed people.

In this paper we try to fill that gap by developing a standard neoclassical OLG growth model à la Samuelson (1958) – Diamond (1965) embodying such features.

Note that in a context of regulation of wages where output gains rather than losses were obtained, the hours of unemployment should be considered as an additional resource instead of a damage. To see this, it is sufficient to take account for the important leisure values associated with unemployment (for instance leisure time, self-enrichment activities, education, home production and so on). In particular leisure associated with the unemployment may have straightforward economic effects as in the case of its use either for education or for exploiting an existing "backyard" technology. For exploring how different may be the effects of the regulated wage in presence of an economic use of the leisure associated with the unemployment, we assume that a home production technology with constant productivity does exist and that such a productivity is lower than both the marginal productivity in the firms sector and the binding minimum wage, so that nobody makes use of the home production technology unless it is unemployed. We show in this case that the higher the productivity of the home technology is, either the more likely or higher the capital accumulation is.

To sum up, our findings show that the introduction of a minimum wage may be beneficial for the long-run economic growth, when a "backyard" technology does exist. The plan of the paper is as follows. In sections 2 and 3 we present the regulated wage model and subsequently the dynamical and steady state results are discussed, in comparison with the competitive wage economy, also showing a numerical illustration. Finally, section 4 concludes.

2. The model

We suppose the existence of an economy where goods and capital markets are both competitive and where the only departure from the textbook OLG model (Diamond (1965))[3] is an imperfect market for labour in which a minimum wage per hour worked ($\underline{w}_t$) is introduced by law.[4] As known, when a

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[1] For instance models introducing monopsonistic labour markets (e.g. West and McKee (1980)), education as a signalling device (Lang (1987)), schooling (Cahuc and Michel (1996)) or training on the job (Ravn and Sorensen (1999)) as motors of human capital accumulation, efficiency wages (Rebitzer and Taylor (1985)), imperfect information and job search (Swinnerton (1996)).

[2] For instance the conclusions of Eisner (1988), who surveyed the literature on the value of household production, suggest that home-produced output is a fraction of 20-50 per cent of the measured gross national product for the U.S. economy.

[3] We refer to, among others, the textbooks of Azariadis (1993) and DeLaCroix and Michel (2002).

[4] Note that, since this model, for simplicity, owns only one firm sector and one type of work, the regulated wage is fixed over the single competitive wage, but, taking account for the existence of different wages, it should be meant as a "binding" minimum over the average wage.

binding minimum wage is introduced in the economy, the labour market does not clear and unemployment occurs.

Individuals. Only young individuals work, assuming a unitary constant labour supply. Depending on the demand for labour in the firms sector, the supplied labour force may be partially unemployed. If employed, wage income is $\underline{w}_t$. We treat $\underline{w}_t$ as policy parameters, whereas the quantity of employed labour force is endogenous. The aggregate unemployment rate is defined as $u_t = (N_t - L_t)/N_t$, where $L_t = (1-u_t)N_t$ is the total number of hours worked by young agents.
In this paper we relax the assumption that unemployed hours are without economic value. In particular, we suppose there exists a home production technology employing only labour factor. We assume per-capita home-produced goods are created, for simplicity, with the following linear technology: $h_t = \beta_t l_t$, where l_t is the labour input and β_t is the average and marginal productivity.[5] Moreover we assume $h_t = \beta_t l_t = \beta_t u_t$. The reason for which the labour input in home production is given by the unemployment rate u_t is simple: if we assumed that the return to labour in home production is always smaller than the regulated wage in the firms sector (that is, $\beta_t < \underline{w}_t$), then the hours of work employed in the home production are only those left unemployed by the introduction of the minimum wage. Furthermore, we also make the technical assumption that the physical labour marginal productivity of the home production is always smaller than the physical labour marginal productivity in the "firms" sector with competitive labour market, that is $\beta_t \in (0, w_t \le \underline{w}_t)$. For doing this, we suppose that $\beta_t = \beta_1 w_t$ with $0 < \beta_1 < 1$ and $\underline{w}_t = \beta_2 w_t$ with $1 < \beta_2 < \infty$ and where w_t is the current competitive wage. The economic meaning of the latter two assumptions is that 1) the marginal productivity in home technology is a fraction – constant over time - of the one in "firms" technology or in other words during the economic growth the labour productivity grows at the same rate in both activities[6] and 2) the regulated wage is always "binding" at any point in the transitional path.
The individual maximisation problem faced by agents of generation t is the following:[7]

$$\max_{\{c_t^y, c_{t+1}^o\}} U_t(c_t^y, c_{t+1}^o) = (c_t^y)^{1-\phi}(c_{t+1}^o)^{\phi}, \tag{1}$$

subject to

$$\begin{aligned} c_t^y + s_t &= \underline{w}_t(1-u_t) + h_t \\ c_{t+1}^o &= (1+r_{t+1})s_t \\ c_t^y, c_{t+1}^o &\ge 0 \end{aligned} .$$

The optimal young and old age consumption functions become:

$$c_t^y(\underline{w}_t, \beta_t) = (1-\phi)W_t(\underline{w}_t, \beta_t), \tag{2}$$

$$c_{t+1}^o(\underline{w}_t, \beta_t) = \phi(1+r_{t+1})W_t(\underline{w}_t, \beta_t), \tag{3}$$

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5 For important contributions, among many others, on home production in macroeconomic models see Benhabib et al. (1991), Greenwood and Hercowitz (1991), Greenwood and Sheshadri (2004). Following Benhabib et al. (1991), p. 1171 "for the time being, we also assume that home production is linear which permits closed form solutions to be obtained".

6 This assumption is obviously simplistic and made for obtaining closed form solutions – with a clear-cut economic interpretation - in a otherwise too complicated dynamical problem. In any case two remarks are concerned here, following Greenwood-Sheshadri (2004), p. 4: 1) "since productivity numbers are not computed for the home sector, given the elusive nature of output and input, the evidence on technological progress is circumstantial"; 2) however it is possible to say that "just as the last 200 years have witnessed technological progress in the market sector, they have witnessed tremendous technological advance in the home sector". Therefore, in line with these latter remarks, our simplistic assumption might not be too simplistic.

7 As known, a Cobb-Douglas utility specification implies that the elasticity of savings with respect to the interest rate is equal to zero. Anyway, by considering a more general CIES utility function, it can be seen via numerical simulations (for economy of space not reported here) that the main findings of this paper are confirmed, provided that the elasticity of savings with respect to the interest rate is not too much positive.

where $W_t(\underline{w}_t, \beta_t) := \underline{w}_t(1-u_t) + \beta_t u_t$ is the total income of the young, as given by the sum of labour income, $\underline{w}_t$, plus the income received through the home-produced goods activities.
The savings function, instead, is the following:

$$s_t(\underline{w}_t, \beta_t) = \phi W_t(\underline{w}_t, \beta_t). \tag{4}$$

Firms. Goods and capital markets are both competitive. The labour market is imperfect and regulated via the introduction of a binding minimum wage per hour worked. The per-capita Cobb-Douglas technology transforms to:

$$y_t = A(1-u_t)\left(\frac{k_t}{1-u_t}\right)^{\alpha}. \tag{5}$$

Standard profit maximisation leads to the following marginal conditions:

$$r_t = \alpha A\left(\frac{k_t}{1-u_t}\right)^{\alpha-1} - 1, \tag{6}$$

$$\underline{w}_t = (1-\alpha)A\left(\frac{k_t}{1-u_t}\right)^{\alpha}. \tag{7}$$

It is important to note that once the wage has been fixed the real interest rate is exogenous, that is, it does not depend on the capital stock. In fact, substituting (20) into (19) for $k_t/(1-u_t)$ we find:

$$r(\underline{w}_t) = \alpha A((1-\alpha)A/\underline{w}_t)^{\frac{1-\alpha}{\alpha}} - 1. \tag{8}$$

An increase in $\underline{w}_t$ always reduces the real interest rate. The short-run unemployment rate is endogenous, and solving eq. (20) for u_t yields:

$$u_t(k_t, \underline{w}_t) = 1 - ((1-\alpha)A/\underline{w}_t)^{\frac{1}{\alpha}} \cdot k_t, \tag{9}$$

which is positively related with the minimum wage and strictly decreasing in the capital per-capita.

The long-run equilibrium. Given the optimal decisions of individuals and firms, the market clearing condition in goods as well as in capital markets is simply given by:

$$(1+n)k_{t+1} = s_t(\underline{w}_t, \beta_t), \tag{10}$$

and combining (10) with (4) we find:

$$(1+n)k_{t+1} = \phi[\underline{w}_t(1-u_t(k_t, \underline{w}_t)) + \beta_t u_t(k_t, \underline{w}_t)]. \tag{11}$$

Substituting out for $u_t(k_t, \underline{w}_t)$ from eq. (9), capital evolves over time according to the following first order difference equation:

$$k_{t+1} = \frac{\phi}{1+n}\beta_t + \frac{\phi}{1+n}((1-\alpha)A)^{\frac{1}{\alpha}}\underline{w}_t^{-\frac{1}{\alpha}}(\underline{w}_t - \beta_t)k_t, \tag{12}$$

where we recall that $\beta_t = \beta_1 w_t$, $\underline{w}_t = \beta_2 w_t$ and $w_t = (1-\alpha)Ak_t^{\alpha}$ is the current competitive wage.
Finally, note that the previous model (1)-(12) boils down to the competitive wage Diamond's model when $\beta_2 = 1$.

3. Dynamical analysis

Note that as regards the existence and uniqueness of equilibrium, eq. (12) behaves as that of the standard neoclassical growth model à la Diamond (see Diamond (1965)).
Steady-state implies $k_{t+1} = k_t := k^*$. When the minimum wage is binding ($\beta_2 > 1$), the per-capita long-run capital stock, unemployment rate and total production $q = y + h$, where now in addition to the output of the "firms" sector there is the home production, are given by the following conditions:

$$k^*(\underline{w},\beta)=\left[\frac{\phi(1-\alpha)A}{1+n}\right]^{\frac{1}{1-\alpha}}\cdot B^{\frac{1}{1-\alpha}}, \tag{13}$$

$$u^*(\underline{w},\beta)=1-((1-\alpha)A/\underline{w})^{\frac{1}{\alpha}}\cdot k^*(\underline{w},\beta), \tag{14}$$

$$q^*(\underline{w},\beta)=y^*(\underline{w},\beta)+h^*(\underline{w},\beta)=Ak^*(\underline{w},\beta)^{\alpha}(1-u^*(\underline{w},\beta))^{1-\alpha}+\beta u^*(\underline{w},\beta), \tag{15}$$

where $B:=\beta_1+\beta_2^{\frac{-(1-\alpha)}{\alpha}}-\beta_2^{\frac{-1}{\alpha}}\beta_1$. It is easy to see that

$$k^*(\underline{w},\beta)=\left[\frac{\phi(1-\alpha)A}{1+n}\right]^{\frac{1}{1-\alpha}}\cdot B^{\frac{1}{1-\alpha}}=k^*(w_{pc})\cdot B^{\frac{1}{1-\alpha}}, \tag{16}$$

that is the long run capital stock in the regulated economy will be higher (lower) than the competitive wage economy depending on whether $B \gtrless 1$.

As regards stability, as known, the general condition requires that $-1<\partial k_{t+1}/\partial k_t<1$. Differentiating eq. (12) with respect to k_t yields:

$$\frac{\partial k_{t+1}}{\partial k_t}=\frac{\phi}{1+n}\alpha(1-\alpha)Ak_t^{\alpha-1}\cdot B. \tag{17}$$

Therefore, stability requires $-1<\frac{\phi}{1+n}\alpha(1-\alpha)Ak_t^{\alpha-1}\cdot B<1$. It can be easily proved that $\partial k_{t+1}/\partial k_t\big|_{k=k^*(\underline{w},\beta)}=\alpha$, that is, given that $0<\alpha<1$, $0<\partial k_{t+1}/\partial k_t<1$ always holds, and the trajectories are converging monotonically towards the steady-state equilibrium.

The existence of both a regulated wage and a backyard technology used only by unemployed workers, modifies the steady-state results of the standard neoclassical growth models in a clear-cut way. The new results can be formally summarised in the following propositions and remarks:

Proposition 1. *The behaviour of the locus of the accumulation* $k_{t+1}=f(k_t)$ *(eq. (12)) with respect to the regulated wage is summarised by the following:* $\frac{\partial k_{t+1}}{\partial \beta_2}\gtrless 0 \quad \Leftrightarrow \quad \beta_1-\beta_2(1-\alpha)\gtrless 0$.

Proof. *The proof straightforwardly derives from the derivative of the locus with respect to the parameter* β_2.

From proposition 1 the following remarks are derived:

Remark 1. *The locus of capital accumulation is increasing with the regulated wage when both the labour productivity of home technology and the weight of capital in the firms technology are sufficiently high.*

Remark 2. *In the economy with regulated wages both all the sequence of momentary equilibria and the stationary state are higher than in the competitive wage economy, provided that* $\beta_1>\frac{1-\beta_2^{\frac{-(1-\alpha)}{\alpha}}}{1-\beta_2^{\frac{-1}{\alpha}}}$. *The simple proof derives from rewriting eq. (12) as* $k_{t+1}^{mw}=\frac{\phi}{1+n}(1-\alpha)Ak_t^{\alpha}\cdot B=k_{t+1}^{cw}\cdot B$*; then, for any values of* $\beta_1>0$ *and* $\beta_2>1$ *satisfying the latter inequality ,* $k_{t+1}^{mw}>k_{t+1}^{cw}$ *for any* $k_t\in(0,\infty)$.[8]

Finally, the following proposition holds:

[8] The superscript mw and cw mean regulated-wage and competitive-wage respectively.

Proposition 2. *The level of the regulated wage which maximises the long run stock of capital is given by the following condition:* $\max k^*(\underline{w},\beta) \iff \beta_2 = \frac{\beta_1}{(1-\alpha)} w$.

Proof. *The above result straightforwardly derives by the unique positive solution of the following derivative:* $\frac{\partial k^*(\underline{w},\beta)}{\partial \beta_2} = 0$.

From proposition 2 we derive the following remark:

Remark 3. *The level of the regulated wage which maximises the long run capital stock is given, if it does exist, by a mark-up over the competitive wage which depends positively on the ratio between the labour productivity in the home production and the weight of labour in the firms production, that is:* $\max k^*(\underline{w},\beta) \iff \underline{w} = \frac{\beta_1}{(1-\alpha)} w$.

The following Figure 1 shows the locus of capital accumulation equation, $k_{t+1} = f(k_t)$, in both cases with and without regulation of wages. The parametric configuration, chosen only for illustrative purposes, is the following: $A = 10$, $\alpha = 0.35$, $\phi = 0.10$, $\beta_1 = 0.80$ and $n = 0$. The capital weight in the Cobb Douglas firms technology is set, as usual,[9] at 0.35, while ϕ, which in this context represents the propensity to save, is set at the realistic value of 0.10. Finally the population is stationary and the labour productivity at home is fixed to the eighty per-cent of that in the firms sector.
In this case, we see, from Figure 1, that, as expected from the analytical considerations above mentioned, the transitional path of the capital stock as well as the steady-state capital stock are always over those of the competitive wage economy when the regulated wages is, for example, higher of about 10 per-cent and 30 per-cent than the competitive level, but are below when the regulated wages is too high, in the example of about 140 per-cent higher than the competitive one.

[Figure 1 about here]

4. Conclusions

In this paper we analysed the effects of the regulated wage in a neoclassical growth model with usual Cobb-Douglas preferences and technology, when a "backyard" technology does exist. To sum up, the main economic findings are the following: under two requirements, both attaining to the technology - that is both the labour home productivity and the capital weight in the firms production should be sufficiently high - the introduction of a "binding" regulated wage fosters the capital accumulation and lead to a higher long term capital stock. However if the regulated wage is set at a too high level the capital accumulation will be inferior to that of the competitive wage economy. Finally, it is worth to note that we are able to pick up the exact level at which the regulated wage should be fixed in order to obtain the maximum of the long term capital stock, expressed as a mark-up over the competitive

[9] Although this value is usual in literature, it should be noted that: 1) the official statistics of many countries display much higher values, probably due to the practice attributing to capital the income of the self-employed (see about the problems of measurement of the capital weight α recent works of Jones (2003, 2005)); 2) in the present context, in which the regulation of wages could concern only the unskilled workers and the capital could include the skilled work (in the present model skilled human capital should be meant as implicitly included - as an exogenous constant part - within the capital accumulation in that, for simplicity, an individual choice for educational activities is not allowed for), higher values of α could be realistic. In fact Mankiw et al. (1992), p. 417, suggest that: i) since the minimum wage is a proxy of the return to labour without human capital, and ii) since the minimum wage has averaged about 30 to 50 percent of the average wage in manufacturing, then 50 to 70 percent of total labour income represents the return to human capital, and if the physical capital's share of income is expected to be about 1/3, the human capital's share of income should be between 1/3 and one half. In sum, with the broad view of capital the coefficient α may be fairly about 0.6 and 0.8.

wage.[10] These results, so far escaped closer scrutiny by economic growth literature,[11] shed a new light on the effects of the regulation of wages and may have interesting policy implications.

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[10] It is worth to note that when the capital accumulation is enhanced by the introduction of the regulated wage, both output and long run lifetime welfare are increased as well, although under conditions slightly different from those shown in the above propositions and remarks. The analytical derivation of these conditions is very involved and is not presented here for brevity. In any case the analysis with respect to output and welfare is beyond of the scope of this paper.

[11] Noteworthy, when a "backyard" technology does exist, our conclusions are reached within a textbook OLG model with the only departure of the assumption of a minimum wage imposed by the government.

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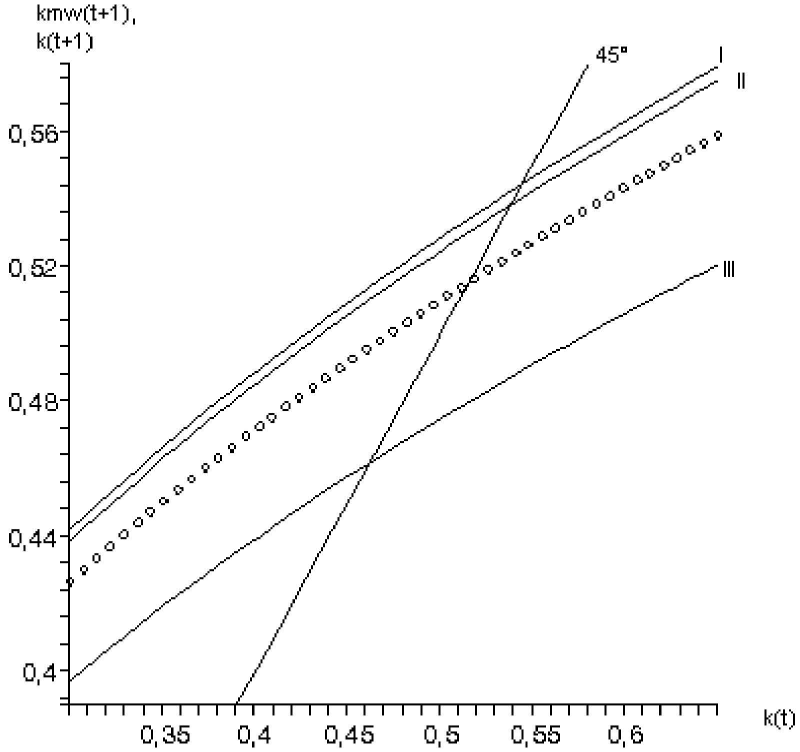

Figure 1. Window enlargement (focusing on the steady states) of the locus of accumulation $k_{t+1} = \frac{\phi}{1+n}\beta_t + \frac{\phi}{1+n}\left((1-\alpha)A\right)^{\frac{1}{\alpha}} \underline{w}_t^{-\frac{1}{\alpha}}\left(\underline{w}_t - \beta_t\right)k_t$ of 1) the regulated wage economy with three different levels of regulated wage and 2) the competitive wage economy. Parameter set: $A = 10$, $\alpha = 0.35$, $\phi = 0.10$, $\beta_1 = 0.80$ and $n = 0$. Legend: curve I: $\beta_2 = 1.25$; curve II: $\beta_2 = 1.1$, curve III: $\beta_2 = 2.4$; pointed curve: competitive wage economy.

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