Discussion Papers No. 277, June 2000
Statistics Norway, Research Department

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Valuation of Social Capital and Environmental Externalities

Abstract:
The transition from more traditional to modern modes of production has large implications for time allocation, accumulation of social capital, market and non-market production, consumption, as well as for the environmental externalities of production and consumption. In this paper we explicitly take into account the time allocation aspect in the formation of social capital. We analyze how time allocation, accumulation of social capital and production depend on the productivity in the transformation of time to social capital, productivity of social capital in the production of commodities and valuation of social capital. We find that a higher valuation of social capital does not necessarily lead to more leisure or other non-market activities, reduced consumption and potentially improved environment, the relationship is highly sensitive to the assumptions about accumulation of social capital.

Keywords: Time allocation, Social capital, Environmental externalities

JEL classification: J22, D62

Acknowledgement: Financial support from the Norwegian Research Council is gratefully acknowledged. Comments from Gert Tinggaard Svendsen, Martin Paldam and other participants at the European Public Choice Society Conference in Siena are much appreciated. The usual disclaimer applies. We would like to thank Anne Skoglund for excellent wordprocessing and editing.

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1. Introduction

In recent years the notion of social capital, developed by Coleman (1988) and Putnam (1993), has found numerous applications in economics, see e.g. the contributions by Fukuyama (1995), Robison and Hanson (1995), Schmid and Robison (1995), Knack and Keefer (1997), Woolcock (1998), Paldam (2000) and Dasgupta and Serageldin (1999). The main idea behind the concept of social capital is that social relations and social networks represent a resource for individuals, organizations and society. Definitions of social capital in the works quoted above emphasize different aspects of social capital, typically the level of trust in society, the ease of cooperation in the workplace and the extent of social networks.

Neither of these approaches to social capital, however, have explicitly recognized the importance of time allocation for the formation of social capital. The new contribution of this paper is that we formalize how time use influences the level of social capital. Time use in different activities has different productivities in transforming time to social capital. Time at the work place has e.g. a component of pure production time and a component of building social capital. Leisure and other non-market time has a component of solitary leisure or unpaid work and a component of building social capital. Moreover, one could distinguish between different types of social capital generated in different sectors.

In this paper, however, we focus on one type of social capital generated in the aggregate time use categories of market work and non-market activities including leisure. We assume that all market work time generates social capital at a given rate and that all non-market time generates the same type of social capital at a different and given rate. In our model the difference between the two productivity rates in building social capital is a crucial parameter for determining the level of social capital as well as time allocation, production and consumption.

Productivity in the transformation of time to social capital, productivity of social capital in the production of commodities, and valuation of social capital differ widely across countries and historically. The transition from non-market to market production and from industrial production to knowledge-based production has led to substantial shifts in the time allocation between market and non-market sectors that have influenced the formation of social capital. When time allocation shifts from non-market to market sectors, aggregate production and consumption may increase and lead to negative environmental externalities. The relation between time use, social capital and environmental externalities thus depends on in which activities social capital primarily is developed, and how this activity pattern changes over time. If social capital is built in time-intensive activities that require little commodity input, an increase in social capital may imply reduced consumption and production and improved environment. If social capital is built in activities that require more commodity inputs, an increase in social capital may imply higher consumption and production and negative environmental impact. In this paper we simplify the distinction between time- and commodity-intensive activities and consider a model where the environmental externalities follow from aggregate consumption.

Our formal model relates to the three aspects of social capital, namely, trust, ease of cooperation and network. We emphasize the network aspect in the accumulation of social capital, the trust aspect in the provision of services from social capital, and the ease of cooperation aspect in the role of social capital in production. However, the three aspects of social capital are highly interdependent. Trust is required for voluntary cooperation to take place, and by working together trust can be further developed. The resources that an individual may obtain from social capital require both social network and trust.

We illustrate the historical trend towards urbanization and more knowledge-based production, characterized by a shift in the formation of social networks and social capital, from non-market to market activities. We analyze some consequences for time allocation, social capital, production, consumption and environmental externalities of this change, formalized by shifts in the valuation of social capital and productivity in the accumulation of social capital and in production processes where social capital is an input.

The paper is organized as follows. In Section 2 we derive the social optimum in a time allocation model with social capital, and we analyze effects of shifts in the parameters of the model. In Section 3 we briefly discuss the corresponding market equilibrium. In Section 4 we present a simple numerical example as an application of the theoretical model to a historical development where time use in the market sector becomes more efficient as compared to the non-market sector for accumulation of social capital.

2. A time-allocation model with social capital: Social optimum

We consider one type of social capital s that is accumulated in market and non-market activities, such that

(1) $$s = \alpha_l l + \alpha_p l_p$$

where l is time devoted to leisure or other non-market activities, and l_p is time devoted to market production. Although the model for simplicity is static, social capital is essentially a dynamic concept that it takes time to develop. An individual can build social capital both during leisure time and time devoted to market production, but depending on social structures, the rate of transformation of time to social capital may differ between the non-market and the market sectors, as expressed by the parameters α_l and α_p. Equation (1) represents the network aspect in the definition of social capital. We do not distinguish between leisure and other non-market activities, hence, the time budget is given by

(2) $$l + l_p = 1$$

when total time is normalized to one. The utility function of the representative consumer is given by

(3) $$u = u\left(c, l, g(s), e\right)$$

where c denotes consumption, $g(s)$ is services from social capital, and e represents negative environmental externalities, so that $u_e < 0$. We assume that the environmental externality arises from emissions that increase with production and consumption. For simplicity we assume that the environmental externality equals average consumption, so that $e = \overline{c}$, where the bar denotes average.

For the individual consumer the return on social capital or services from social capital may e.g. be specified as

(4) $$g\left(s_i\right) = \beta s_i + \left(1 - \beta\right)\overline{s}$$

so that the return on social capital accruing to individual i is a weighted average of its own chosen amount of social capital s_i and the average level $\overline{s}$ of social capital in society, seen as exogenous for individual i. Note that here $\overline{s}$ represents the social capital externality in consumption since $\overline{s}$ positively influences the utility of individual i. Here β represents the trust aspect in the definition of social capital. When β is large, individual i has less trust in the provision of social capital services from others. Formally, when $\beta = 1$, there is no social capital externality in consumption, and services from social capital in the utility function only depend on individual social capital. When β declines towards zero, the social capital externality $\overline{s}$ contributes more in the services from social capital. The subscript i in (4) will be dropped in the following as we focus on the representative consumer.

We consider the Cobb-Douglas specification of the utility function,

(5) $$u = c^{\gamma_c} l^{\gamma_l} g(s)^{\gamma_s} e^{\gamma_e} \quad \text{where} \quad \gamma_c, \gamma_l, \gamma_s > 0 \text{ and } \gamma_e < 0 .$$

The parameter γ_s represents the social valuation of the social capital externality $\overline{s}$ in consumption, whereas γ_e represents the social valuation of the environmental externality e. We assume that $|\gamma_e| < \gamma_c$ so that $\gamma_c + \gamma_e > 0$.

There is no capital accumulation, so in equilibrium we have that the production function is given by

(6) $$c = f(\overline{L})$$

where $\overline{L}$ is average effective labor supply. Each individual's effective labor supply is $\overline{L} = l_p s^b \overline{s}^d$. Here b represents the contribution to labor productivity from individual social capital, whereas d represents the contribution to labor productivity from average social capital, i.e. here $\overline{s}$ represents the social capital externality in production. Both b and d represent the ease of cooperation aspect in the definition of social capital. In a symmetric equilibrium $s = \overline{s}$ and $l_p = \overline{l}_p$. Hence average effective labor supply is

$$\overline{L} = \overline{l}_p \overline{s}^{(b+d)}.$$

With Cobb-Douglas specification the production function is

(7) $$c = f(\overline{L}) = \overline{L}^a \quad \text{where} \quad a,b,d > 0 \text{ and } a\left(1+b+d\right) < 1,$$

i.e. we assume decreasing returns to scale. Here a represents the total output elasticity of effective labor (including social capital). In social optimum where $s = \overline{s}$ and $l_p = \overline{l}_p$ we have that $g(s) = s$. Hence, we replace $g(s)$ by s in (3), and $\overline{s}$ by s and $\overline{l}_p$ by l_p in the production function (7) which now becomes

(8) $$c = \left(1-l\right)^a s^{a(b+d)}.$$

With these substitutions the Lagrangian for social optimum is given by

(9) $$L = u\left(c,l,s,e\right) + \mu_c\left(\left(1-l\right)^a s^{a(b+d)} - c\right) + \mu_s\left(\alpha_l l + \alpha_p\left(1-l\right) - s\right) + \mu_e\left(c-e\right).$$

The first-order conditions for social optimum are given by

$$u_c + \mu_e - \mu_c = 0$$
$$u_l - \mu_c \frac{\partial f}{\partial l_p} + \mu_s \left(\alpha_l - \alpha_p\right) = 0$$
$$u_s + \mu_c \frac{\partial f}{\partial s} - \mu_s = 0$$
$$u_e - \mu_e = 0.$$

In the Cobb-Douglas case the first-order conditions yield the following condition to determine l

$$\frac{\gamma_l}{l} + \frac{\gamma_s + a(b+d)(\gamma_c + \gamma_e)}{l+\alpha} = \frac{a(\gamma_c + \gamma_e)}{1-l} \tag{10}$$

where $\alpha = \alpha_p / \left(\alpha_l - \alpha_p\right)$. We must have $\alpha_l \neq \alpha_p$ in order to have a non-zero denominator. Note that the left hand side of (10) is infinite for $l = 0$, and decreasing in l, while the right hand side is increasing in l, and infinite for $l = 1$, hence there exists a unique interior solution for l such that $0 < l < 1$. We will now discuss the effect of shifts in the parameters. The shift analysis is summarized in Table 1 and Table 2.

Let us first discuss shifts in the productivity parameters for building social capital, as summarized in Table 1. We consider three interpretations of shifts in α_l and α_p. First, we consider partial increases in α_l and α_p, respectively (Type 1 shift). Secondly, we consider proportional increases in α_l and α_p so that α is constant (Type 2 shift). Finally, we consider shifts under the restriction that $\alpha_l + \alpha_p$ is constant (Type 3 shift). Our subsequent discussion in Section 4 of shifts over time in the relative importance of non-market and market activities for building social capital corresponds to the third type of shifts, where α_p increases as α_l decreases.

By shift analysis of (10), see Appendix, we find that with Type 1 and Type 3 shifts leisure increases when the productivity of leisure in building social capital increases, and leisure decreases when the productivity of labor market time in building social capital increases. This follows immediately from inspection of (10) and using the definition of α. For the Type 2 shift where the relative difference between α_l and α_p is constant, α is constant, and there is no effect on leisure.

Table 1. Effects of positive shifts in the productivity parameters for building social capital when leisure is more efficient in producing social capital $(\alpha > 0)$ and labor market time is more efficient in producing social capital $(\alpha < -1)$. Social optimum

	$\alpha > 0$			$\alpha < -1$		
	l	s	c	l	s	c
Type 1 shift:						
α_l (α_p constant)	+	+	? (1a)	+	? (1a)	? (1a)
α_p (α_l constant)	–	? (2a)	+	–	+	+
Type 2 shift:						
α_l (α constant)	0	+	+	0	+	+
α_p (α constant)	0	+	+	0	+	+
Type 3 shift:						
α_l ($\alpha_l + \alpha_p = 1$)	+	? (1b)	? (1c)	+	? (1a)	? (1c)
α_p ($\alpha_l + \alpha_p = 1$)	–	? (2a)	? (2b)	–	? (2b)	? (2b)

(1a): Large l contributes to positive effect,
(1b): Positive if $l > 0.5$,
(1c): Negative if $l < 0.5$,
(2a): Large $1-l$ contributes to positive effect,
(2b): Positive if $1-l > 0.5$.

The effects on social capital and consumption are derived in the Appendix and will be discussed in the following. For a partial increase in α_l (Type 1 shift) social capital increases in the situation where leisure is more efficient for building social capital. Similarly, for a partial increase in α_p social capital increases in the situation where labor market time is more efficient for building social capital. A partial increase in α_l has an ambiguous effect on social capital when labor market time is more efficient for building social capital, but a high level of leisure relative to labor market time tends to give a positive effect. Similarly, a partial increase in α_p has an ambiguous effect on social capital when leisure is more efficient for building social capital, but a high level of labor market time relative to leisure tends to give a positive effect.

A partial increase in α_l has an ambiguous effect on consumption, as the decline in labor market time may have a larger negative effect than the positive effect from the increase in social capital (for $\alpha > 0$). A high level of leisure tends to increase social capital sufficiently to ensure a positive effect on consumption when labor market time is more efficient for building social capital. A partial increase in α_p has an unambiguously positive effect on consumption as both labor input and social capital increase. A proportional increase in α_l and α_p so that α is constant (Type 2 shift) increases social capital by the same factor, labor input is unchanged, and consumption unambiguously increases.

Shifts in α_l and α_p so that $\alpha_l + \alpha_p = 1$ (Type 3 shift) have ambiguous effects on social capital and consumption. However, we find a somewhat similar pattern in the effects on social capital as in the case of partial shifts in α_l and α_p. For a Type 3 shift, an increase in α_l and a corresponding decline in α_p will increase social capital in the situation where leisure is more efficient for building social capital, provided that leisure time exceeds labor market time. Similarly, an increase in α_p and corresponding decline in α_l will increase social capital in the situation where labor market time is more efficient for building social capital, provided that labor market time exceeds leisure time. For an increase in α_l and decline in α_p when labor market time is more efficient for building social capital, a high level of leisure will tend to give a positive effect on social capital. For an increase in α_p and decline in α_l when leisure is more efficient for building social capital, a high level of labor market time will tend to give a positive effect on social capital. The effects on consumption are ambiguous. When α_l increases and α_p declines, we find that the effect on consumption is negative if $l < 0.5$. When α_p increases and α_l declines, we find that the effect on consumption is positive if $1 - l > 0.5$.

As an example of shifts in the parameters of the utillity and production function we now consider the effect on leisure of an increasing valuation of the environmental externality. The other shifts are analyzed in the Appendix and summarized in Table 2. An increasing valuation of the environmental externality γ_e gives a negative shift to the right-hand side of (10). The effect on the left-hand side depends on the parameters α_l and α_p. For $\alpha_l > \alpha_p$, $\alpha > 0$ and the shift is negative on the left-hand side, too. However, we can show that the effect of increasing valuation of environmental externalities on leisure is unambiguously positive. This can be seen by comparing the shifts in the right-hand side and left-hand side of (10) for a given l. If the shift in the right-hand side (positive effect on leisure) is larger than the shift in the left-hand side (negative effect on leisure), leisure will increase. We will now show that this follows from (10). Consider the shift in γ_e as a shift in the composite parameter $\gamma_c + \gamma_e$. Hence, the shift in the right-hand side of (10), for a given l, is given by $a/(1-l)$, and the shift in the left-hand side, for a given l, is given by $a(b+d)/(l+\alpha)$. The condition for leisure to increase is that

(11) $$\frac{a}{1-l} > \frac{a(b+d)}{l+\alpha}.$$

Multiplying both sides by $\gamma_c + \gamma_e$ and inserting from (10), we find that (11) is satisfied if

(12) $$\frac{\gamma_l}{l} + \frac{\gamma_s}{l+\alpha} > 0$$

which is satisfied since $\alpha > 0$ by assumption in this case. For $\alpha_l < \alpha_p$, $\alpha < -1$, the shift of the left-hand side of (10) is positive, and an increasing valuation of environmental externalities will increase socially optimal leisure. Hence, an increasing valuation of the environmental externality will increase socially optimal leisure and decrease socially optimal labor input, irrespective of the value of α.

Table 2. Effects of positive shifts in parameters for the utility and production functions when leisure is more efficient in producing social capital $(\alpha > 0)$ and labor market time is more efficient in producing social capital $(\alpha < -1)$. Social optimum

	$\alpha > 0$			$\alpha < -1$		
	l	s	c	l	s	c
$\lvert\gamma_e\rvert$	+	+	–	+	–	–
γ_c	–	–	+	–	+	+
γ_s	+	+	–	–	+	+
γ_l	+	+	–	+	–	–
a	–	–	?	–	+	?
$b+d$	+	+	? (– if $s<1$)	–	+	? (+ if $s>1$)

By inspection of (10) we see that an increasing valuation of consumption γ_c or an increasing labor productivity a has the opposite effect on leisure as compared to an increasing valuation of the environmental externality γ_e. Positive shifts in γ_c or a will unambiguously decrease socially optimal leisure and increase socially optimal labor input. The effect on social capital of an increasing valuation of consumption or a positive shift in a depends on whether $\alpha > 0$ or $\alpha < -1$.

As shown in the Appendix, an increasing valuation of the environmental externality will increase social capital when leisure is more efficient for building social capital, and decrease social capital when labor market time is more efficient for building social capital. An increasing valuation of the environmental externality will lead to lower consumption and have a positive effect on the environment. When labor market time is more effective in producing social capital $(\alpha < -1)$, both labor input and social capital decrease with an increasing valuation of the environmental externality, and we find an unambiguous reduction in consumption and positive effect on the environment, as expected. However, in the Appendix we show that also in the case when leisure is more effective than work time in producing social capital $(\alpha > 0)$ and labor input decreases while social capital increases, an increasing valuation of the environmental externality will lead to an unambiguous reduction in consumption and positive effect on the environment. Similarly, an increasing valuation of consumption will lead to higher consumption and have a negative effect on the environment.

From (10) we find that an increasing valuation of social capital γ_s or an increasing productivity of social capital $b+d$ will increase socially optimal leisure when $\alpha > 0$ and decrease socially optimal leisure when $\alpha < -1$. Social capital increases both when leisure increases for $\alpha > 0$ and when leisure decreases for $\alpha < -1$. We find that an increasing valuation of social capital will lead to higher consumption in the case where leisure decreases and both labor input and social capital increase $(\alpha < -1)$ and lower consumption in the case where leisure increases and labor input decreases and social capital increases $(\alpha > 0)$. From (10) we see that an increasing valuation of leisure γ_l will unambiguously increase socially optimal leisure. The effect on social capital, however, depends on α. Social capital increases with γ_l for $\alpha > 0$ and decreases with γ_l for $\alpha < -1$. We find that when γ_l increases, consumption will decrease.

3. A time-allocation model with social capital: Market equilibrium

In a market equilibrium the wage rate equals the marginal productivity of the total effective labor supply. We will now analyze how the social capital in production influences the wage rate. The production function $F(L)$ in terms of total effective labor supply $L = n\overline{L}$ is defined by

(13) $$F(L) = A\left(n\overline{L}\right)^a$$

where we use (7) and the restriction that $An^{a-1} = 1$. In order to find the marginal productivity of individual *i*, we need to take into account that the labor supply of *i* influences the marginal productivity both via its own social capital s_i and via the average social capital of all other individuals than *i*, denoted by $\overline{s}_{-i}$ and defined by

(14) $$\overline{s}_{-i} = \frac{1}{n-1}\sum_{k \neq i} s_k .$$

Total effective labor supply is given by

(15)
$$L = n\overline{L} = l_{p_i} s_i^b \overline{s}_{-i}^d + \sum_{j \neq i} l_{p_j} s_j^b \overline{s}_{-j}^d$$
$$= l_{p_i} s_i^b \overline{s}_{-i}^d + (n-1) l_{p_j} s_j^b \overline{s}_{-j}^d$$

where the latter inequality follows from the assumption that all individuals $j = 1,...,i-1,i+1,...,n$ have the same characteristics. Differentiating the production function $F(L)$ with respect to l_{p_i} when we recall that s_i is included in $\overline{s}_{-j}$, and finally considering the equilibrium where $s_i = s_j = s$, $\overline{s}_{-i} = \overline{s}_{-j} = \overline{s}$ and $s = \overline{s}$ we find that the wage rate is given by, see Appendix for details,

(16)
$$w = F'(L)\frac{dL}{dl_p} = \frac{a\overline{L}^a}{l_p}\left(1 + (b+d)\varepsilon\right).$$

Here ε denotes the elasticity of social capital with respect to market labor

(17)
$$\varepsilon = \frac{ds}{dl_p}\frac{l_p}{s} = -\frac{l_p}{1 - l_p + \alpha} = -\frac{1-l}{l+\alpha}$$

where $\varepsilon > 0$ for $\alpha < -1$ and $\varepsilon < 0$ for $\alpha > 0$, i.e. the market labor elasticity of social capital is positive when market labor is more effective in building social capital and negative when leisure or non-market time is more effective in building social capital. It follows that the effect of the social capital externality on the equilibrium wage rate is positive when social capital is more efficiently built in the workplace, and the effect of the social capital externality on the wage rate is negative when social capital is more efficiently built in the non-market sector, as compared to a situation with no social capital in production.

We now consider a market equilibrium where the individual takes the wage rate as given and maximizes utility given the budget constraint

(18)
$$c = wl_p + m$$

where m is non-wage income. The individual will take average level of social capital and environmental externalities as given, so that the effect of individual consumption c_i on e can be disregarded. In contrast to the social optimum where $s = \overline{s}$, the individual consumer in the market equilibrium takes $\overline{s}$ as given and adjusts s, taking into account the services from social capital. The Lagrangian is given by

(19) $L = u\left(c,l,g(s);e\right) + \mu_c\left(w\left(1-l\right)+m-c\right) + \mu_g\left(\beta s + \left(1-\beta\right)\overline{s} - g(s)\right) + \mu_s\left(\alpha_l l + \alpha_p\left(1-l\right) - s\right)$.

From the first-order conditions we find that

(20) $$\frac{\gamma_l}{l} + \frac{\beta\gamma_s + a\left(b+d\right)\gamma_c}{l+\alpha} = \frac{a\gamma_c}{1-l}$$

when we use the definition of ε in (17) and moreover assume that the valuation of services from social capital is identical in market equilibrium and social optimum so that $\gamma_{g(s)} = \gamma_s$, that the production function is given by (7), and that (20) characterizes an equilibrium where $s = \overline{s}$.

Note that the market equilibrium equals the social optimum for $\gamma_e = 0$ and $\beta = 1$. The market equilibrium is unaffected by γ_e and the social optimum is unaffected by β. The presence of an environmental externality contributes to excessive emissions in the market equilibrium compared to the social optimum. The effects of increasing valuation of consumption γ_c, increasing valuation of social capital γ_s, increasing valuation of leisure γ_l, increasing total output elasticity of effective labor a and increasing productivity of social capital $\left(b+d\right)$ have the same signs as in the analysis of the social optimum, see Table 2. Note that both in the market equilibrium as well as in the social optimum the amount of leisure is continuous in α_l, for α_l close to α_p, even though α is discontinuous. A negative shift in the productivity of leisure time for building social capital compared to on the job time, induces a negative shift in the amount of leisure, as discussed in relation to the social optimum, see Table 1, except for a type 2 shift where leisure is unaffected.

Let us now compare the market equilibrium and social optimum in view of the two types of externalities, i.e. the environmental externality and the consumption externality of social capital. Note that the production externality of social capital affects social optimum and market equilibrium identically. The environmental externality only affects the social optimum. The average level of social capital $\overline{s}$ gives rise to a consumption externality depending on β in market equilibrium. By a similar shift exercise as above, we find that in the market equilibrium, social capital decreases as β decreases, while the social optimum is unaffected by β. A reduction in β implies that the market equilibrium will give too little social capital, compared to the social optimum. Note that a shift in β is equivalent to a shift in γ_s, where γ_s is the valuation of the social capital externality in consumption.

The effect of β on leisure, on the other hand, depends on the sign of $\alpha_l - \alpha_p$. When leisure is more effective in producing social capital $(\alpha > 0)$, an under-supply of social capital in market equilibrium as compared to social optimum (caused by low β) corresponds to too little leisure in market equilibrium as compared to social optimum. The opposite is the case when on the job time is more effective in producing social capital $(\alpha < -1)$. Then an under-supply of social capital in market equilibrium corresponds to too much leisure in market equilibrium as compared to social optimum.

Comparing the effects of the environmental externality and the social capital externality in consumption, we find that in the case where leisure is more efficient in building social capital $(\alpha > 0)$ the two externalities pull in the same direction—an increase in the environmental externality will also imply that the market equilibrium will give too little social capital compared to the social optimum (since an increase in $|\gamma_e|$ will increase social capital in social optimum for $\alpha > 0$). However, for $\alpha < -1$ the two externalities pull in opposite directions. The environmental externality contributes to excessive social capital in market equilibrium (in the sense that an increase in $|\gamma_e|$ will decrease social capital in social optimum for $\alpha < -1$), while the consumption externalities related to social capital pull in the other direction with too little social capital in the market equilibrium. The total effect depends on the relative strength of these two effects.

4. The shift from non-market to market work in building social capital

Structural changes in society influence the allocation of time between non-market and market sectors as well as the contribution from time use in these sectors in accumulating social capital. In the numerical example below, we illustrate the development from a traditional society with a large non-market sector to a society with an extensive knowledge-based production. We focus on four highly stylized cases that are meant to capture the development of key parameters over time. The example is based on the social optimum model.

In traditional societies with a substantial non-market sector, social capital is largely connected to family and local community. With a large informal sector, a good network would be crucial for providing access to services that were important for both production and private welfare. We assume that social capital in this situation (Case 1) is more efficiently built on non-market time, so that $\alpha_l > \alpha_p$, i.e. $\alpha > 0$. Moreover, society has a high valuation of the social capital externality in consumption, and there is high productivity of social capital in production. Table 3 illustrates benchmark values for leisure (non-market work), social capital and consumption under these assumptions.

As more of the economy is included in the formal sector, social capital will be less important for getting access to services from the social network and have less influence on production and consumption. This would correspond to decreasing valuation of social capital γ_s and decreasing productivity $b+d$ (Case 2). Both imply less leisure for $\alpha > 0$ and more leisure for $\alpha < -1$, in social optimum as well as in the market equilibrium. In Case 2 we still assume that social capital is more efficiently built in the non-market sector, so that $\alpha_l > \alpha_p$, and thus $\alpha > 0$ so that leisure (non-market time) declines. Moreover, social capital is reduced, and for the combination of parameter values in Table 3 consumption also is reduced.

Table 3. Effect on leisure, social capital and consumption of shift in parameters. Reference case $\gamma_l = \gamma_c = \gamma_s = 1$, $\gamma_e = -0.2$, $a = 0.5$, $b = d = 0.45$. Social optimum

	l	s	c
Case 1 Leisure more efficient for building social capital $\alpha_l = 1.5, \alpha_p = 1$ High valuation of social capital $\gamma_s = 1.5$ High productivity of social capital $b = d = 0.45$	0.79	1.40	0.53
Case 2 Leisure more efficient for building social capital $\alpha_l = 1.5, \alpha_p = 1$ Low valuation of social capital $\gamma_s = 1$ Low productivity of social capital $b = d = 0.15$	0.77	1.38	0.51
Case 3 Market work more efficient for building social capital $\alpha_1 = 1, \alpha_p = 1.5$ Low valuation of social capital $\gamma_s = 1$ Low productivity of social capital $b = d = 0.15$	0.64	1.18	0.62
Case 4 Market work more efficient for building social capital $\alpha_l = 1, \alpha_p = 1.5$ Low valuation of social capital $\gamma_s = 1$ High productivity of social capital $b = 0.15, d = 0.75$ (same effect as $b = d = 0.45$)	0.62	1.19	0.67

Next, in Case 3 the move to industrial production along production lines in a factory could make social capital even less important in production. However, the presence of trade unions in industrial societies can represent an important aspect of social capital. A reduction in the role of social capital will further reduce $b+d$, and hence also reduce the amount of leisure for $\alpha > 0$, and increase leisure for $\alpha < -1$. Social capital may still be efficiently built in the non-market sector, however, we now focus on the shift towards a situation where social capital is more efficiently built in the market sector. Hence, in Case 3 we assume that $\alpha_p > \alpha_l$, and we consider an increase in α_p and a decline in α_l so that $\alpha_l + \alpha_p$ is constant (Type 3 shift[1]) as discussed above.

Table 3 shows that the shift from Case 2 where $\alpha_l > \alpha_p$ and $\alpha > 0$ to Case 3 where $\alpha_p > \alpha_l$ and $\alpha < -1$ has a much larger effect than the shifts in the valuation of social capital and the productivity of social capital. The shift from $\alpha > 0$ to $\alpha < -1$ implies a reduction in leisure, a reduction in social capital and an increase in consumption. In contrast to the theoretical discussion above, where the effect on social capital of an increase in α_p is ambiguous we here find an increase in labor input that has been sufficient to increase consumption although social capital decreases.

Finally, in an economy characterized by a high degree of urbanization, well educated workforce and where much of production is knowledge-based, social networks are very important for the productivity, and hence $b+d$ will increase (Case 4). An employee with an extensive social network and good knowledge of whom to ask when a particular question arises will be an important resource pool for everybody in the firm. In this case productivity to a large extent depends on the average social capital, rather than only on each worker's private social capital. Hence, d will increase more than b with the transition to knowledge-based production. On the other hand, the knowledge-based society is also characterized by a high degree of individuality in the workplace.

Moreover, in a knowledge-based economy, the job related network is relatively more important than the non-market network for production, and labor market time is more efficient for building social capital than leisure (non-market) time. Hence, we assume that $\alpha_p > \alpha_l$ and $\alpha < -1$. As noted above, a negative shift in α_l will have a negative impact on leisure time, and once $\alpha_l < \alpha_p$ a further increase in $b+d$ will reduce leisure even more. When $\alpha_p > \alpha_l$ an increase in $b+d$ implies a reduction in leisure, a small increase in social capital and an increase in consumption. The latter result follows from

[1] Note that $\alpha_l + \alpha_p \neq 1$, in contrast to the Type 3 shift analyzed in Section 2. We have chosen $\alpha_l + \alpha_p > 1$ in order to obtain a case with $s > 1$, where $dc/d(b+d) > 0$ for $\alpha < -1$. The shift from Case 2 to Case 3 illustrates a situation where social capital decreases and consumption increases.

Table 2 since the level of social capital is larger than one. To summarize the numerical illustration, we find that the shift in α_l and α_p with increasing productivity of labor market time in building social capital and corresponding declines in the productivity of leisure time in building social capital, so that $\alpha_l + \alpha_p$ is constant, has a much larger effect as compared to shifts in the valuation and productivity of social capital.

Let us now consider the effect of an increasing valuation of the environmental externality. Table 4 illustrates a case where $\gamma_e = -0.5$ and the other assumptions are as in Table 3.

Table 4. Effect on leisure, social capital and consumption of shift in parameters. Reference case $\gamma_l = \gamma_c = \gamma_s = 1$, $\gamma_e = -0.5$, $a = 0.5$, $b = d = 0.45$. Social optimum

	l	s	c
Case 1 Leisure more efficient for building social capital $\alpha_l = 1.5, \alpha_p = 1$ High valuation of social capital $\gamma_s = 1.5$ High productivity of social capital $b = d = 0.45$	0.86	1.43	0.44
Case 2 Leisure more efficient for building social capital $\alpha_l = 1.5, \alpha_p = 1$ Low valuation of social capital $\gamma_s = 1$ Low productivity of social capital $b = d = 0.15$	0.84	1.42	0.42
Case 3 Market work more efficient for building social capital $\alpha_1 = 1, \alpha_p = 1.5$ Low valuation of social capital $\gamma_s = 1$ Low productivity of social capital $b = d = 0.15$	0.72	1.14	0.54
Case 4 Market work more efficient for building social capital $\alpha_l = 1, \alpha_p = 1.5$ Low valuation of social capital $\gamma_s = 1$ High productivity of social capital $b = 0.15, d = 0.75$ (same effect as $b = d = 0.45$)	0.71	1.14	0.57

Comparing Table 3 and Table 4 we see that an increasing valuation of the environmental externality unambiguously leads to more leisure as shown in the theoretical discussion above. The effect on social capital, however, depends on α. An increasing valuation of the environmental externality implies that in each of the four cases social capital increases when $\alpha > 0$ and decreases when $\alpha < -1$. Consumption decreases, and the environmental externality is reduced.

In the above analysis, the shift from a traditional society with a small formal sector (Case 1), to a knowledge-based economy (Case 4), will decrease leisure time. The model may thus potentially explain the trend toward reduced leisure as claimed by Schor (1991). On the other hand, Robinson and Godbey (1997) argue that leisure time has been increasing over the last decades. A simplified model like the one presented here, can point at some of the mechanisms behind the change in time use in relation to social capital as an input factor in production and as a direct determinant of welfare.

A further application of this framework is to analyze the issue of underinvestment in social capital. Underinvestment in or depreciation of social capital takes place when social networks disappear without being adequately replaced by other types of social networks or by collective action. Such underinvestments in social capital may lead to negative social externalities, e.g. alienation, social problems and crime. Putnam (1993) focuses on social capital as those social structures that lead to higher efficiency and welfare. However, different societies at different points in time require different types of social capital. As Levi (1996) notes in her essay on social and "unsocial" capital, the stability of the traditional society may impair the innovation and economic growth leading to increase in individual welfare. In this analysis it would be more relevant to distinguish between social capital formed in the market sector and in the non-market sector. Our emphasis on the role of time allocation for social capital is a first approach towards these complex issues. A relevant next step would be to explicitly introduce household production models, see e.g. Apps and Rees (1997, 1999), and distinguish between social capital generated in the work place, in household production and in leisure.

5. Conclusion

This paper analyzes the relationship between time use, social capital and environmental externalities in a simple time allocation model. Although the specifications of both social capital and the environmental externality are extremely simple, the analysis reveals a complex relationship between the parameters of the model and the social capital and environmental externalities. As expected, an increasing valuation of the environmental externality will lead to reduced consumption and have a positive effect on the environment regardless of whether social capital is accumulated more efficiently in the market or non-market sector. Similarly, an increasing valuation of leisure will have a positive effect on the environment, and an increasing valuation of consumption will have a negative effect on the environment.

However, an increasing valuation of social capital will have a positive effect on the environment if social capital is more efficiently built in the non-market sector, and a negative effect on the environment if social capital is more efficiently built in the market sector. The effect on the environment of an increase in productivity is ambiguous. In the case where social capital is more efficiently built in the non-market sector, an increase in the productivity of social capital has a positive effect on the environment if the level of social capital is less than one. In the case where social capital is more efficiently built in the market sector, the productivity increase has a negative effect on the environment if the level of social capital is larger than one.

The numerical example of the shift from the non-market sector to the market sector as more efficient for building social capital illustrates that the effect on time use, social capital and consumption are highly sensitive to the rates of transformation of time to social capital in the two sectors. Although the model is highly stylized and more suggestive than conclusive, it illustrates a number of important mechanisms that are useful for further analysis of the relation between time use, social capital, consumption and environmental externalities.

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Effects of shifts in α_l and α_p

By shift analysis of (10) we find that $dl/d\alpha_l > 0$ and $dl/d\alpha_p < 0$ for shifts of type 1 and 3, and that l is not influenced by shifts of type 2. Below we consider the effects on social capital and consumption. Recall that social capital is given by

(A.1) $$s = \alpha_l l + \alpha_p (1-l) = (\alpha_l - \alpha_p) l + \alpha_p = (\alpha_l - \alpha_p)(l + \alpha).$$

The effect on consumption is given by

(A.2) $$\frac{dc}{d\alpha_l} = ac\left(-\frac{1}{1-l}\frac{dl}{d\alpha_l} + \frac{b+d}{s}\frac{ds}{d\alpha_l} \right)$$

(A.3) $$\frac{dc}{d\alpha_p} = ac\left(-\frac{1}{1-l}\frac{dl}{d\alpha_p} + \frac{b+d}{s}\frac{ds}{d\alpha_p} \right).$$

The effect on s is analyzed in the three cases below.

Type 1 shift: Partial shift in α_l and α_p

From (A.1) we have that

(A.4) $$\frac{ds}{d\alpha_l} = (\alpha_l - \alpha_p)\frac{dl}{d\alpha_l} + l > 0 \text{ for } \alpha > 0.$$

For $\alpha < -1$ the effect on s is ambiguous, but a large l contributes to a positive effect.

(A.5) $$\frac{ds}{d\alpha_p} = (\alpha_l - \alpha_p)\frac{dl}{d\alpha_p} + 1 - l > 0 \text{ for } \alpha < -1.$$

For $\alpha > 0$ the effect on s is ambiguous, but a large $1-l$ contributes to a positive effect.

Using (A.4) and (A.5) in (A.2) and (A.3) we find

(A.6) $$\frac{dc}{d\alpha_l} = ac\left(\left(-\frac{1}{1-l} + \frac{b+d}{l+\alpha} \right)\frac{dl}{d\alpha_l} + \frac{b+d}{s} l \right)$$

where the first term is negative if

$$\frac{1}{1-l} > \frac{b+d}{l+\alpha}$$

which is satisfied automatically if $\alpha < -1$. When $\alpha > 0$, it follows from (10) and (12) that the inequality is satisfied.

Hence, the first term is negative and the second term is positive, so that the net effect is ambiguous. However, a large *l* contributes to a positive effect. Moreover,

(A.7) $$\frac{dc}{d\alpha_p} = ac\left(\left(-\frac{1}{1-l} + \frac{b+d}{l+\alpha}\right)\frac{dl}{d\alpha_p} + \frac{b+d}{s}(1-l)\right) > 0.$$

Type 2 shift: α constant

Consider a shift where both α_l and α_p increase by a factor *k*, which implies that α is unchanged. By definition, *s* increases by the factor *k*.

(A.8) $$\frac{ds}{d\alpha_l} = \frac{ds}{d\alpha_p} = k$$

From (A.2) and (A.3) we have that

(A.9) $$\frac{dc}{d\alpha_l} = \frac{dc}{d\alpha_p} = ack\frac{b+d}{s}.$$

Type 3 shift: $\alpha_l + \alpha_p = 1$

Note that for Type 3 shifts we have that $\alpha_p = 1-\alpha_l$ implies that $\alpha = (1-\alpha_l)/(2\alpha_l - 1)$, and $\alpha_l = 1-\alpha_p$ implies that $\alpha = \alpha_p/(1-2\alpha_p)$. In this case *s* is given by

(A.10) $$s = (2\alpha_l - 1)l + 1 - \alpha_l$$

or, equivalently,

(A.11) $$s = (1-2\alpha_p)l + \alpha_p.$$

From (A.10) we get

(A.12) $$\frac{ds}{d\alpha_l} = (2\alpha_l - 1)\frac{dl}{d\alpha_l} + 2l - 1$$

which is positive for $\alpha_l > 0.5$ and $l > 0.5$. Note that in this case $\alpha_l > 0.5$ implies that $\alpha > 0$. For $\alpha_l < 0.5$, i.e. $\alpha < -1$, the effect on *s* is ambiguous, but a large *l* contributes to a positive effect. From (A.11) we get

(A.13) $$\frac{ds}{d\alpha_p} = (1 - 2\alpha_p)\frac{dl}{d\alpha_p} - 2l + 1$$

which is positive for $\alpha_p > 0.5$ and $l < 0.5$. Note that in this case $\alpha_p > 0.5$ implies that $\alpha < -1$. For $\alpha_p < 0.5$, i.e. $\alpha > 0$, the effect on *s* is ambiguous, but a small *l* (large $1 - l$) contributes to a positive effect.

Using (A.12) and (A.13) in (A.2) and (A.3) we find

(A.14) $$\frac{dc}{d\alpha_l} = ac\left(\left(-\frac{1}{1-l} + \frac{b+d}{s}(2\alpha_l - 1)\right)\frac{dl}{d\alpha_l} + \frac{b+d}{s}(2l-1)\right)$$

and

(A.15) $$\frac{dc}{d\alpha_p} = ac\left(\left(-\frac{1}{1-l} + \frac{b+d}{s}(1 - 2\alpha_p)\right)\frac{dl}{d\alpha_p} - \frac{b+d}{s}(2l-1)\right).$$

To determine the sign of the first term, use (A.1) and note that

(A.16) $$\alpha_p = 1 - \alpha_l \;\Rightarrow\; \alpha_l - \alpha_p = 2\alpha_l - 1 \;\Rightarrow\; \frac{2\alpha_l - 1}{s} = \frac{1}{l+\alpha}$$

and

(A.17) $$\alpha_l = 1 - \alpha_p \;\Rightarrow\; \alpha_l - \alpha_p = 1 - 2\alpha_p \;\Rightarrow\; \frac{1 - 2\alpha_p}{s} = \frac{1}{l+\alpha}.$$

Hence, we use (11) and find that the first term in (A.14) is negative. The sign of the second term depends on *l*, so the net effect is ambiguous. However, when $l < 0.5$ the effect on consumption is negative. In (A.15), the first term is positive. The sign of the second term depends on *l*, so the net effect is ambiguous. However, when $l < 0.5$ or $1 - l > 0.5$ the effect on consumption is positive.

Effects of shifts in the parameters of the utility and production functions

The effect of parameter shifts on social capital and consumption follows from the corresponding shift in leisure. In particular, note that for constant α_l and α_p the effect on social capital of a shift in any other parameter value, say a, is given by

$$\text{(A.18)} \qquad \frac{ds}{da} = \frac{ds}{dl}\frac{dl}{da} = \left(\alpha_l - \alpha_p\right)\frac{dl}{da}.$$

Since $ds/dl > 0$ when $\alpha > 0$ and $ds/dl < 0$ when $\alpha < -1$ and $dl/da < 0$ in both cases, it follows that $ds/da < 0$ when $\alpha > 0$ and $ds/da > 0$ when $\alpha < -1$. The effect on socially optimal consumption of a shift in the valuation of consumption or environmental externality is found by differentiating the production function (8) w.r.t. $\gamma_c + \gamma_e$

$$\text{(A.19)} \qquad \frac{dc}{d\left(\gamma_c + \gamma_e\right)} = c\frac{dl}{d\left(\gamma_c + \gamma_e\right)}a\left(-\frac{1}{1+l} + \frac{b+d}{l+\alpha}\right) > 0$$

where the sign follows from (11) for the case of $\alpha > 0$ and by inspection for the case of $\alpha < -1$. The effect on socially optimal consumption of a shift in a is given by

$$\text{(A.20)} \qquad \frac{dc}{da} = c\left(a\frac{dl}{da}\left(-\frac{1}{1-l} + \frac{b+d}{l+\alpha}\right) + \log\left(1-l\right) + \left(b+d\right)\log s\right)$$

where log denotes the natural logarithm. For $\alpha > 0$ it follows from (11) and the result that $dl/da < 0$ that the first term of dc/da is positive. For $\alpha < -1$ it follows immediately that the first term is positive. The second term of dc/da is negative. The third term is positive (negative) when s is greater than (less than) one. Hence, the sign of dc/da is ambiguous. In order to find the effect on consumption of a shift in $b+d$, consider the derivative

$$\text{(A.21)} \qquad \frac{dc}{d\left(b+d\right)} = c\left(a\frac{dl}{d\left(b+d\right)}\left(-\frac{1}{1-l} + \frac{b+d}{l+\alpha}\right) + a\log s\right).$$

For $\alpha > 0$, leisure increases with $b+d$ and provided that $s < 1$, the effect on consumption is negative. If $s > 1$, the effect on consumption is ambiguous. For $\alpha < -1$, leisure decreases with $b+d$ and provided that $s > 1$, the effect on consumption is positive. If $s < 1$, the effect on consumption is ambiguous.

Marginal productivity of labor in market equilibrium

Differentiating the production function (13) with respect to l_{p_i} when total labor supply is given by (15), we obtain

$$w = F'(L) = \left[s_i^b \,\overline{s}_{-i}^d + l_{p_i} \frac{b}{s_i} s_i^b \,\overline{s}_{-i}^d \frac{ds_i}{dl_{p_i}} + \left(n-1\right) l_{p_j} \frac{d}{\overline{s}_{-j}} s_j^b \,\overline{s}_{-j}^d \frac{d\overline{s}_{-j}}{ds_i} \frac{ds_i}{dl_{p_i}} \right]$$

(A.22)

$$= a\,f\left(\overline{L}\right) \frac{n\,s^b \overline{s}^d \left(1 + \left(\frac{b}{s} + \frac{d}{\overline{s}}\right) l_p \frac{ds}{dl_p}\right)}{n\,l_p\, s^b \overline{s}^d}$$

$$= a \frac{f\left(\overline{L}\right)}{l_p} \left(1 + \left(b+d\right) \frac{ds}{dl_p} \frac{l_p}{s}\right) = a \frac{f\left(\overline{L}\right)}{l_p} \left(1 + \left(b+d\right)\varepsilon\right)$$

when we assume that $s_i = s_j = s$, $\overline{s}_{-i} = \overline{s}_{-j} = \overline{s}$ and $s = \overline{s}$, and recall the production function (7).