Endogenous work ethics*

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Abstract

In the present paper, we study the interaction between work ethics and technology adoption. Work ethics is a social norm that shapes individual preferences for leisure versus consumption. Conversely, work ethics depends on how consumers spend their leisure. We use the overlapping generations model and find that: the higher the return on work, the higher the work ethics; and, it is possible that societies with high (low) work ethics do (not) adopt new technologies even though societies with high and low work ethics would both be better off adopting the new technologies in the long run. Consequently, work ethics can help us understand income inequalities across countries.

Keywords Economic development · Overlapping generations economies · Technology adoption · Work ethics

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Employment in the modern sector requires not only formal training, but also a certain attitude to work which may best be described as the capacity to work regularly and attentively. This attitude is not easily acquired by people who are accustomed to come and go, to work and rest as they please. Those who work within the confines of the family are not likely to acquire this attitude unless their position is so precarious that they are forced into working harder and longer in order to subsist. It is well known that people who are accustomed to hard work in intensive agriculture are more able to adapt themselves to other types of work than are people accustomed to the more leisurely rhythm of work in shifting agriculture.

Boserup (2007)

1 Introduction

Motivation: The determinants of technology adoption are the object of an ongoing debate in economics. There seems to be a consensus that differences in technology across countries account for most of the differences in GDP per capita and wages of workers with similar skills (Foster and Rosenzweig, 2010). Consequently, understanding technology adoption is crucial to understand global inequalities.

This debate is also vivid in economic history. There are disputed explanations of why the industrial revolution took place in 18th century England and not elsewhere. They have ranged from religion (Weber, 1994) and culture (Clark, 2007) to politics (Mokyr, 1990) and economics (Allen, 2009). But in all of them, the study of the microeconomic determinants of technology adoption is relevant.

In the present paper, we want to account for the role of work ethics in technology adoption, and therefore in trajectories of growth and wealth of nations. Work ethics is considered to be a social norm that shapes individual preferences for leisure versus consumption. It is underlining the importance of work and fostering the determination to work. Work ethics is modelled as a public good which is transferred from one generation to the other and reinforced by laborious activities that we shall name busy leisure in the paper.

The distinction between idle and busy leisure has been standing for long in western history. The Latin word for leisure is *otium*, its negation is *negotium* from which the Oxford English Dictionary provides negoce as an archaic French word for business. Otium designated the time free from agriculture or military operations (André, 1962). The free time could be consumed in idleness (*otium otiosum*) or in business (*otium negotiosum*) taking care of domestic affairs. In Roman culture, idleness and work ethics were seen as opposites

(André, 1962). We build on this distinction and disentangle idle leisure from busy leisure as arguments of the utility function, and include (collective) work ethics as another argument. The effect of work ethics on preferences is straightforward and intuitive: higher work ethics decreases marginal utility of idle leisure and increases marginal utility of busy leisure.

The interplay between idle and busy leisure is subtler. It is standard to assume that more leisure decreases the marginal utility of leisure – as per concavity of the utility function. We assume the same in the two-dimensional space of idle and busy leisure – Assumption (U.1). Moreover, we assume that, at least on some part of the consumption set, more idle leisure decreases the marginal utility of idle leisure less than more busy leisure does – Assumption (U.3). In the language of work ethics, (U.3) implies that busy leisure is more effective than idle leisure in decreasing marginal utility of idle leisure: consuming busy leisure is an effective way to like idleness less.

The introduction of busy leisure and work ethics in economic models allows us to propose a new explanation of why different economies adopt different technologies even though they have access to the same set of technologies.

Now, what are the determinants of work ethics? In an environment where labour is highly productive, perhaps because the soil is fertile, people have a strong incentive to invest their free time into busy leisure to lower their marginal utility of idle leisure, and altogether be more productive. Therefore, variations in the natural environment can explain why different economies have developed different work ethics.

Overview of the paper: In the present paper work ethics in society is included in simple stationary overlapping generations economies. Consumers can allocate their time between labour, idle leisure and busy leisure.

Our assumptions ensure that consumption of idle leisure depends negatively on the wage and work ethics; and that both consumption of busy leisure and supply of labour depend positively on the wage and work ethics (Corollary 1). Consequently, consumption of busy leisure follows the same pattern as supply of labour.

Let us provide some intuition on why consumption of busy leisure depends positively on the wage. Basically, if the wage goes up, then busy leisure goes up because the return on labour has increased making the indirect return on busy leisure higher. More technically, since the wage is the price of leisure and leisure is an ordinary good (in our model), if the wage goes up, then the demand for leisure goes down. How does it affect the mix between idle and busy leisure? If both idle and busy leisure went down, then by Assumptions (U.1) and (U.3) the marginal utility of idle leisure would increase less than the marginal utility of busy leisure. This would prevent marginal utilities of idle and busy leisure to be equalized, which is a necessary condition of utility maximization. Hence either idle or busy leisure has to go up. Since busy leisure is more effective than idle leisure in changing marginal utility, idle leisure goes down a lot and busy leisure goes up a little.

The fact that consumption of idle (resp. busy) leisure depends negatively (resp. positively) on work ethics flows quite intuitively from (U.3) – namely: higher work ethics decreases marginal utility of idle leisure (resp. increases marginal utility of busy leisure). Hence there is a positive externality from work ethics in society to individual busy leisure. Reciprocally we assume that individual busy leisure reinforces work ethics in society – Assumption (W.1). A virtuous circle is at play.

Steady states are equilibria (consumers maximize utility subject to their budget constraints, firms maximize profits and markets clear) at which generations have identical possibilities. Steady states are shown to exist in Theorem 2. A comparative statics analysis shows that adopting a technology with higher labour productivity will result in higher (real) wage and work ethics (Theorem 3), and consequently in higher busy leisure and labour supply (Corollary 2). With the virtuous circle at play, the rise of work ethics amplifies the raise of real wages.

But it will not always be the case that an economy will adopt a technology with higher labour productivity. In line with the opening quote of Boserup (2017), consider for example an economy blessed with low hanging fruits; people have lower incentives to invest in busy leisure, work longer and build on their work ethics; this might result in lower incentives to adopt a technology with higher labour productivity. On the contrary, in an economy deprived of these low hanging fruits, but with fertile soil, people have higher incentives to invest in busy leisure, work longer and build on their work ethics. This might result in higher incentives to adopt a technology with higher labour productivity, and ultimately in higher welfare than in the "blessed" economy. Consequently, the absence of low hanging fruits can be a blessing and their presence a curse. Theorem 4 illustrates such a situation.

Work ethics and knowledge have some similarities. But work ethics shapes individual preferences, whereas knowledge contributes to human capital and shapes technologies. In a nutshell, work ethics is a social norm and knowledge is an input. A more detailed discussion of work ethics, knowledge and capital is found in the final remarks.

Related literature: The present paper introduces a model of endogenous preference formation. It is linked to the literature on social norms. Postlewaite (2011) emphasizes the transmission of norms over time. A recent literature in economics has introduced the idea that individual preferences are directly shaped by the environment: e.g., Benhabib and Bisin (2010) discuss the role of advertising; it can be the environment in which individuals are raised: Bisin and Verdier (2000) propose a model of cultural transmission from parents to children. Burke and Young (2011) emphasize the feedback loop between individual and group behavior as a key feature of social norms. All these features are present in our model.

The transmission of work ethics from one generation to the next links our model to a body of work in economic history, of which Clark (2007) is a prominent piece. It argues that the Industrial Revolution was the result of some kind of natural selection during the Malthusian era, in which economically successful agents had more surviving offspring. This resulted in a transmission of attributes such as devotion to hard work. In contrast, our focus is on societies and environment instead of families and culture, and we emphasize social norms rather than natural selection.

Another prominent piece is Allen (2011). Although it dismisses cultural explanations of technology adoption and economic success, it accounts for various mentalities with respect to work versus leisure. E.g., it describes the bare-bones subsistence shifting agriculture of the Yakö group in the rain forest of Eastern Nigeria, and the intensive capitalistic economy of the Krobo group across Ghana and Côte d'Ivoire, commenting that "the Krobo look like Weber's Protestant ethic in operation" (p. 102).

Plan of the paper: In Section 2 the setup including assumption and maximization problems of agents is introduced. In Section 3 the notions of equilibrium and steady state are defined and it is shown there are steady states. In Section 4 the interaction between work ethics and adoption of new technology is analyzed. Section 5 concludes the paper with some final remarks.

2 Setup

Consider a stationary overlapping generations economy where time extends from $-\infty$ to ∞.

There are three standard goods, namely a consumption good, capital and labour. The consumption good is numeraire, the price of capital is $1+r_t$ and the price of labour is w_t. There is one less standard good, namely work ethics in society.

There is a continuum of identical consumers with mass one in every generation. Consumers care about leisure when young and consumption when old. Leisure is split into idle and busy leisure. The preferences for leisure are formed by work ethics in society. Let o_t be idle leisure, n_t busy leisure and z_t work ethics at date t, and c_{t+1} consumption at date $t+1$. Then the utility of (o_t, n_t, z_t, c_{t+1}) for a consumer in generation t is $U(o_t, n_t, z_t) + c_{t+1}$. The utility function is assumed to be quasi-linear in consumption to highlight the interactions between the two forms of leisure and work ethics. Time not used on leisure is used to work; it is denoted ℓ_t. The total available time is normalized to one: $o_t + n_t + \ell_t = 1$.

There is a continuum of identical firms with mass one at every date. The firms transform capital and labour into the consumption good by use of a constant returns to scale technology. If no inputs are used, then the output is zero, but if some inputs are used, then output is the sum of some constant ω_F and output of production: $Y_t = \omega_F + F(K_t, L_t)$. The constant is supposed to capture how productive the environment is and the production function $F : \mathbb{R}^2_{++} \to \mathbb{R}_{++}$ is supposed to capture how productive inputs are.

Firms are owned by old consumers and there are no markets for capital. As long as there is a single technology in the economy, it is not important whether there are markets for capital or not. Indeed prices can simply be such that demand and supply for capital are equal in equilibrium.

Work ethics at date $t+1$ depends on busy leisure and work ethics at date t. Let $W : \mathbb{R}^2_{++} \to \mathbb{R}_{++}$ be the transformation function for work ethics so $z_{t+1} = W(n_t, z_t)$.

There are externalities between work ethics and preferences on the one hand, and between busy leisure and work ethics on the other hand. Hence a virtuous circle is at play.

An economy is described by the utility function, the production technology and the transformation function for work ethics $\mathscr{E} = (U, \omega_F, F, W)$.

The consumer problem

The consumer problem at date t is:

$$\max_{(o_t, n_t, s_t, \ell_t, c_{t+1})} \quad U(o_t, n_t, z_t) + c_{t+1}$$

$$\text{s.t.} \quad \begin{cases} o_t + n_t &= 1 - \ell_t \\ s_t &= w_t \ell_t \\ c_{t+1} &= (1 + r_{t+1}) s_t. \end{cases}$$

The consumer problem can be decomposed into two problems, namely finding the optimal (o_t, n_t) for fixed ℓ_t and finding the optimal ℓ_t. Finding the optimal (o_t, n_t) for fixed ℓ_t is now studied in detail.

The leisure allocation problem

Let $(\ell, z) \in [0, 1[\times \mathbb{R}_{++}$ be the time allocated to work and work ethics. Then the leisure allocation problem is:

$$\max_{(o,n)} \quad U(o, n, z)$$

$$\text{s.t.} \quad o + n = 1 - \ell.$$

The utility function U is assumed to satisfy the following assumptions:

(U.1) $U \in C^2(\mathbb{R}^3_{++}, \mathbb{R})$ where for all (o,n,z), $U'_o(o,n,z) > 0$, and for all $(a_o, a_n) \neq 0$,

$$U''_{oo}(o,n,z)a_oa_o + U''_{on}(o,n,z)a_oa_n + U''_{no}(o,n,z)a_na_o + U''_{nn}(o,n,z)a_na_n \;<\; 0.$$

(U.2) For all $(\bar{o},\bar{n},\bar{z}) \in \mathbb{R}^3_+$ with $\bar{o} = 0$ or $\bar{n} = 0$, $\lim_{(o,n,z)\to(\bar{o},\bar{n},\bar{z})} U(o,n,z) \;=\; -\infty$.

(U.3) There is an open set $X \subset \mathbb{R}^2_{++}$ such that for some $(o,n,z) \in X$, $U'_o(o,n,z) = U'_n(o,n,z)$ and for all $(o,n,z) \in X$, $U'_o(o,n,z) = U'_n(o,n,z)$ implies

$$U''_{oo}(o,n,z) \;>\; U''_{on}(o,n,z) \;\text{ and }\; U''_{oz}(o,n,z) \;<\; 0 \;<\; U''_{nz}(o,n,z).$$

Assumption (U.1) states that the utility function is twice continuously differentiable, differentiably strictly increasing in idle leisure and differentiably strictly concave in idle and busy leisure. Assumption (U.2) states that utility tends to minus infinity as idle or busy leisure converges to zero. Assumption (U.3) implies: busy leisure is more effective than idle leisure in decreasing marginal utility of idle leisure; and, increasing work ethics decreases the marginal utility of idle leisure and increases the marginal utility of busy leisure.

Strict concavity of U ensures that there is at most one solution to the leisure allocation problem. Differentiability and utility tending to minus infinity when idle or busy leisure converge to zero ensure there is at least one solution to the leisure allocation problem. According to Berge's maximum theorem the solution $(o(\ell,z), n(\ell,z))$ is a continuous function of (ℓ,z) and the indirect utility function $I : [0,1[\times\mathbb{R}_{++} \to \mathbb{R}$ defined by $I(\ell,z) = U(o(\ell,z), n(\ell,z), z)$ is continuous.

Lemma 1 *Assume (U.1) and (U.2) are satisfied. Then solutuion is continuously differentiable functions $(o,n) \in C^1([0,1[\times\mathbb{R}_{++}, \mathbb{R}^2_{++})$ with derivatives:*

$$\begin{cases} o'_\ell(\ell,z) \;=\; \dfrac{U''_{on} - U''_{nn}}{U''_{oo} - U''_{on} - U''_{no} + U''_{nn}} \quad \textit{and} \quad o'_z(\ell,z) \;=\; \dfrac{-U''_{oz} + U''_{nz}}{U''_{oo} - U''_{on} - U''_{no} + U''_{nn}} \\[2ex] n'_\ell(\ell,z) \;=\; \dfrac{-U''_{oo} + U''_{no}}{U''_{oo} - U''_{on} - U''_{no} + U''_{nn}} \quad \textit{and} \quad n'_z(\ell,z) \;=\; \dfrac{U''_{oz} - U''_{nz}}{U''_{oo} - U''_{on} - U''_{no} + U''_{nn}}. \end{cases}$$

Proof: Since the solution (o,n) is in $\mathbb{R}^2_{++}$, it is characterized by the first-order condition:

$$\begin{cases} U'_o(o,n,z) \;=\; U'_n(o,n,z) \\ o + n \;=\; 1 - \ell. \end{cases}$$

The implicit function theorem applied to the first-order conditions with $U = U(o,n,z)$ gives the derivatives of the solution (o,n) with respect to (ℓ,z). □

It follows from Lemma 1 that (U.3) implies idle leisure o is increasing in total leisure $1-\ell$ and decreasing in work ethics z, and busy leisure n is decreasing in total leisure and increasing in work ethics.

Theorem 1 *For* $(o(\ell,z),n(\ell,z),z)\in X$*:*

$$\begin{cases} o'_\ell(\ell,z) < 0 \text{ and } o'_z(\ell,z) < 0 \\ n'_\ell(\ell,z) > 0 \text{ and } n'_z(\ell,z) > 0. \end{cases}$$

Proof: Assumption (U.1) with $(a_o,a_n)=(1,-1)$ yields that the denominators of the expressions in Lemma 1 are negative: $U''_{oo}-U''_{on}-U''_{no}+U''_{nn}<0$. The signs of o'_z, n'_ℓ and n'_z then follow immediately from (U.3). As for the sign of o'_ℓ, it follows from the observation that $o'_\ell+n'_\ell=-1$. □

The indirect utility function I is twice continuously differentiable. For (ℓ,z) such that $(o(\ell,z),n(\ell,z),z)\in X$, its derivatives (and their signs) are as follows:

$$\begin{cases} I'_\ell(\ell,z) = -U'_o < 0 \\ I'_z(\ell,z) = U'_z \gtrless 0 \\ I''_{\ell\ell}(\ell,z) = \dfrac{U''_{oo}U''_{nn}-U''_{on}U''_{no}}{U''_{oo}-U''_{on}-U''_{no}+U''_{nn}} < 0 \\ I''_{\ell z}(\ell,z) = -\dfrac{(-U''_{no}+U''_{nn})U''_{oz}+(U''_{oo}-U''_{on})U''_{nz}}{U''_{oo}-U''_{on}-U''_{no}+U''_{nn}} > 0 \\ I''_{zz}(\ell,z) = \dfrac{-U''_{oz}U''_{zo}+U''_{oz}U''_{zn}+U''_{nz}U''_{zo}-U''_{nz}U''_{zn}}{U''_{oo}-U''_{on}-U''_{no}+U''_{nn}}+U''_{zz} \gtrless 0. \end{cases}$$

Moreover $\lim_{\ell\to 1} I(\ell,z) = -\infty$.

Back to the consumer problem

With the indirect utility function the consumer problem becomes:

$$\max_{\ell_t} I(\ell_t,z_t)+\tilde{w}_t\ell_t,$$

where $\tilde{w}_t=(1+r_{t+1})w_t$ is the real wage. There is a unique solution $\ell(\tilde{w}_t,z_t)$ to the consumer problem for all $(\tilde{w}_t,z_t)\in\mathbb{R}^2_{++}$. Moreover, there is an open set $P\subset\mathbb{R}^2_{++}$ such that $(\tilde{w},z)\in P$ implies $(o(\ell,z),n(\ell,z),z)\in X$. In the sequel we assume $(\tilde{w},z)\in P$.

According to the implicit function theorem, the solution to the consumer problem is a differentiable function of the parameters $(\tilde{w},z)$. The derivatives of the solution are:

$$\begin{cases} \ell'_{\tilde{w}}(\tilde{w},z) = -\dfrac{1}{I''_{\ell\ell}(\ell(\tilde{w},z),z)} > 0 \\ \ell'_z(\tilde{w},z) = -\dfrac{I''_{\ell z}(\ell(\tilde{w},z),z)}{I''_{\ell\ell}(\ell(\tilde{w},z),z)} > 0. \end{cases}$$

The labour supply is increasing in the real wage and work ethics. Therefore, as a corollary to Theorem 1, idle leisure is decreasing, and busy leisure increasing, in both the real wage and work ethics.

Corollary 1 *For* $(\tilde{w},\tilde{z}) \in P$*:*

$$\begin{cases} \ell'_{\tilde{w}}(\tilde{w},z) > 0 \text{ and } \ell'_{z}(\tilde{w},z) > 0 \\ o'_{\tilde{w}}(\ell(\tilde{w},z),z) < 0 \text{ and } o'_{z}(\ell(\tilde{w},z),z) < 0 \\ n'_{\tilde{w}}(\ell(\tilde{w},z),z) > 0 \text{ and } n'_{z}(\ell(\tilde{w},z),z) > 0. \end{cases}$$

Firms

The firm problem is

$$\max_{(Y_t,K_t,L_t)} \quad Y_t - (1+r_t)K_t - w_tL_t$$
$$\text{s.t.} \quad Y_t \leq F(K_t,L_t).$$

The production function is assumed to satisfy

(F.1) $F \in C^2(\mathbb{R}^2_{++},\mathbb{R}_{++})$ with $F'_K(K,L),F'_L(K,L) > 0$ and for all $(a_K,a_L) \neq 0$ orthogonal to $(F'_K(K,l),F'_L(K,L))$,

$$F''_{KK}(K,l)a_Ka_K + F''_{KL}(K,L)a_Ka_L + F''_{LK}(K,L)a_La_K + F''_{LL}(K,L)a_La_L < 0.$$

Assumption (F.1) states that the production function is differentiably increasing and differentiably strictly quasi-concave.

The first-order conditions of the firm problem are

$$\begin{cases} F'_K(K_t,L_t) = 1+r_t \\ F'_L(K_t,L_t) = w_t. \end{cases}$$

For $k_t = K_t/L_t$ and $f(k_t) = F(k_t,1)$ the first-order conditions become

$$\begin{cases} f'(k_t) = 1+r_t \\ f(k_t) - k_tf'(k_t) = w_t. \end{cases}$$

3 Equilibria and steady states

Equilibria are prices, consumption and production plans and work ethics such that consumers maximize their utilities, firms maximize their profits and markets clear. Steady states are equilibria for which all generations have identical opportunities. Existence of steady states and how wages and work ethics depend on technology in steady state are studied in the present section.

Definitions of equilibria and steady states

At an equilibrium consumers maximize utilities subject to their budget constraints, firms maximize their profits subject to their technology constraints and markets for the good, capital and labour clear.

Definition 1 *An **equilibrium** is prices, consumption and production plans and work ethics*

$$((\bar{r}_t, \bar{w}_t)_{t\in\mathbb{Z}}, (\bar{c}_{t+1}, \bar{o}_t, \bar{n}_t, \bar{s}_t)_{t\in\mathbb{Z}}, (\bar{Y}_t, \bar{K}_t, \bar{L}_t)_{t\in\mathbb{Z}}, (\bar{z}_t)_{t\in\mathbb{Z}})$$

such that for every t,

- $(\bar{c}_{t+1}, \bar{o}_t, \bar{n}_t, \bar{s}_t)$ *is a solution to the consumer problem.*
- $(\bar{Y}_t, \bar{K}_t, \bar{L}_t)$ *is a solution to the firm problem.*
- $\bar{c}_t + \bar{s}_t = \bar{Y}_t$, $\bar{K}_t = \bar{s}_{t-1}$ *and* $\bar{L}_t = 1 - (\bar{o}_t + \bar{n}_t)$.
- $\bar{z}_{t+1} = W(\bar{n}_t, \bar{z}_t)$.

To lighten notation, let $n((1+r_t)w_{t-1}, z_{t-1}) = n(\ell((1+r_t)w_{t-1}, z_{t-1}), z_{t-1})$. Then $((r_t, w_t)_{t\in\mathbb{Z}}, (z_t)_{t\in\mathbb{Z}})$ is part of an equilibrium if and only if for every t,

$$\left\{\begin{array}{rcl} 1+r_t - F'_K(w_{t-1}\ell((1+r_t)w_{t-1}, z_{t-1}), \ell((1+r_{t+1})w_t, z_t)) & = & 0 \\ w_t - F'_L(w_{t-1}\ell((1+r_t)w_{t-1}, z_{t-1}), \ell((1+r_{t+1})w_t, z_t)) & = & 0 \\ z_t - W(n((1+r_t)w_{t-1}, z_{t-1}), z_{t-1}) & = & 0. \end{array}\right. \quad (1)$$

Therefore the evolution of the economy is described by a three-dimensional dynamical system.

Definition 2 *A **steady state** is an equilibrium for which prices, consumption and production plans and work ethics are constant across dates.*

At steady states Equations (1) becomes

$$\left\{\begin{array}{rcl} f'(w) & = & 1+r \\ f(w) - wf'(w) & = & w \\ W(n((1+r)w, z), z) & = & z. \end{array}\right. \quad (2)$$

The second equation determines w, the first equation determines r as a function of w and the third equation determines z as a function of w and r. Therefore at steady state the production sector determines the interest rate and the wage, and the consumption sector determines work ethics. These variables can be used to find the other variables at steady state. Hence steady states can be parameterized by these variables.

Existence of steady states

To ensure there are steady states, some additional assumptions are needed. For the production function F the following two assumptions are considered:

(F.2) $\lim_{k\to 0} f(k)/k - f'(k) > 1$ and $\lim_{k\to\infty} f(k)/k - f'(k) < 1$.

(F.3) $kf'(k)$ is increasing in k.

Assumption (F.2) implies $\lim_{k\to 0} f'(k) = \infty$ in case $\lim_{k\to 0} f(k) = 0$ and $\lim_{k\to\infty} f'(k) < 1$. Assumption (F.3) states that the part of output associated with capital is increasing in capital. Cobb-Douglas and CES production functions satisfy all three assumptions.

For the transformation function W the following assumption is considered:

(W.1) $W \in C^2$ with $W'_n(n,z), W'_z(n,z) > 0$, $\lim_{z\to 0} W(n,z)/z > 1 > \lim_{z\to\infty} W(n,z)/z$.

Theorem 2 *For all economies (U, ω_F, F, W) there is a steady state (r,w,z) with $r,w,z > 0$.*

Proof: There is $w > 0$ such that $w = f(w) - wf'(w)$ according to Assumption (F.2). For all $w > 0$ there is a unique $r > -1$ such that $1+r = f'(w)$. There is $\bar{n} > 0$ such that for all z, $n((1+r)w,z) \geq \bar{n}$ according to Assumption (U.2). Therefore there is $z > 0$ such that $W(n((1+r)w,z),z) = z$ according to Assumption (W.1). (Note that (F.3) is not needed for existence of steady states.) □

Remark: There can be multiple steady states because there can be multiple solutions to the second and the third equations in Equations (2).

Let $E_F \subset \mathbb{R}^3_{++}$ be the set of steady states parameterized by the production function F:

$$E_F = \{(r,w,z) \mid f'(w) = 1+r,\ f(w) - wf'(w) = w \text{ and } W(n((1+r)w,z),z) = z\}.$$

The set of steady states depends on the economy in question. However, since the utility function and the transformation function are fixed, and the production function is varied, the set of steady states is parameterized by production functions and not by economies.

Comparative statics of steady states

Let us now compare economies which are identical except for their production functions. A nice property holds in case there is a unique steady state: the economy with higher labour productivity, and higher capital productivity times labour productivity, has higher wages, real wages and work ethics at steady state.

When there are multiple steady states, the economy with higher labour productivity, and higher capital productivity times labour productivity, has higher minimum and maximum wages, real wages and work ethics at steady state.

To lighten the notation, for functions ϕ defined on E_F let $\min_{E_F} \phi$ denote the minimum of the function on E_F.

Theorem 3 *For an economy $\mathscr{E} = (U, \omega_F, F, W)$ and a technology G suppose for all k, $g(k) - kg'(k) > f(k) - kf'(k)$ and $g'(k)(g(k) - kg'(k)) > f'(k)(f(k) - kf'(k))$.*

- *Wages and real wages increase with a change of technology to G:*

$$\begin{cases} \min_{E_F} w_F < \min_{E_G} w_G \quad \textit{and} \quad \max_{E_F} w_F < \max_{E_G} w_G \\ \min_{E_F} \tilde{w}_F < \min_{E_G} \tilde{w}_G \quad \textit{and} \quad \max_{E_F} \tilde{w}_F < \max_{E_G} \tilde{w}_G. \end{cases}$$

- *Work ethics increases with a change of technology to G:*

$$\min_{E_F} z_F < \min_{E_G} z_G \quad \textit{and} \quad \max_{E_F} z_F < \max_{E_G} z_G.$$

Proof: Since $g(k) - kg'(k) > f(k) - kf'(k)$ for all k, it follows that wages increase with a change of technology. According to Assumption (F.3), $Ka'_K(K, L)$ is strictly increasing in K for $a \in \{F, G\}$. Since $g'(k)(g(k) - kg'(k)) > f'(k)(f(k) - kf'(k))$ for all k it follows that the return on work increases with a change of technology, because $(1+r_a)w_a = a'_K(K, L)a'_L(K, L)$ for both a. Work ethics increase with a change of technology because n is increasing in $\tilde{w}$ according to Lemma 1. □

As a corollary to Theorem 3 it follows that demand for busy leisure and supply of labour are increasing in the change of technology.

Corollary 2 *For an economy $\mathscr{E} = (U, \omega_F, F, W)$ and a technology G suppose for all k, $g(k) - kg'(k) > f(k) - kf'(k)$ and $g'(k)(g(k) - kg'(k)) > f'(k)(f(k) - kf'(k))$. Then busy leisure and labour increase with a change of technology to G:*

$$\begin{cases} \min_{E_F} n(\tilde{w}_F, z_F) < \min_{E_G} n(\tilde{w}_G, z_G) \quad \textit{and} \quad \max_{E_F} n(\tilde{w}_F, z_F) < \max_{E_G} n(\tilde{w}_G, z_G) \\ \min_{E_F} \ell(\tilde{w}_F, z_F) < \min_{E_G} \ell(\tilde{w}_G, z_G) \quad \textit{and} \quad \max_{E_F} \ell(\tilde{w}_F, z_F) < \max_{E_G} \ell(\tilde{w}_G, z_G). \end{cases}$$

Proof: Both busy leisure and labour supply are increasing in rw and z according to Lemma 1. Both $(1+r)w$ and z are increasing in a change of technology according to Theorem 3. □

4 Switching technology

In the present section we highlight the importance of work ethics in the adoption of a new technology. We consider two economies that are identical except for their technologies (ω_F, F) and (ω_G, G). They are such that:

- Before the new technology is introduced, welfare in the F-economy is *higher* than welfare in G-economy.
- The F-economy does not adopt the new technology H.
- The G-economy adopts the new technology.
- After the new technology is introduced, welfare in the F-economy is *lower* than welfare in the H-economy.

Consequently, low work ethics in the F-economy prevents it from benefiting from the new technology even though it would eventually benefit from it.

Theorem 4 *For all economies (U, ω_G, G, W) with $U'_z(o,n,z) > 0$ there are two other production technologies (ω_F, F) and (ω_H, H) such that for $(r_F, w_F, z_F) \in E_F$, $(r_G, w_G, z_G) \in E_G$ and $(r_H, w_H, z_H) \in E_H$:*

$$\begin{cases} (1+r_F)w_F\ell_F + I(\ell_F, z_F) + \omega_F & > & (1+r_G)w_G\ell_G + I(\ell_G, z_G) + \omega_G \\ (1+r_F)w_F\ell_F + I(\ell_F, z_F) + \omega_F & > & \max\limits_{(\ell,L)} H(w_F\ell, L) - w_F L + I(\ell, z_F) + \omega_H \\ (1+r_G)w_G\ell_G + I(\ell_G, z_G) + \omega_G & < & \max\limits_{(\ell,L)} H(w_G\ell, L) - w_G L + I(\ell, z_G) + \omega_H \\ (1+r_F)w_F\ell_F + I(\ell_F, z_F) + \omega_F & < & (1+r_H)w_H\ell_H + I(\ell_H, z_H) + \omega_H, \end{cases}$$

where $\ell_F = \ell((1+r_F)w_F, z_F)$, $\ell_G = \ell((1+r_G)w_G, z_G)$ and $\ell_H = \ell((1+r_H)w_H, z_H)$.

Proof: All (U, ω_G, G, W) can be used to construct the three production functions. Suppose $\omega_G = 0$. Let F be an affine transformation of G so $F_a(K,L) = \alpha_G F(K,L) + \omega_F$ with $\alpha_F > 0$ and $\omega_F \geq 0$. It follows from Theorem 3 that there is $\alpha_F \in]0,1[$ such that $(r_F, w_F, z_F) \in E_F$ implies $w_F < w_G$, $r_F w_F < r_G w_G$ and $z_F < z_G$.

Let $U_a \in \mathbb{R}$ for $a \in \{F, G\}$ be defined by $U_a = (1+r_a)w_a\ell_a + I(\ell_a, z_a)$. Then the first inequality is satisfied for $\omega_F > U_G - U_F$. Let H be defined by $H(K,L) = G(K,L) + U_F - U_H + \varepsilon$ with $\varepsilon \in \mathbb{R}$. Then $E_H = E_G$. The third inequality is satisfied for $\varepsilon > 0$ because

$$\max_{(\ell,L)} G((1+r_G)w_G\ell, L) - w_G L + I(\ell, z_G) + U_F - U_G + \varepsilon \;=\; U_F + \varepsilon.$$

The fourth inequality is satisfied for $\varepsilon < \omega_F$ because $U'_z(\ell,e,z) > 0$ and $z_F < z_H$ so

$$\max_{(\ell,L)} (1+r_H)w_H\ell_H + I(\ell_H,z_H) + U_F - U_H + \varepsilon \;=\; U_F + \varepsilon.$$

The second inequality is satisfied because

$$\max_{(\ell,L)} G((1+r_F)w_F\ell,L) - w_FL + I(\ell,z_F) + U_F - U_H + \varepsilon \;<\; U_F + \varepsilon.$$

Therefore the four inequalities are satisfied for $\omega_F > U_G - U_F$ and $\varepsilon \in]0,\omega_F[$. □

The economies constructed in Theorem 4 highlight how old technologies influence adoption of new technologies indirectly through work ethics. The F-economy has a more productive environment than the G-economy: $\omega_F > \omega_G$, but lower marginal product of labour. Hence work is more costly to supply and less valuable in the F-economy than in the G-economy, leading to lower work ethics in the F-economy.

The new H-technology is more productive than the G-technology. Therefore consumers in the G-economy do want to adopt H. On the contrary, consumers in the F-economy do not want to adopt H because the productivity of its environment is too low compared to that of F: $\omega_H < \omega_F$. This could be overcome by exploiting the higher labor productivity in H, but the low level of work ethics prevents that from happening.

The figures below illustrate our discussion of Theorem 4. Consumers in the F-economy do not adopt H because at L_F it would reduce output: $\Delta Y_{F\to H} < 0$; whereas consumers in the G-economy adopt H because at L_G it increases output: $\Delta Y_{G\to H} > 0$, resulting in a higher output than with technology G *and* F: $Y_H > Y_F, Y, G$.

The argument made by Boserup (2017) in the opening quote of the paper that "people who are accustomed to hard work [...] are more able to adapt themselves to other types of work than are people accustomed to the more leisurely rhythm of work [...]" could be translated in our setup as follows: a higher work ethics entails a higher *ability to adapt* to new technologies. Such an argument could only reinforce the mechanism at work in the above illustration.

Suppose to the contrary that the new technology is adopted in both economies. Assume there is a unique globally stable steady state with the new technology. Then both economies will converge to the steady state and consequently behave identically in the long run. However, the two economies will behave differently in the short run because they have different work ethics when they adopt the new technology. Naturally the difference between short and long run depends on how fast work ethics evolve.

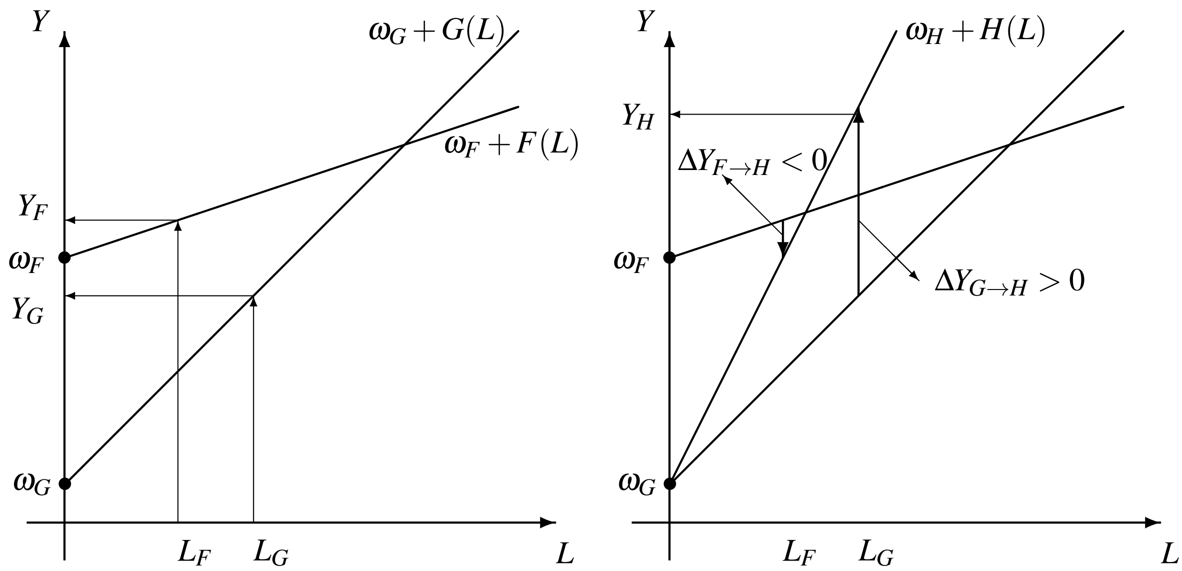

Figure 1: *Illustration of Theorem 4.*

5 Final Remarks

In the present paper we have developed a theory of how work ethics in society is formed. Our focus has been on the influences of technologies on work ethics and work ethics on technology adoption. The primary driver in formation of work ethics is the productivity of labour. Naturally technology ultimately determines the productivity of labour, but institutions are important too in that they can influence productivity directly as inputs and indirectly in being part of the economic environment.

Work ethics provides a new account for differences in technology adoption and therefore global inequalities. The phenomena described are similar to those obtained with models with, e.g., human capital, but the mechanisms at work differ greatly.

Physical capital, knowledge and work ethics differ in at least two respects. First, physical capital and knowledge are inputs whereas work ethics is a social norm that shapes preferences. Second, physical capital is a private good, whereas knowledge and work ethics are public goods. Perhaps variations across economies in each of the three variables could help explain differences in adoption patterns. Policies directed at changing them should be expected to be different.

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