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## From the Inner Citadel to the Outside World: Tilgher's Hypothesis and the Emergence of Modern Man

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# From the Inner Citadel to the Outside World: Tilgher's Hypothesis and the Emergence of Modern Man<sup>\*†</sup>

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## Abstract

According to the Italian philosopher Tilgher (1922), the birth of the bourgeois society during the Pre-Industrial era involved the replacement of the Ancient Man by the Modern Man, and consisted of a reorientation of efforts from spiritual exercises developing the *inner* self (what Marcus Aurelius called the 'Inner Citadel') to efforts reshaping the *outside* world. However, from a microeconomic perspective, a reallocation of efforts/time does not necessarily reveal a change of preferences. To study the conditions under which the Pre-Industrial rise in working time reveals a shift in life-goals (the emergence of Modern Man), this paper develops a unified growth model with endogenous preferences and time allocation choices, where individuals first choose whether they pursue extra-world self-realization (Ancient Man) or intra-world self-realization (Modern Man), and, then, based on their preferences, allocate their time between spiritual labor and material labor. It is shown that, contrary to Tilgher's hypothesis, a rise in working time does not necessarily reveal a shift from extra-world to intra-world self-realization, but can occur while keeping life-goals unchanged. Our model contributes also to inform debates about the decline of religious holidays in France (1640-1780).

*Keywords:* unified growth theory, endogenous preferences, time allocation, Industrious Revolution, secularization.

*JEL classification codes:* E24, N33, Z12, Z13.

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# 1 Introduction

The emergence of Modern Man is one of the most challenging puzzles in economic history. The problem consists of explaining how human-beings, who had been living in (quasi) static societies for millennia, could enter an era of massive and rapid economic and social transformations. As stated by Clark (2007): ‘How did stasis before 1800 transform itself into dynamism thereafter?’

In order to explain that puzzle, economic historians identified long-run trends at work during the Pre-Industrial era, and which transformed human-beings into a ‘New Man’ more adapted to the quest for prosperity: the rise of literacy and numeracy (Schofield 1973), the decline of impatience (Hudson 2000) and the fall of violence (Cockburn 1991). Economic historians identified also Pre-Industrial trends that created conditions favorable to the transition from subsistence economies trapped in a Malthusian regime towards modern economies with rising standards of living: institutional changes (North 1981, Acemoglu et al 2005); early stages of the demographic transition (Galor 2011, 2022); the urbanization (de Vries 1984); the rise in work hours (de Vries 1994, 2008); the creation of a market for ideas (Mokyr 2002, 2005, 2016, de la Croix et al 2018).

These findings qualify the extent to which the Pre-Industrial Man was living in a timeless world and provide a general explanation of what Rostow (1960) called the ‘pre-conditions for the economic take-off’. Nonetheless, they cast only partial light on the emergence of Modern Man, because they do not necessarily involve the production of a new Man with new life-goals or new preferences. However, if Pre-Industrial patterns did not affect preferences, they could hardly have implied any change in humans’ incentives or in humans’ will to response to technological or institutional changes associated with the Industrial Revolution.

A missing piece of the puzzle can be found in the works of historians of mentalities. Studying the emergence of Modern Man, the Italian philosopher Adriano Tilgher (1887-1941) formulated, in his essay *La visione greca della vita* (1922), the hypothesis of a change, across history, in the attitude of human-beings towards the outside world. Tilgher’s hypothesis goes as follows:<sup>1</sup>

Classical Antiquity seeks sovereign virtue and happiness in absolute detachment from the world. Bourgeois civilization seeks happiness and virtue in the gradual subjugation of the world to the will of man.

Tilgher regards the birth of the bourgeois civilization during the Pre-Industrial era as the replacement of the Ancient Man by the Modern Man. These two historical ideal-types differ in their attitudes towards the outside world: detachment *versus* control.<sup>2</sup> *Whereas the Ancient Man oriented his efforts towards a detachment from the outside world, so as to better master himself, the Modern Man reorients his efforts towards the control of the outside world.* History

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<sup>1</sup>See Tilgher (1920), p. 68 (translation by the author).

<sup>2</sup>The term ‘ideal-type’, which was introduced by Weber (1920), refers to a product of scientific abstraction that incorporates, within an abstract object, the pure form of some traits, which exist only in imperfect forms in the world.

does not involve a Man with time-invariant life-goals and time-invariant incentives: History consists of the replacement of the Ancient Man (oriented towards what Marcus Aurelius called his ‘Inner Citadel’) by the Modern Man (aimed at controlling the external world).

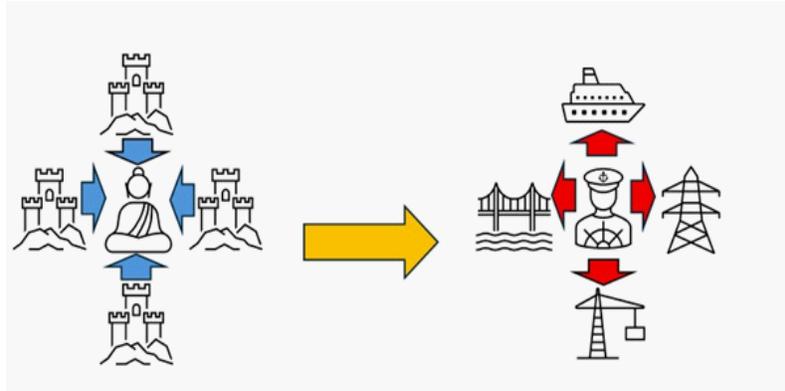


Figure 1. Tilgher’s hypothesis about the emergence of Modern Man.

According to Tilgher, the change in life-goals from the flourishing of the inner self to the control of the outside world implied a reallocation of time/efforts from spiritual labor to material labor (Figure 1). Spiritual exercises (*askesis*) are defined by Hadot (1995) as ‘voluntary and personal practices aimed at operating a change of oneself’.<sup>3</sup> They correspond to Kolm’s (1986) ‘self-formation’, which includes - but is not restricted to - meditations and can be done outside or within a religion.<sup>4</sup> Since Ancient times, spiritual exercises have been a key occupation in societies.<sup>5</sup> However, according to Tilgher, when the bourgeois society is born, a change of attitude towards the outside world led to a decline of spiritual labor, which was replaced by material labor. As such, Tilgher’s hypothesis provides a possible causal mechanism for the rise in work hours over 1600-1800 known as the Industrious Revolution (de Vries 1994, 2008).<sup>6</sup>

Tilgher’s hypothesis is not reducible to the secularization thesis, which involves a decline of religions (Bruce 2011, Strulik 2016a, Becker et al 2024, Becker

<sup>3</sup>Hadot (1995, p. 276) (translation by the author).

<sup>4</sup>According to Hadot (2002, p. 26), spiritual exercises include also: remembering the happy past (Epicurean meditations), imagination exercises and dialogues with oneself.

<sup>5</sup>Hadot (2002, p. 370-372) argued that, during the Antiquity, philosophy was a mode of living that committed the entire human existence, and, as such, was a spiritual exercise. This explains that, when the Christian doctrine developed, it had, to be recognized as a philosophy, to include the practice of spiritual exercises. It is only in the Middle Ages that there has been a progressive separation between philosophy and spiritual exercises. This evolution is linked to the development of universities, whose main goal was to educate future professors and teachers, instead of guiding students towards the ‘good life’ (Hadot, 2002, p. 297-298).

<sup>6</sup>On the Industrious Revolution - its existence, scope and measurement -, see also Clark and van der Werf (1998), Allen and Weisdorf (2011).

et al 2025). Tilgher points to a general conversion process - a change of attitude towards the outside world - at work both within and outside religions. As shown by Weber (1920), the quest for Salvation involved a balance between ‘otherworldly asceticism’ (i.e., extra-world self-realization, that is, looking for Salvation by fleeing the world) and ‘worldly asceticism’ (i.e., intra-world self-realization, that is, looking for Salvation by acting in the world). However, with urbanization, the quest for Salvation led to a shift from otherworldly to worldly asceticism, in line with Tilgher’s general conversion process.<sup>7</sup>

Under Tilgher’s hypothesis, the reorientation of efforts towards the outside world is linked to the emergence of the Modern Man, whose life-goals differ from the ones pursued by the Ancient Man. However, from a microeconomic perspective, a reallocation of time/effort does not necessarily reveal the existence of a change of preferences. A change in how time/effort is allocated can occur while preferences remain unchanged.<sup>8</sup> In the light of this, the relationship between Tilgher’s hypothesis, the emergence of Modern Man and the Industrious Revolution is in need of clarification. Does the Industrious Revolution reveal the existence of a transition from the Ancient Man (looking for extra-world self-realization) to the Modern Man (looking for intra-world self-realization)? Or could the Industrious Revolution occur *without* the emergence of a New Man?

Preferences being unobservable, it is hard to know, from time allocation choices, whether these choices reveal a change of pursued life-goals. The usual way by which economists examine the existence of stable preferences - the revealed preferences method - consists of studying changes in the budget set (Samuelson 1948, Varian 1982).<sup>9</sup> However, in the context of Tilgher’s hypothesis, an additional difficulty lies in the fact that, although the production of material goods was quantified by economic historians, spiritual development is intangible and, hence, less documented. The examination of Tilgher’s hypothesis requires to build a model of endogenous preferences and time allocation that incorporates hypotheses about the spiritual production process, and to study, on its basis, whether changes in time allocation reveal changes in life-goals.

The goal of this paper is to examine, from a microeconomic perspective, the relationship between Tilgher’s hypothesis, the emergence of Modern Man and the Industrious Revolution. For that purpose, we develop a unified growth model with endogenous preferences and time allocation choices.<sup>10</sup> To study the conditions under which changes in time allocation reveal a shift of preferences, we rely on a two-stage choice model: in the first stage, individuals choose whether they pursue extra-world self-realization (that is, only spiritual development is valued) or intra-world self-realization (that is, only material output is valued), which are modelled by means of quasi-linear preferences, and,

<sup>7</sup>The cause was that production in towns was less subject to random events (Weber 1920).

<sup>8</sup>The two characters on Figure 1 may be either pursuing the *same* life-goal (intra-world or extra-world self-realization), or, alternatively, they may be pursuing *different* life-goals.

<sup>9</sup>See Chambers and Echenique (2016) for a synthesis.

<sup>10</sup>Given that Tilgher’s hypothesis is about a global change in life-goals, our model does not assume heterogeneous preferences but, instead, common metapreferences used by all individuals to choose between extra-world and intra-world self-realizations. This approach is complementary to models with heterogeneous preferences (Bisin and Verdier 2001, 2011, 2025).

then, in the second stage, individuals choose - under their selected preferences - how to allocate time between spiritual labor (aimed at promoting spiritual development) and material labor (aimed at producing material goods).

This paper first examines the conditions under which the model can explain that the society has, after a long period of stable working time, shifted to a regime characterized by a rise in working time (the Industrious Revolution). Then, we try to disentangle, at the microeconomic level, between cases where the rise in working time has been associated with a shift, in stage 1, from the goal of extra-world self-realization to the goal of intra-world self-realization, or, alternatively, cases where the rise in working time occurred without any change of preferences. Finally, we use data on the decline of the number of religious holidays (*fêtes chômées*) in France (1640-1780) to compare the plausibility of various microeconomic explanations of the French Industrious Revolution.

Anticipating our results, we show that, within our framework, the Industrious Revolution can be explained or rationalized in various ways. *The Industrious Revolution does not necessarily involve a transition from the Ancient Man (extra-world self-realization) to the Modern Man (intra-world self-realization). It cannot be excluded that the Industrious Revolution took place either as a consequence of the quest for extra-world self-realization, or as a consequence of the quest for intra-world self-realization.* Contrary to Tilgher's hypothesis, the re-orientation of efforts towards reshaping the outside world does not necessarily reveal the emergence of Modern Man.

Our numerical application to old-regime France reveals that, out of all rationalizations of the French Industrious Revolution based on our model, the most accurate explanation - from a quantitative perspective - consists of a quest, by the Modern Man, for intra-world self-realization, without any change of life-goals. *This numerical result does not corroborate Tilgher's hypothesis: from a quantitative perspective, the best explanation of the French Industrious Revolution does not involve a transition from the Ancient Man to the Modern Man.* Our numerical application casts also original light on debates among historians about the cause of the French Industrious Revolution. Given that the best quantitative 'match' is achieved by the explanation consisting of a quest for intra-world self-realization, our results do not support explanations of the Industrious Revolution based on an increased desire for material goods, such as Voth (2000). Moreover, since our results assign a major role to productivity gains in material goods' production - and a minor role to the patterns internal to spirituality - , our findings do not corroborate explanations of the decline of religious holidays as a purely religious phenomenon (Grenier 2012).

By studying the conditions under which the Industrious Revolution reveals a change of life-goals, the present paper is related to the literature about the pre-conditions for the economic take-off (Rostow 1960) and to the literature about the emergence of Modern Man (Mokyr 2002, 2016, Clark 2007). In particular, this paper is linked to the literature studying the Industrious Revolution (Hayami 1986, 2015, de Vries 1994, 2008, Clark and van der Werf 1998, Voth 1998, 2000, Allen and Weisdorf 2011, Grenier 2012). Our contribution consists in developing a theoretical framework that allows us to distinguish, from

a microeconomic perspective, between the cases where the rise in working time reveals the existence of a change in life-goals, and the cases where the rise in working time does not reveal the existence of a change of preferences.

This paper is also related to Unified Growth Theory (Galor 2005, 2010, 2011, 2022), and, in particular, to unified growth models studying the secularization process and its interactions with long-run dynamics, such as Strulik (2016a, 2016b), Prettnner and Strulik (2017) and de la Croix et al (2023). While Prettnner and Strulik (2017) study contraception and de la Croix et al (2023) focus on marriage, this paper is closer to Strulik (2016a, 2016b), which study time allocation choices between religious activities and other activities. Whereas Strulik (2016b) considers interactions of choices with cognitive styles, our model is closer to Strulik (2016a), which is based on endogenous preferences through a choice of identity, in line with the economics of identity (Akerlof and Kranton 2000, 2010). The present paper differs from Strulik (2016a) on two grounds: first, Strulik (2016a) focuses on the secularization process, whereas our paper considers the reorientation of efforts towards the outside world (independently from religious beliefs); second, Strulik (2016a) models the choice of identity while focusing on the marginal utility of the consumption of material goods under log-linear preferences, whereas we consider, under quasi-linear preferences, a shift from the valuation of spiritual output to the valuation of material output.

Finally, although Tilgher’s hypothesis is not limited to religious activities, this paper is also related to the literature studying interactions of religions with capitalism (Weber 1904-05, 1920, Iannaccone 1998, Becker et al 2024, Becker et al 2025). Capitalist development was shown to cause the decline of religions (Wilson 1982, Inglehart 2000, Bruce 2011). The contribution of this paper is to examine, from a theoretical viewpoint, the conditions under which the Pre-Industrial decline of spiritual activities is due to a change of life-goals, or follows from a change of social circumstances for a given life-goal.

The paper is organized as follows. Tilgher’s hypothesis is presented in Section 2. Section 3 presents the model. The time allocation problem is studied in Section 4. The long-run dynamics of the economy is examined in Section 5, where different rationalizations of the Industrious Revolution are proposed, with or without a change of preferences. Then, Section 6 uses data on religious holidays in old-regime France (1640-1780) to compare these rationalizations of the Industrious Revolution. Section 7 concludes.

## 2 Tilgher’s hypothesis and the rise of Modernity

In *La visione greca della vita* (1922), Adriano Tilgher proposed to draw the contours of the Ancient Greeks’ conception of human existence, by relying on writings from various philosophical traditions such as Platonism and Neoplatonism (Plato, Simplicius and Plotinus), Aristotelianism (Aristotle), Epicureanism (Lucretius) and Stoicism (Seneca, Marcus Aurelius).<sup>11</sup> But *La visione greca*

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<sup>11</sup>The essay *la visione greca della vita* is based on a series of lectures delivered by Tilgher in Rome, Bologna and Napoli in 1921.

*della vita* cannot be reduced to a portrait of Ancient Greek thought: this essay is an attempt to compare the Greeks' view of life with the one prevailing under Modernity. As such, Tilgher's essay aims at providing nothing less than an outline of a history of Western mentality over the very long run.

From the perspective of Ancient Greeks, history is an eternal repetition of the same things.<sup>12</sup> There exists only a finite number of possible events, whereas time is infinite. Hence, if there is a causal chain that goes from one event to another, it must be the case that, at one point in time, the succession of events reproduces a chain that took place earlier. Anything that happened in the past can be expected to happen again in the future.

The theory of the eternal return is orthogonal to Modern thought. The Greeks myth of the eternal return excludes any form of progress, whereas Modernity relies on the myth of endless progress. Under the theory of the eternal return, there is nothing new to be discovered, so that perfection - exemplified by divinities - requires immobility, passivity and contemplation. However, for those who believe in progress, the unexplored, the unattainable and the undiscovered generate fascination. Perfection will here require activity and movement. This leads to a major divide between Ancient and Modern ways of looking at life:<sup>13</sup>

This is the reason why the Greek soul lacked those feelings in which the thirst for the infinite, the nostalgia for the unlimited [...], the ardent desire for the new and the unknown are expressed. Those feelings are, on the other hand, so characteristic of the modern soul, and have led them to the immense realms of the air, to the inaccessible summits of the mountains, to the boundless expanse of the oceans, to the discovery of new territories and new peoples, to the conquest of an ever greater power in all areas of human activity. The Greek athlete performs his games in the confined palestra, and nothing is more opposed to him than the characteristic figures which manifest the modern thirst for the unknown and the unattainable: the mountaineer, the aviator, the explorer, the navigator. The figures of a Magellan or a Nansen, fascinated by the vertigo of the unexplored, are perfectly inconceivable in Greek Antiquity, where Ulysses travels against his will and yearns only to return home.

Once history is regarded as an endless repetition of wars, epidemics and famines, there is nothing like a 'good news' to be expected. Humans are then regarded as subject to 'the rule of chance and destiny'.<sup>14</sup> Greek tragedies exemplify this view of a life as something that can suddenly be destroyed. But this dark description of life does not imply the absence of perspectives. As Tilgher underlines, Ancient Greeks - although they believe in the eternal return - cannot be regarded as 'pessimistic'.<sup>15</sup> The remedy consists of *ascetism*, that

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<sup>12</sup>This view of history as an eternal return has traces that go back to Presocratic thinkers such as Anaximander, Pythagoras and Heraclitus. See Barnes (2022).

<sup>13</sup>Tilgher (1922), p. 25 (translation by the author).

<sup>14</sup>Tilgher (1922), p. 33.

<sup>15</sup>Tilgher (1922), p. 41.

is, self-formation: this is about trying to reconquer oneself. As Tilgher argues, humans are, from the Ancient Greeks' perspective, nothing else than 'fallen gods'.<sup>16</sup> Therefore, one must find ways to 're-access' the god within oneself.<sup>17</sup> This reconquest of oneself takes the form of ascetism: it is about sacrificing external things for the sake of developing inside forces.<sup>18</sup> Such a sacrifice of external goods (wealth, health, honours, etc.) is grounded on the intuition that God is eternal, autonomous, and free. As a consequence, if humans want to reconquer the divine part in themselves, they have to focus on their own selves and leave side external things, which are too contingent. According to Tilgher, the Greeks conception of the 'good life' - whether one adopts an Epicurean, a Stoic or a Neoplatonic perspective - will consist in adopting two moral precepts: *sustine* (that is, support things that you cannot change) and *abstine* (that is, do not desire).<sup>19</sup> Here is Tilgher's description of these two moral precepts:<sup>20</sup>

*Endure*, in other words, renounce wanting to change what you cannot change, namely the course of external events which do not depend on you, and seek happiness not in resisting destiny, but in understanding and free and voluntary adherence to what destiny wants. [...] *Abstain*, in other words, do not place happiness in the conquest and possession of what is outside you and which, consequently, does not depend on you. Wealth, freedom, health, life itself, do not depend on us, are therefore not true goods, and possessing them or not essentially adds or takes away nothing from happiness.

From the Ancient Greeks's perspective, freedom is achieved by breaking all chains that attach men to things that are outside men's control. The quest towards the good life requires the person to re-center herself on what Marcus Aurelius called her 'Inner Citadel'. This re-centering of the person towards her inner self requires some detachment from the outside world.<sup>21</sup>

By freedom, the Greeks did not mean the freedom of will, as we modern do, but the state of mind of one who has detached himself from the outside world and, therefore, has achieved within himself the calm, the perfect quietude, in other words the immobility and permanence which characterize divine life for the Greek soul. For all Greek schools, the moral ideal resides unanimously in calm, serenity, which the storms of the outside world cannot disturb. The man who has achieved in himself this absolute detachment from the world of difference and becoming, who, in a word, has separated the divine

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<sup>16</sup>Tilgher (1922), p. 41.

<sup>17</sup>Tilgher (1922), p. 42.

<sup>18</sup>Tilgher (1922), p. 45.

<sup>19</sup>Tilgher (1922), p. 45. The precise form of these two moral precepts varies across philosophical doctrines. For instance, the *abstine* precept has taken different forms: the Stoic discipline of desires (that is, do not wish for anything that is outside control) differs from the Epicurean discipline of desires (that is, only pursue pleasures that are natural and necessary).

<sup>20</sup>Tilgher (1922), p. 45-46 (translation by the author).

<sup>21</sup>Tilgher (1922), p. 46 (translation by the author).

within him from the element of darkness and matter outside him, floats freely like an atom in the void and escapes the blows of Destiny like an athlete who, coated in oil, escapes the grip of the adversary.

The detachment from external things has key implications for *the value of work*. Whereas the Modern Man values work a lot - since work is seen as a necessary instrument for the control of the outside world and, *in fine*, for progress -, the Ancient Man, who does not want to control the outside world, wants to reduce work as much as possible:<sup>22</sup>

For Modern Man, the imperative is one. Create, act, work, *infuturati*, overcome death by immortalizing yourself in the results of your work. For the Ancient Greeks, for whom the future is predetermined, work has no more meaning than value: it is a burden that should be reduced as much as possible.

The attitude of the Ancient Greeks towards work can only be understood provided we formulate it in relationship with the ancient definition of the ‘good life’. From the Ancient Greeks perspective, the ‘good life’ consists of imitating God, or turning back to the divine part of humans. Given that God is autonomous, free and independent from external forces, the ideal of the ‘good life’ must exhibit such an autonomy or independence from the outside world.<sup>23</sup>

The emergence of Modern Man consists of a change of the attitude towards the outside world: it is a transition from ascetism and inner freedom towards action and control over the outside world. This change is described as follows:<sup>24</sup>

Classical Antiquity carried the pride of ascetic renunciation and inner freedom to excess. Bourgeois civilization has carried an opposite pride to frenzy: the pride of active will and power. Classical Antiquity seeks sovereign virtue and happiness in absolute detachment from the world. Bourgeois civilization seeks happiness and virtue in the gradual subjugation of the world to the will of man.

Tilgher regards the birth of the bourgeois society as the replacement of the Ancient Man (looking for the absolute domination of himself) by the Modern Man (looking for the absolute domination of the outside world).

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<sup>22</sup>Tilgher (1922), p. 52 (translation by the author).

<sup>23</sup>This key point is underlined by Tilgher in his article *Civilization of wisdom and civilization of power* (Tilgher 1920), p. 65 (translation by the author):

And since for the Ancients, the essential character of divinity, that in which its absolute perfection consists, is to have no need of anything outside of itself, it is to possess in itself and exclusively the reason for its being, it is the same for man also and Antiquity places the highest virtue and happiness in its independence with regard to all that is external to its will.

<sup>24</sup>Tilgher (1920), p. 68 (translation by the author).

**Claim 1 (Tilgher’s hypothesis)** *The birth of the bourgeois society in the Pre-Industrial era involved the replacement of the Ancient Man by the Modern Man, and consisted of a reorientation of efforts, from spiritual exercises developing the inner self towards efforts aimed at reshaping the outside world.*

According to Tilgher’s hypothesis, the reorientation of efforts towards the control of the outside world is associated to a change of life-goals: the replacement of the Ancient Man (looking for extra-world self-realization) by the Modern Man (looking for intra-world self-realization). *This fundamental conversion consists of a change of preferences, and, hence, of responsiveness to incentives.*

Tilgher’s hypothesis involves two distinct historical ideal-types, i.e., abstract objects of scientific inquiry, which do not exist in the real world in such pure forms (Weber 1920). The Ancient Man and the Modern Man are ‘pure’ forms of human-beings fully oriented towards a distinct life-goal, but who differ from humans existing in the world (who have more ‘mixed’ life-goals). These pure forms are used for historical explanation, in the present case, to explain the birth of the bourgeois society. Our examination of Tilgher’s hypothesis will thus involve these two historical ideal-types, and study the extent to which time allocation choices reveal a transition from one ideal-type to another.

It should be stressed here that the conversion or change of human nature that Tilgher highlights cannot be reduced to subjective and/or objective secularization. Spiritual exercises do not require the existence of God.<sup>25</sup> Hence, the rise of the bourgeois society does not collapse to the ‘death of God’ in Nietzsche’s terms. As underlined by Weber (1920), all religions have exhibited, across centuries, a tendency towards rationalization, that is, a decline of magical elements (e.g. offerings). This rationalization implied a reorientation of efforts towards the outside world, what Weber called a shift from extra-world asceticism to intra-world asceticism. This shift coincides, within religions, to the general conversion process described by Tilgher (1922).<sup>26</sup>

From the perspective of economic history, a merit of Tilgher’s hypothesis consists of providing one possible causal mechanism explaining the rise in working time during the Pre-Industrial era (1600-1800), an episode known as the Industrious Revolution (de Vries, 1994, 2008). Tilgher’s hypothesis regards the Industrious Revolution as caused by a change of preferences (from the will to detach oneself from the world to the will of controlling the world). The remainder of this paper will develop a theoretical model that will allow us to reexamine that hypothesis, by studying whether a reallocation of time from spiritual labor towards material labor reveals - or not - a change in the underlying preferences.

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<sup>25</sup>To illustrate this, let us consider Stoicism. Stoicism recommends a detachment from things outside control. But as it is stressed by Hadot (2001), this detachment is not conditional on God’s existence. Whether God exists or not, it is in the interests of humans to be detached from things that are not under their control. Indeed, if the world is a set of chaotic forces, humans should not let their happiness depend on these forces. Note also that the Stoic detachment from things not under control can take various forms. Microeconomic accounts of Stoic detachment are studied by Ponthiere (2024), on the basis of Epictetus’s *Manual*.

<sup>26</sup>For instance, the dynamics of Christianity exemplifies the shift described in Tilgher’s hypothesis. See Tilgher (1922), p. 48.

### 3 The model

In order to formalize Tilgher’s hypothesis about the emergence of Modern Man, this section develops a unified growth model with time allocation decisions. The time allocation decision is modeled as a two-stage process. In a first stage, individuals choose their preferences or life-goals: they can choose either to pursue extra-world self-realization (that is, realizing oneself by detaching oneself from the world) or intra-world self-realization (that is, realizing oneself by reshaping the world). Then, in a second stage, individuals choose, based on these preferences, how to allocate time between spiritual exercises developing the inner self and standard labor aimed at producing material goods.

**Generalities** Let us consider a two-period overlapping generations economy where time is discrete and goes from 0 to  $+\infty$ . Period 1 of life is childhood: children are born without preferences, and make no choice. Only a fraction  $\pi$  of them survives to adulthood. Period 2 of life is adulthood: individuals choose first their life-goals (either extra-world self-realization or intra-world self-realization), and, then, choose how to allocate time accordingly.

At the microeconomic level, that model is inspired by Kolm (1986), who first used rational choice theory to model the choice between material labor and spiritual labor. At the macroeconomic level, this model is close to Strulik (2016a), who constructed a unified growth model where individuals decide how to allocate their time while assigning positive value to religious activities.

**Demography** Each adult gives birth to  $n > 0$  children. But only a fraction  $\pi \in ]0, 1[$  of those children reaches adulthood. Hence the size of cohorts follows:

$$N_{t+1} = \pi n N_t \tag{1}$$

where  $N_t$  is the number of adults at  $t$ . Each child is raised at no cost. Without loss of generality, we assume a strictly positive initial population size:  $N_0 > 0$ .

**Time constraint** Each period has a length normalized to unity. During adulthood, time can be used for two activities: either for the production of material goods or for spiritual development. The time constraint is:

$$\bar{\ell} + \ell_t + \bar{m} + m_t = 1 \tag{2}$$

where  $\bar{\ell} + \ell_t$  is the total labor time, which is divided into a fixed component  $\bar{\ell}$  and a variable component  $\ell_t$  (chosen at each period), while  $\bar{m} + m_t$  is the total time dedicated to spiritual exercises, which is divided into a fixed component  $\bar{m}$  and a variable component  $m_t$  (also chosen at each period).

**Land use** Like time, land can be used for two activities: either for the production of material goods or for spiritual development:

$$X_t^\ell + X_t^m = X \tag{3}$$

where  $X_t^\ell$  is the surface of land used for material production at time  $t$ , while  $X_t^m$  is the surface of land used for spiritual development at time  $t$ , whereas  $X$  is the total surface of land.

For the sake of simplicity, we assume that the surface of land dedicated to each activity is proportional to the part of time dedicated to that activity:

$$\frac{X_t^\ell}{X} = \frac{\bar{\ell} + \ell_t}{1} \text{ and } \frac{X_t^m}{X} = \frac{\bar{m} + m_t}{1} \quad (4)$$

**Material production** The production of material goods involves land, labor and productive knowledge. Total material output at time  $t$ ,  $Y_t$ , is obtained through the production process:

$$Y_t = A_t (X_t^\ell)^{1-\alpha} [(\bar{\ell} + \ell_t) L_t]^\alpha \quad (5)$$

where  $A_t$  is the stock of productive knowledge at  $t$ ,  $L_t$  is the number of workers at  $t$  ( $L_t = N_t$ ), while  $\alpha$  is a technical parameter.

Productive knowledge  $A_t$  includes all pieces of knowledge relevant for the production of material goods, and which increase the productivity of labor.<sup>27</sup> It is assumed to be proportional to the number of workers, so that:

$$A_t = AL_t \quad (6)$$

where  $A > 0$  is a technical parameter.

Given that  $X_t^\ell = (\bar{\ell} + \ell_t) X$ , material output per worker can be written as:

$$y_t \equiv \frac{Y_t}{L_t} = A (\bar{\ell} + \ell_t) X^{1-\alpha} L_t^\alpha \quad (7)$$

**Spiritual production** The economy produces not only material goods, but, also, spiritual development of its members. The state of spiritual development is produced by means of land, spiritual labor and spiritual knowledge. Total spiritual output at time  $t$ ,  $S_t$ , is obtained through the production process:

$$S_t = Z_t (X_t^m)^{1-\beta} [(\bar{m} + m_t) N_t]^\beta \quad (8)$$

where  $Z_t$  is the stock of spiritual knowledge at  $t$ , while  $\beta$  is the elasticity of spiritual output to total spiritual labor.

Spiritual knowledge  $Z_t$  is knowledge about the meaning and purpose of life. This kind of knowledge includes religious knowledge, but is not restricted to it. It can also rely on Ancient philosophical doctrines such as Epicureanism or Stoicism. These doctrines relied on a particular conception of the ‘good life’, defined as a life in accordance with one’s position in the Universe. Spiritual knowledge is, like productive knowledge, proportional to the number of adults:

$$Z_t = ZN_t \quad (9)$$

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<sup>27</sup>As such, productive knowledge includes what Mokyr called ‘useful knowledge’, that is, knowledge about the physical environment, but is not reduced to it (Mokyr 2002, 2005).

where  $Z$  is a technical parameter.

Since  $X_t^m = (\bar{m} + m_t) X$ , spiritual output per adult can be rewritten as:

$$s_t \equiv \frac{S_t}{N_t} = Z (\bar{m} + m_t) X^{1-\beta} N_t^\beta \quad (10)$$

**Preferences** Individuals allocate their time between productive work  $\ell_t$  and meditation time  $m_t$ , in such a way as to maximize their utility, subject to their time budget constraint. Their utility can take two distinct forms, depending on whether they pursue *extra-world self-realization* (what Weber called ‘otherworldly asceticism’) or *intra-world self-realization* (‘worldly asceticism’). Extra-world self-realization consists of the flourishing of the inner self, whereas intra-world self-realization consists of developing the outside world.<sup>28</sup>

The selection of the goal preceding naturally the selection of the means to achieve that goal, this paper supposes that individuals choose their utility function *prior* to choosing how to allocate their time.<sup>29</sup>

The time allocation choice is modelled as a two-stage process:

**Stage 1** Individuals choose whether they want to pursue extra-world self-realization or intra-world self-realization.

**Stage 2** Conditionally on the life-goal chosen in stage 1, individuals choose how to allocate their time between material labor and spiritual labor.

As usual in economics, this problem is solved by backward induction: each individual selects the optimal allocation of time conditional on a particular life-goal (either extra-world self-realization or intra-world self-realization), and, then, selects the life-goal that leads to the largest utility.

Denoting the utility from extra-world self-realization by  $U^S(s_t, \ell_t, m_t)$  and the utility from intra-world self-realization by  $U^Y(y_t, \ell_t, m_t)$ , the problem of time allocation can be written as:<sup>30</sup>

$$\begin{aligned} & \max_{\ell_t, m_t} \{ \max \{ U^S(s_t, \ell_t, m_t), U^Y(y_t, \ell_t, m_t) \} \} & (11) \\ & \text{s.t. } \ell_t + \bar{\ell} + m_t + \bar{m} = 1 \\ & \text{s.t. } s_t = Z (\bar{m} + m_t) X^{1-\beta} L_t^\beta \\ & \text{s.t. } y_t = A (\bar{\ell} + \ell_t) X^{1-\alpha} L_t^\alpha \end{aligned}$$

<sup>28</sup>It should be stressed here that the choice between these two life-goals - extra-world *versus* intra-world self-realization - concerns all individuals, no matter whether or not they believe in God’s existence. If individuals adhere to a religion, this choice between two life-goals can be described as a choice between two ways to search for Salvation: either searching for Salvation by reshaping oneself, in order to look like God; or searching for Salvation by reshaping the outside world. But if individuals do not adhere to a religion, a similar dilemma occurs, between realizing oneself through a work on oneself, or through a work on the outside world.

<sup>29</sup>The model of choice of preferences is a kind of theoretical shortcut allowing to study the endogeneity of preferences in a simple setting. Alternative approaches include models of cultural transmission (Bisin and Verdier 2001, 2011, 2025).

<sup>30</sup>We assume a full intrapersonal comparability of utilities under the different self-realization goals. That assumption is standard in models of preferences choices (Akerlof and Kranton 2000, 2010, Strulik 2016a).

Individuals choose the time allocation  $(\ell_t, m_t)$  that maximizes the maximum utility, either under extra-world self-realization (where spiritual output is valued), or under intra-world self-realization (where material output is valued).

As it is common since Jevons (1871), time allocation choices are made while taking into account the disutility of labor - whether this is material labor or spiritual labor - .  $U^S(s_t, \ell_t, m_t)$  and  $U^Y(y_t, \ell_t, m_t)$  include the disutility of material and spiritual labor, but differ only regarding the product that is valued: either the spiritual output  $s_t$  or the material output  $y_t$ .

For simplicity, utility functions  $U^S(s_t, \ell_t, m_t)$  and  $U^Y(y_t, \ell_t, m_t)$  are supposed to be quasi-linear:

$$U^S(s_t, \ell_t, m_t) \equiv s_t - \delta \frac{(\bar{m} + m_t)^2}{2} - \varepsilon \frac{(\bar{\ell} + \ell_t)^2}{2} \quad (12)$$

$$U^Y(y_t, \ell_t, m_t) \equiv y_t - \delta \frac{(\bar{m} + m_t)^2}{2} - \varepsilon \frac{(\bar{\ell} + \ell_t)^2}{2} \quad (13)$$

where  $\delta > 0$  captures the strength of the disutility of spiritual labor, while  $\varepsilon > 0$  captures the strength of the disutility of material labor.

## 4 The allocation of time

Let us solve the problem of time allocation faced by an adult at period  $t$ , that is, conditionally on stocks of productive knowledge and spiritual knowledge equal to respectively  $A_t$  and  $Z_t$ . As usual, we will proceed by backward induction, and solve first the choice of optimal time allocation conditionally on a particular life-goal (either extra-world self-realization or intra-world self-realization), and, then, use these solutions to select the optimal life-goal.

**Optimal time allocation under extra-world self-realization** The problem of the individual is:

$$\max_{\ell_t} Z(1 - \ell_t - \bar{\ell}) X^{1-\beta} L_t^\beta - \delta \frac{(1 - \ell_t - \bar{\ell})^2}{2} - \varepsilon \frac{(\ell_t + \bar{\ell})^2}{2}$$

The first-order condition (FOC) for an optimal quantity of extra labor  $\ell_t$  is:

$$-ZX^{1-\beta}L_t^\beta + \delta(1 - \ell_t - \bar{\ell}) - \varepsilon(\ell_t + \bar{\ell}) \leq 0 \quad (14)$$

The first term captures the marginal reduction of spiritual output due to a marginal rise in  $\ell_t$ . The second term is the marginal utility gain thanks to reducing slightly the time dedicated to spiritual exercises arising thanks to the rise of  $\ell_t$ . The third term is the marginal utility loss from increasing slightly  $\ell_t$ .

The second-order condition (SOC) for a global maximum is:

$$-\delta - \varepsilon < 0 \quad (15)$$

Isolating  $\ell_t$  from the FOC yields:

$$\ell_t^* = \frac{\delta(1 - \bar{\ell}) - \varepsilon\bar{\ell} - ZX^{1-\beta}L_t^\beta}{\delta + \varepsilon} \quad (16)$$

Let us denote  $\Gamma \equiv \delta(1 - \bar{\ell}) - \varepsilon\bar{\ell}$  and  $\Xi \equiv \delta\bar{m} - \varepsilon(1 - \bar{m})$ . Note also that  $1 - \bar{\ell} = \ell_t + m_t + \bar{m} > \bar{m}$  and  $1 - \bar{m} = \bar{\ell} + \ell_t + m_t > \bar{\ell}$ , so that we have  $1 - \bar{\ell} > \bar{m}$  and  $1 - \bar{m} > \bar{\ell}$ . Hence, given  $1 - \bar{\ell} > \bar{m}$  and  $1 - \bar{m} > \bar{\ell}$ , we have that  $\Gamma > \Xi$ .

Suppose that  $\Gamma > 0$ . Denote  $z_t \equiv ZX^{1-\beta}L_t^\beta$ . Three cases can arise:

- If  $z_t \geq \Gamma$ , we have  $\ell_t^* = 0$ .
- If  $\Xi < z_t < \Gamma$ , we have  $\ell_t^* = \frac{\delta - (\delta + \varepsilon)\bar{\ell} - z_t}{\delta + \varepsilon} < 1 - \bar{m} - \bar{\ell}$ .
- If  $z_t \leq \Xi$ , we have  $\ell_t^* = 1 - \bar{m} - \bar{\ell}$ .<sup>31</sup>

However, if  $\Gamma \leq 0$ , there is only one case:  $\ell_t^* = 0$ .

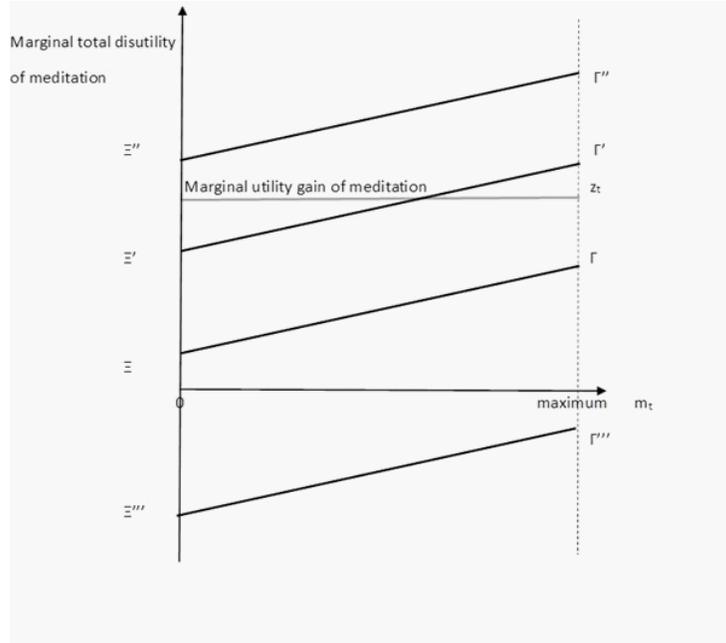


Figure 2. Optimal time allocation under extra-world self-realization.

<sup>31</sup>Indeed, the upper corner is achieved when:

$$\ell_t = \frac{\delta - (\delta + \varepsilon)\bar{\ell} - Z(X)^{1-\beta}L_t^\beta}{\delta + \varepsilon} \geq 1 - \bar{m} - \bar{\ell}$$

This happens when:  $Z(X)^{1-\beta}L_t^\beta \leq \delta - (1 - \bar{m})(\delta + \varepsilon) = \Xi$ .

The four cases are illustrated on Figure 2.  $\Xi$  is the marginal total disutility of spiritual labor when spiritual labor is at its minimum (i.e.,  $m_t = 0$ ), while  $\Gamma$  is the marginal total disutility of spiritual labor when spiritual labor is at its maximum (i.e.,  $m_t = 1 - \bar{\ell} - \bar{m}$ ). We see that, when the marginal productivity of spiritual labor  $z_t$  exceeds  $\Gamma$ , maximal meditation time is optimal. On the contrary, when  $\Xi < z_t < \Gamma$ , it is optimal to have an interior meditation time. Finally, when  $\Xi$  exceeds  $z_t$ , it is optimal to have the minimal meditation time.

The result that, under  $\Gamma > z_t$ , individuals pursuing the goal of extra-world self-realization choose to work more than the minimal working time  $\bar{\ell}$  is somewhat surprising, because individuals who look for extra-world self-realization do not value material output. The intuition is that, when the marginal disutility of meditation at the maximal meditation time is sufficiently high, it is optimal for individuals to spend less than the total available time to spiritual exercises (in order to avoid a too large disutility from meditation), and, hence, to choose  $\ell_t > 0$ , even if they do not value material output *per se*.

Substituting for these solutions in  $U^S(s_t, \ell_t, m_t)$ , we obtain Lemma 1.

**Lemma 1 (Utility levels under extra-world self-realization)** *Denote  $z_t \equiv ZX^{1-\beta}L_t^\beta$ . Denote  $\Gamma \equiv \delta(1 - \bar{\ell}) - \varepsilon\bar{\ell}$  and  $\Xi \equiv \delta\bar{m} - \varepsilon(1 - \bar{m})$ . When individuals choose the time allocation that maximizes  $U^S(s_t, \ell_t, m_t)$ , we have:*

- When  $\Gamma > 0$ :

$$U^S(s_t^*, \ell_t^*, m_t^*) = \begin{cases} z_t(1 - \bar{\ell}) - \delta\frac{(1 - \bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2} & \text{when } z_t \geq \Gamma \\ z_t\left(\frac{\varepsilon + z_t}{\delta + \varepsilon}\right) - \delta\frac{\left(\frac{\varepsilon + z_t}{\delta + \varepsilon}\right)^2}{2} - \varepsilon\frac{\left(\frac{\delta - z_t}{\delta + \varepsilon}\right)^2}{2} & \text{when } \Xi < z_t < \Gamma, \\ z_t\bar{m} - \delta\frac{(\bar{m})^2}{2} - \varepsilon\frac{(1 - \bar{m})^2}{2} & \text{when } z_t \leq \Xi \end{cases}$$

- When  $\Gamma \leq 0$ :

$$U^S(s_t^*, \ell_t^*, m_t^*) = z_t(1 - \bar{\ell}) - \delta\frac{(1 - \bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2}$$

**Proof.** This follows from the study of the FOC. ■

**Optimal time allocation under intra-world self-realization** The problem of the individual is:

$$\max_{\ell_t} A(\ell_t + \bar{\ell})X^{1-\alpha}L_t^\alpha - \delta\frac{(1 - \ell_t - \bar{\ell})^2}{2} - \varepsilon\frac{(\ell_t + \bar{\ell})^2}{2}$$

The FOC is:

$$AX^{1-\alpha}L_t^\alpha + \delta(1 - \bar{\ell} - \ell_t) - \varepsilon(\ell_t + \bar{\ell}) \leq 0 \quad (17)$$

The SOC is:

$$-\delta - \varepsilon < 0 \quad (18)$$

Isolating  $\ell_t$  yields:

$$\ell_t^{**} = \frac{AX^{1-\alpha}L_t^\alpha + \delta(1-\bar{\ell}) - \varepsilon\bar{\ell}}{\delta + \varepsilon} \quad (19)$$

Using the notations  $\Gamma \equiv \delta(1-\bar{\ell}) - \varepsilon\bar{\ell}$ ,  $\Xi \equiv \delta\bar{m} - \varepsilon(1-\bar{m})$  and  $a_t \equiv AX^{1-\alpha}L_t^\alpha$ , we can see that, when  $\Gamma < 0$ , three cases can arise:

- If  $a_t \leq -\Gamma$ , we have  $\ell_t^{**} = 0$ .
- If  $-\Gamma < a_t < -\Xi$ , we have  $\ell_t^{**} = \frac{AX^{1-\alpha}L_t^\alpha + \delta(1-\bar{\ell}) - \varepsilon\bar{\ell}}{\delta + \varepsilon} < 1 - \bar{\ell} - \bar{m}$ .
- If  $-\Xi \leq a_t$ , we have  $\ell_t^{**} = 1 - \bar{\ell} - \bar{m}$ .<sup>32</sup>

Note that, when  $\Gamma \geq 0$ , there is only one solution:  $\ell_t^{**} = 1 - \bar{\ell} - \bar{m}$ .

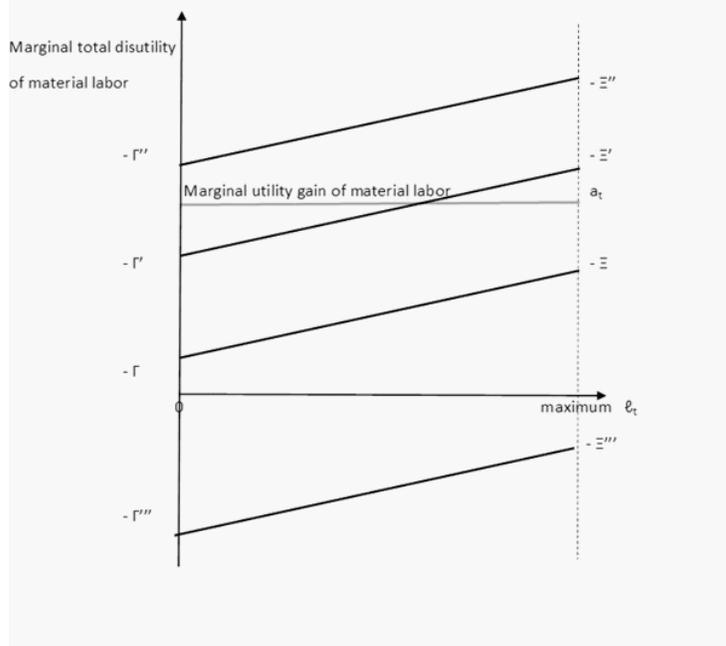


Figure 3. Optimal time allocation under intra-world self-realization.

<sup>32</sup>The upper corner occurs when:

$$\frac{A(X)^{1-\alpha}L_t^\alpha + \delta(1-\bar{\ell}) - \varepsilon\bar{\ell}}{\delta + \varepsilon} \geq 1 - \bar{m} - \bar{\ell}$$

This happens when:  $A(X)^{1-\alpha}L_t^\alpha \geq \varepsilon - \bar{m}(\delta + \varepsilon) = -\Xi$ .

The four cases are illustrated on Figure 3, where  $-\Gamma = \varepsilon\bar{\ell} - \delta(1 - \bar{\ell})$  is the marginal total disutility of material labor at the minimal material labor (i.e.,  $\ell_t = 0$ ), while  $-\Xi = \varepsilon(1 - \bar{m}) - \delta\bar{m}$  is the marginal total disutility of material labor at the maximal material labor (i.e.,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ).

Under  $a_t < -\Xi$ , individuals pursuing intra-world self-realization choose to work less than the maximal working time. The intuition is that, if the marginal disutility of material labor at the maximal working time is sufficiently high, it is optimal for individuals to spend less than the total available time to material labor (in order to avoid a too large disutility of working) and to choose meditations  $m_t > 0$ , even if spiritual development is not valued in itself.

**Lemma 2 (Utility levels under intra-world self-realization)** *Denote  $a_t \equiv AX^{1-\alpha}L_t^\alpha$ . Denote  $\Gamma \equiv \delta(1 - \bar{\ell}) - \varepsilon\bar{\ell}$  and  $\Xi \equiv \delta\bar{m} - \varepsilon(1 - \bar{m})$ . When individuals choose the time allocation that maximizes  $U^Y(y_t, \ell_t, m_t)$ , we have:*

- When  $\Gamma < 0$ :

$$U^Y(y_t^{**}, \ell_t^{**}, m_t^{**}) = \begin{cases} a_t\bar{\ell} - \delta\frac{(1-\bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2} & \text{when } a_t \leq -\Gamma \\ a_t\frac{a_t+\delta}{\delta+\varepsilon} - \delta\frac{(\frac{\varepsilon-a_t}{\delta+\varepsilon})^2}{2} - \varepsilon\frac{(\frac{a_t+\delta}{\delta+\varepsilon})^2}{2} & \text{when } -\Gamma < a_t < -\Xi \\ a_t(1 - \bar{m}) - \delta\frac{(\bar{m})^2}{2} - \varepsilon\frac{(1-\bar{m})^2}{2} & \text{when } -\Xi \leq a_t \end{cases}$$

- When  $\Gamma \geq 0$ :

$$U^Y(y_t^{**}, \ell_t^{**}, m_t^{**}) = a_t(1 - \bar{m}) - \delta\frac{(\bar{m})^2}{2} - \varepsilon\frac{(1 - \bar{m})^2}{2}$$

**Proof.** This follows from the study of the FOC. ■

**The choice of preferences** The choice of life-goals - either extra-world self-realization or intra-world self-realization - is done by individuals through the comparison of utilities  $U_t^S(s_t^*, \ell_t^*, m_t^*)$  and  $U_t^Y(y_t^{**}, \ell_t^{**}, m_t^{**})$ . In the following, we assume, without loss of generality, that in the very special case of strict equality of utilities under extra-world self-realization and intra-world self-realization, individuals choose extra-world self-realization as a life-goal.

Extra-world self-realization (EWSR) is chosen if and only if:

$$U^S(s_t^*, \ell_t^*, m_t^*) \geq U^Y(y_t^{**}, \ell_t^{**}, m_t^{**})$$

whereas intra-world self-realization (IWSR) is chosen if and only if:

$$U^S(s_t^*, \ell_t^*, m_t^*) < U^Y(y_t^{**}, \ell_t^{**}, m_t^{**})$$

Using Lemmas 1 and 2, we can deduce the chosen life-goals and time allocations at the temporary equilibrium at time  $t$ , that is, conditionally on the hourly productivity  $a_t$  for material goods and conditionally on the hourly productivity  $z_t$  for spiritual development. In total, and allowing for various preferences ( $\Gamma \geq 0$ ), the temporary equilibrium takes one of 16 distinct forms (Lemma 3).

**Lemma 3 (Life-goals and time allocations at the temporary equilibrium)**

Denote:  $a_t \equiv AX^{1-\alpha}L_t^\alpha$  and  $z_t \equiv ZX^{1-\beta}L_t^\beta$ . Denote  $\Gamma \equiv \delta(1-\bar{\ell}) - \varepsilon\bar{\ell}$  and  $\Xi \equiv \delta\bar{m} - \varepsilon(1-\bar{m})$ . At the temporary equilibrium, the following cases are possible:

- If  $\Gamma < 0$ :
  - If  $a_t \leq -\Gamma$  and if  $z_t(1-\bar{\ell}) \geq a_t\bar{\ell}$ , EWSR and  $\ell_t = 0$ .
  - If  $a_t \leq -\Gamma$  and if  $z_t(1-\bar{\ell}) < a_t\bar{\ell}$ , IWSR and  $\ell_t = 0$ .
  - If  $-\Gamma < a_t < -\Xi$  and if  $\left[ \begin{array}{l} z_t(1-\bar{\ell}) - \frac{\delta(1-\bar{\ell})^2}{2} - \frac{\varepsilon(\bar{\ell})^2}{2} \\ \geq a_t\left(\frac{a_t+\delta}{\delta+\varepsilon}\right) - \frac{\delta\left(\frac{\varepsilon-a_t}{\delta+\varepsilon}\right)^2}{2} - \frac{\varepsilon\left(\frac{a_t+\delta}{\delta+\varepsilon}\right)^2}{2} \end{array} \right]$ ,  
EWSR and  $\ell_t = 0$ .
  - If  $-\Gamma < a_t < -\Xi$  and if  $\left[ \begin{array}{l} z_t(1-\bar{\ell}) - \frac{\delta(1-\bar{\ell})^2}{2} - \frac{\varepsilon(\bar{\ell})^2}{2} \\ < a_t\left(\frac{a_t+\delta}{\delta+\varepsilon}\right) - \frac{\delta\left(\frac{\varepsilon-a_t}{\delta+\varepsilon}\right)^2}{2} - \frac{\varepsilon\left(\frac{a_t+\delta}{\delta+\varepsilon}\right)^2}{2} \end{array} \right]$ ,  
IWSR and  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ .
  - If  $-\Xi \leq a_t$  and if  $\left[ \begin{array}{l} z_t(1-\bar{\ell}) - \frac{\delta(1-\bar{\ell})^2}{2} - \frac{\varepsilon(\bar{\ell})^2}{2} \\ \geq a_t(1-\bar{m}) - \frac{\delta(\bar{m})^2}{2} - \frac{\varepsilon(1-\bar{m})^2}{2} \end{array} \right]$ , EWSR and  
 $\ell_t = 0$ .
  - If  $-\Xi \leq a_t$  and if  $\left[ \begin{array}{l} z_t(1-\bar{\ell}) - \frac{\delta(1-\bar{\ell})^2}{2} - \frac{\varepsilon(\bar{\ell})^2}{2} \\ < a_t(1-\bar{m}) - \frac{\delta(\bar{m})^2}{2} - \frac{\varepsilon(1-\bar{m})^2}{2} \end{array} \right]$ , IWSR and  
 $\ell_t = 1 - \bar{\ell} - \bar{m}$ .
- If  $\Gamma = 0$ :
  - If  $\left[ \begin{array}{l} z_t(1-\bar{\ell}) - \frac{\delta(1-\bar{\ell})^2}{2} - \frac{\varepsilon(\bar{\ell})^2}{2} \\ \geq a_t(1-\bar{m}) - \frac{\delta(\bar{m})^2}{2} - \frac{\varepsilon(1-\bar{m})^2}{2} \end{array} \right]$ , EWSR and  $\ell_t = 0$ .
  - If  $\left[ \begin{array}{l} z_t(1-\bar{\ell}) - \frac{\delta(1-\bar{\ell})^2}{2} - \frac{\varepsilon(\bar{\ell})^2}{2} \\ < a_t(1-\bar{m}) - \frac{\delta(\bar{m})^2}{2} - \frac{\varepsilon(1-\bar{m})^2}{2} \end{array} \right]$ , IWSR and  $\ell_t = 1 - \bar{\ell} - \bar{m}$ .
- If  $\Gamma > 0$ :
  - If  $z_t \geq \Gamma$  and if  $\left[ \begin{array}{l} z_t(1-\bar{\ell}) - \frac{\delta(1-\bar{\ell})^2}{2} - \frac{\varepsilon(\bar{\ell})^2}{2} \\ \geq a_t(1-\bar{m}) - \frac{\delta(\bar{m})^2}{2} - \frac{\varepsilon(1-\bar{m})^2}{2} \end{array} \right]$ , EWSR and  
 $\ell_t = 0$ .
  - If  $z_t \geq \Gamma$  and if  $\left[ \begin{array}{l} z_t(1-\bar{\ell}) - \frac{\delta(1-\bar{\ell})^2}{2} - \frac{\varepsilon(\bar{\ell})^2}{2} \\ < a_t(1-\bar{m}) - \frac{\delta(\bar{m})^2}{2} - \frac{\varepsilon(1-\bar{m})^2}{2} \end{array} \right]$ , IWSR and  $\ell_t =$   
 $1 - \bar{\ell} - \bar{m}$ .

- If  $\Xi < z_t < \Gamma$  and if  $\left[ \begin{array}{l} z_t \left( \frac{\varepsilon+z_t}{\delta+\varepsilon} \right) - \frac{\delta \left( \frac{\varepsilon+z_t}{\delta+\varepsilon} \right)^2}{2} - \frac{\varepsilon \left( \frac{\delta-z_t}{\delta+\varepsilon} \right)^2}{2} \\ \geq a_t(1-\bar{m}) - \frac{\delta(\bar{m})^2}{2} - \frac{\varepsilon(1-\bar{m})^2}{2} \end{array} \right]$ , *EWSR*  
and  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ .
- If  $\Xi < z_t < \Gamma$  and if  $\left[ \begin{array}{l} z_t \left( \frac{\varepsilon+z_t}{\delta+\varepsilon} \right) - \frac{\delta \left( \frac{\varepsilon+z_t}{\delta+\varepsilon} \right)^2}{2} - \frac{\varepsilon \left( \frac{\delta-z_t}{\delta+\varepsilon} \right)^2}{2} \\ < a_t(1-\bar{m}) - \frac{\delta(\bar{m})^2}{2} - \frac{\varepsilon(1-\bar{m})^2}{2} \end{array} \right]$ , *IWSR*  
and  $\ell_t = 1 - \bar{\ell} - \bar{m}$ .
- If  $z_t \leq \Xi$  and if  $z_t \bar{m} \geq a_t(1-\bar{m})$ , *EWSR* and  $\ell_t = 1 - \bar{\ell} - \bar{m}$ .
- If  $z_t \leq \Xi$  and if  $z_t \bar{m} < a_t(1-\bar{m})$ , *IWSR* and  $\ell_t = 1 - \bar{\ell} - \bar{m}$ .

**Proof.** Lemma 3 is obtained by combining the conditions of Lemma 1 and Lemma 2. The first of the two conditions appearing in each case of Lemma 3 determines  $U^Y(y_t^{**}, \ell_t^{**}, m_t^{**})$  when  $\Gamma < 0$ , and  $U^S(s_t^*, \ell_t^*, m_t^*)$  when  $\Gamma > 0$ . The second condition appearing in each case of Lemma 3 describes whether  $U^S(s_t^*, \ell_t^*, m_t^*) \geq U^Y(y_t^{**}, \ell_t^{**}, m_t^{**})$ . ■

A first observation to be made is that life-goals and time allocations prevailing at the temporary equilibrium depend on the levels of hourly productivity  $a_t$  and  $z_t$ : a higher hourly productivity in the production of material goods  $a_t$  tends, *ceteris paribus*, to favor intra-world self-realization with a higher working time, whereas a higher hourly productivity in spiritual development  $z_t$  tends, *ceteris paribus*, to favor extra-world self-realization with lower working time.

Having stressed this, it is theoretically possible, in some cases, that the choice of life-goal does not affect the chosen time allocation, that is, that the optimal time allocation is *invariant* to the postulated life-goal. For instance, under  $\Gamma < 0$  and  $a_t \leq -\Gamma$ , no matter whether the individual chooses to pursue extra-world or intra-world self-realization, in any case he chooses the minimum working time.<sup>33</sup> Thus, selecting a different life-goal does not necessarily lead to choosing unequal working times: it is possible, under some conditions, that the same time allocation is achieved under each of the two life-goals.

In the light of Lemma 3, it is impossible, on the sole basis of the observed working time, to deduce the life-goal pursued by individuals: this may be extra-world self-realization or intra-world self-realization. However, if we have additional information on structural parameters - in particular, the sign of  $\Gamma$  -, some deductions can be made. Our results are summarized in Corollary 1.

**Corollary 1 (Revealed life-goals at the temporary equilibrium)** • *In the absence of information about the sign of  $\Gamma$ , it is impossible to infer life-goals from the observed time allocation.*

- *If  $\Gamma < 0$  is known,  $\ell_t > 0$  reveals that the pursued life-goal is IWSR.*
- *If  $\Gamma = 0$  is known,  $\ell_t = 0$  reveals that the pursued life-goal is EWSR, whereas  $\ell_t = 1 - \bar{\ell} - \bar{m}$  reveals that the pursued life-goal is IWSR.*

<sup>33</sup>Moreover, when  $\Gamma > 0$  and  $z_t \leq \Xi$ , individuals choose the maximal labor time, no matter whether they pursue extra-world or intra-world self-realization.

- If  $\Gamma > 0$  is known,  $\ell_t < 1 - \bar{\ell} - \bar{m}$  reveals that the pursued life-goal is EWSR.

**Proof.** This corollary follows from Lemma 3. ■

Without information about the sign of  $\Gamma$ , it is hard to infer pursued life-goals from time allocation choices. Given that preferences are hardly observable, neither  $\delta$  nor  $\varepsilon$  can be known for sure, so that the sign of  $\Gamma$  remains uncertain. This makes the inference of life-goals from observed time allocation choices difficult. Fortunately, as we shall see, History provides a richer informational basis: it does not provide a *single* temporary equilibrium, but, rather, a *series* of temporary equilibria. Hence, provided assumptions are made on the dynamics of material and spiritual labor productivities, an observed pattern for time allocation can allow us to infer more information about the pursued life-goals.

## 5 Long-run dynamics

In order to study the long-run dynamics, let us first notice that, based on Lemma 3, hourly productivities  $a_t$  and  $z_t$  are the only variables determining the chosen life-goal and time allocation. Since  $a_t \equiv AX^{1-\alpha}L_t^\alpha$  and  $z_t \equiv ZX^{1-\beta}L_t^\beta$ , it can be shown that the indirect utility from adopting either extra-world self-realization or intra-world self-realization is a continuous differentiable function of a single variable, the adult population size  $N_t = L_t$ .

**Corollary 2 (Indirect utility under extra-world self-realization)** *The indirect utility of extra-world self-realization  $U^S(s_t^*, \ell_t^*, m_t^*)$  can be rewritten as a continuous differentiable function  $W^S(L_t)$  with  $\frac{\partial W^S}{\partial L_t} \geq 0 \iff \beta \geq 0$ .*

**Proof.** See the Appendix. ■

**Corollary 3 (Indirect utility under intra-world self-realization)** *The indirect utility of intra-world self-realization  $U^Y(y_t^{**}, \ell_t^{**}, m_t^{**})$  can be rewritten as a continuous differentiable function  $W^Y(L_t)$  with  $\frac{\partial W^Y}{\partial L_t} \geq 0 \iff \alpha \geq 0$ .*

**Proof.** See the Appendix. ■

As a consequence of Lemma 3 and of Corollaries 2 and 3, the choice of life-goals and the choice of time allocation are entirely determined, given the structural parameters, by the level of the adult population size  $L_t$ . Hence, the dynamic system under study is unidimensional, with  $L_t$  as a unique latent variable driving the choice of life-goals, the choice of time allocation, as well as the dynamics of material output production and spiritual development.

In line with demographic evidence, let us assume some demographic growth.

**Condition 1 (Population growth)** *We have:  $\pi n > 1$ .*

Under population growth, various kinds of intertemporal paths for life-goal and time allocation can be replicated and explained within the model, depending

on (i) technical parameters  $\alpha$  and  $\beta$  capturing the elasticities of material and spiritual outputs to the number of adults; (ii) preference parameters  $\delta$  and  $\varepsilon$ , which determine, jointly with  $\bar{\ell}$  and  $\bar{m}$ , the sign of  $\Gamma$ .

Regarding point (i), we will, for the sake of presentation, consider two polar cases, which differ concerning the extent to which population growth is detrimental or favorable for the development of societies. Those assumptions are denoted respectively Conditions 2 and 3.

**Condition 2 (Malthusian economy)** *We have:  $\alpha = 0$  and  $\beta < 0$ .*

Condition 2 states that population growth is detrimental to the society, in the spirit of Malthus (1798). Indeed, Condition 2 implies that, for a fixed time allocation, population growth does not increase material output per worker, which remains stagnant.<sup>34</sup> Population growth is thus not an engine for the growth of material output. Even worse: the second part of Condition 2 states that, for a fixed time allocation, population growth deteriorates spiritual development. This is in line with Malthus’s later views, according to which the propagation of ‘vice’ and population growth are related social phenomena (Malthus 1830).

**Condition 3 (Weylandian economy)** *We have:  $\alpha > 0$  and  $\beta = 0$ .*

Contrary to Condition 2, Condition 3 states that population growth is favorable for the society. This is in line with Weyland’s critique of Malthus’s principle of population, exposed in his *Principles of Population and Production* (Weyland 1816). Against Malthus’s doctrine, Weyland (1816) argued that *demographic pressure is the unique source of progress for societies*.<sup>35</sup> In line with Weyland’s optimism, Condition 3 states that, for a fixed time allocation, population growth increases output per worker, but does not deteriorate spiritual development.

Combining Condition 1 with either Condition 2 or 3 and with either  $\Gamma < 0$  or  $\Gamma > 0$  yields four classes of economies, leading to 30 distinct historical patterns. Each of these historical patterns provides an explanation for the rise of working time as a consequence of population growth, which, given the fixity of the land surface  $X$ , can be interpreted as the Pre-Industrial urbanization/densification process (de Vries 1984). These 30 historical patterns differ concerning the underlying assumptions on initial conditions  $L_0$ , elasticities  $\alpha$  and  $\beta$ , and preference parameters  $\delta$  and  $\varepsilon$  (implying either  $\Gamma < 0$  or  $\Gamma > 0$ ). Importantly, whereas some of these historical patterns explain the rise of the working time by means of a change in life-goals (from extra-world self-realization to intra-world self-realization) in line with Tilgher’s hypothesis, other patterns do not involve a change of preferences. The 30 distinct historical patterns are classified in the following four propositions.<sup>36</sup>

<sup>34</sup>On the various ways to model Malthusian intuitions about stagnation due to population growth, see Eltis (1984), Galor (2011) and Ponthiere (2022).

<sup>35</sup>On Weyland’s criticism of Malthus, see Ponthiere (2022).

<sup>36</sup>In the following, we leave aside the special case where  $\Gamma = 0$ , on the grounds that this case only yields bang-bang transitions (see Lemma 3).

**Proposition 1 (long-run dynamics under Conditions 1 and 2 under  $\Gamma < 0$ )**  
Assume Conditions 1 and 2 as well as  $\Gamma < 0$ . Denote:

$$L^* \equiv \left[ \frac{AX\bar{\ell} - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} + \delta \frac{(1-\bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{ZX^{1-\beta} (1-\bar{\ell})} \right]^{\frac{1}{\beta}}$$

$$L^{**} \equiv \left[ \frac{AX \left( \frac{AX+\delta}{\delta+\varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon-AX}{\delta+\varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{AX+\delta}{\delta+\varepsilon} \right)^2}{2} + \delta \frac{(1-\bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{ZX^{1-\beta} (1-\bar{\ell})} \right]^{\frac{1}{\beta}}$$

$$L^{***} \equiv \left[ \frac{AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} + \delta \frac{(1-\bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{ZX^{1-\beta} (1-\bar{\ell})} \right]^{\frac{1}{\beta}}$$

The dynamics of the economy belongs to one of the following cases:

Case I.1.a If  $AX \leq -\Gamma$  and  $L_0 \leq L^*$ , the economy exhibits two regimes:

- Regime 1: when  $L_t \leq L^*$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = y_0 = A\bar{\ell}X$  and  $s_t = Z(1-\bar{\ell})X^{1-\beta}L_t^\beta \leq s_0$ .
- Regime 2: when  $L_t > L^*$ , there is IWSR,  $\ell_t = 0$ ,  $y_t = y_0 = A\bar{\ell}X$  and  $s_t = Z(1-\bar{\ell})X^{1-\beta}L_t^\beta \leq s_0$ .

Case I.1.b If  $AX \leq -\Gamma$  and  $L_0 > L^*$ , we have a truncated case of Case I.1.a, where the economy starts and remains in Regime 2 of Case I.1.a.

Case I.2.a If  $-\Gamma < AX < -\Xi$  and  $L_0 \leq L^{**}$ , the economy exhibits two regimes:

- Regime 1: when  $L_t \leq L^{**}$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = y_0 = A\bar{\ell}X$  and  $s_t = Z(1-\bar{\ell})X^{1-\beta}L_t^\beta \leq s_0$ .
- Regime 2: when  $L_t > L^{**}$ , there is IWSR,  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(\bar{\ell} + \ell_t)X \geq y_0$  and  $s_t = Z(1-\bar{\ell} - \ell_t)X^{1-\beta}L_t^\beta < s_0$

Case I.2.b If  $-\Gamma < AX < -\Xi$  and  $L_0 > L^{**}$ , we have a truncated case of Case I.2.a, where the economy starts and remains in Regime 2 of Case I.2.a.

Case I.3.a If  $-\Xi \leq AX$  and  $L_0 \leq L^{***}$ , the economy exhibits two regimes:

- Regime 1: when  $L_t \leq L^{***}$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = y_0 = A\bar{\ell}X$  and  $s_t = Z(1-\bar{\ell})X^{1-\beta}L_t^\beta \leq s_0$ .
- Regime 2: when  $L_t > L^{***}$ , there is IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1-\bar{m})X$  and  $s_t = Z\bar{m}X^{1-\beta}L_t^\beta < s_0$ .

Case I.3.b If  $-\Xi \leq AX$  and  $L_0 > L^{***}$ , we have a truncated case of Case I.3.a, where the economy starts and remains in Regime 2 of Case 1.3.a.

**Proof.** See the Appendix. ■

Under  $\Gamma < 0$  and Conditions 1 and 2, History takes the form either of a transition from the life-goal of extra-world self-realization to the life-goal of intra-world self-realization, or, alternatively, has always involved individuals looking for intra-world self-realization. Regarding the allocation of time, this has remained constant in the absence of change of life-goals, whereas in case of a shift from extra-world to intra-world self-realization, there has been a jump from zero extra material labor time to another, fixed level of extra material labor, which was either zero, interior or maximal, depending on the cases.

Consider now the dynamics when  $\Gamma < 0$  and Condition 1 prevail, but when Condition 2 (Malthus) is replaced by Condition 3 (Weyland).

**Proposition 2 (long-run dynamics under Conditions 1 and 3 under  $\Gamma < 0$ )**

Assume Conditions 1 and 3 as well as  $\Gamma < 0$ . Denote:

$$\begin{aligned}
L' &\equiv \left[ \frac{-\Gamma}{AX^{1-\alpha}} \right]^{\frac{1}{\alpha}} < L'' \equiv \left[ \frac{-\Xi}{AX^{1-\alpha}} \right]^{\frac{1}{\alpha}} \\
L^+ &\equiv \left[ \frac{ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} + \delta \frac{(1-\bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{AX^{1-\alpha}\bar{\ell}} \right]^{\frac{1}{\alpha}} \\
L^{++} &\text{ such that } \left[ \begin{aligned} & ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \\ & = AX^{1-\alpha}L^{++\alpha} \left( \frac{AX^{1-\alpha}L^{++\alpha} + \delta}{\delta + \varepsilon} \right) - \delta \left( \frac{\varepsilon - AX^{1-\alpha}L^{++\alpha}}{\delta + \varepsilon} \right)^2 - \varepsilon \left( \frac{AX^{1-\alpha}L^{++\alpha} + \delta}{\delta + \varepsilon} \right)^2 \end{aligned} \right] \\
L^{+++} &\equiv \left[ \frac{ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} + \delta \frac{(\bar{m})^2}{2} + \varepsilon \frac{(1-\bar{m})^2}{2}}{AX^{1-\alpha}(1-\bar{m})} \right]^{\frac{1}{\alpha}}
\end{aligned}$$

The dynamics of the economy belongs to one of the following cases:

Case II.1.a If  $L_0 \leq L^+ < L' < L''$  and  $ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \leq AX^{1-\alpha}L'^\alpha \bar{\ell} - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$ , the economy exhibits 4 regimes:

- Regime 1: when  $L_t \leq L^+ < L' < L''$ , there is EWSR,  $l_t = 0$ ,  $y_t = A\bar{\ell}X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = s_0 = Z(1-\bar{\ell})X$ .
- Regime 2: when  $L^+ < L_t < L' < L''$ , there is IWSR,  $l_t = 0$ ,  $y_t = A\bar{\ell}X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = s_0 = Z(1-\bar{\ell})X$ .
- Regime 3: when  $L^+ < L' \leq L_t < L''$ , there is IWSR,  $0 < l_t < 1-\bar{\ell}-\bar{m}$ ,  $y_t = A(\bar{\ell}+l_t)X^{1-\alpha}L_t^\alpha > y_0$  and  $s_t = Z(1-\bar{\ell}-l_t)X < s_0$ .
- Regime 4: when  $L^+ < L' < L'' \leq L_t$ , there is IWSR,  $l_t = 1-\bar{\ell}-\bar{m}$ ,  $y_t = A(1-\bar{m})X^{1-\alpha}L_t^\alpha > y_0$  and  $s_t = Z\bar{m}X < s_0$ .

Case II.1.b If  $L^+ < L_0 < L' < L''$  and  $ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \leq AX^{1-\alpha}L'^\alpha \bar{\ell} - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$ , we have a truncated case of Case II.1.a, where the economy starts in Regime 2 of Case II.1.a and exhibits 3 regimes.

*Case II.1.c* If  $L^+ < L' \leq L_0 < L''$  and  $ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \leq AX^{1-\alpha} L'^\alpha \bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$ , we have a truncated case of Case II.1.a, where the economy starts in Regime 3 of Case II.1.a and exhibits 2 regimes.

*Case II.1.d* If  $L^+ < L' < L'' \leq L_0$  and  $ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \leq AX^{1-\alpha} L'^\alpha \bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$ , we have a truncated case of Case II.1.a, where the economy starts and remains in Regime 4 of Case II.1.a.

*Case II.2.a* If  $L_0 \leq L^{++} < L''$  and  $AX^{1-\alpha} L'^\alpha \bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} < ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} < AX^{1-\alpha} L''^\alpha (AX^{1-\alpha} L''^\alpha + \delta) - \delta \frac{(\varepsilon - AX L''^\alpha)^2}{\delta + \varepsilon} - \varepsilon \frac{(AX^{1-\alpha} L''^\alpha + \delta)^2}{2}$ , the economy exhibits 3 regimes:

- Regime 1: when  $L_t \leq L^{++} < L''$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = A\bar{\ell}X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = s_0 = Z(1 - \bar{\ell})X$ .
- Regime 2: when  $L^{++} < L_t < L''$ , there is IWSR,  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(\bar{\ell} + \ell_t)X^{1-\alpha}L_t^\alpha > y_0$  and  $s_t = Z(1 - \bar{\ell} - \ell_t)X < s_0$ .
- Regime 3: when  $L^{++} < L'' \leq L_t$ , there is IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1 - \bar{m})X^{1-\alpha}L_t^\alpha > y_0$  and  $s_t = Z\bar{m}X < s_0$ .

*Case II.2.b* If  $L' < L^{++} < L_0 < L''$  and  $AX^{1-\alpha} L'^\alpha \bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} < ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} < AX^{1-\alpha} L''^\alpha (AX^{1-\alpha} L''^\alpha + \delta) - \delta \frac{(\varepsilon - AX L''^\alpha)^2}{\delta + \varepsilon} - \varepsilon \frac{(AX^{1-\alpha} L''^\alpha + \delta)^2}{2}$ , we have a truncated case of Case II.2.a, where the economy starts in Regime 2 of Case II.2.a and exhibits 2 regimes.

*Case II.2.c* If  $L' < L^{++} < L'' \leq L_0$  and  $AX^{1-\alpha} L'^\alpha \bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} < ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} < AX^{1-\alpha} L''^\alpha (AX^{1-\alpha} L''^\alpha + \delta) - \delta \frac{(\varepsilon - AX L''^\alpha)^2}{\delta + \varepsilon} - \varepsilon \frac{(AX^{1-\alpha} L''^\alpha + \delta)^2}{2}$ , we have a truncated case of Case II.2.a, where the economy starts and remains in Regime 3 of Case II.2.a.

*Case II.3.a* If  $L_0 \leq L^{+++}$  and  $ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \geq AX^{1-\alpha} L''^\alpha (1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$ , the economy exhibits 2 regimes:

- Regime 1: when  $L_t \leq L^{+++}$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = A\bar{\ell}X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = s_0 = Z(1 - \bar{\ell})X$ .
- Regime 2: when  $L^{+++} < L_t$ , there is IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1 - \bar{m})X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = Z\bar{m}X < s_0$ .

*Case II.3.b* If  $L^{+++} < L_0$  and  $ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \geq AX^{1-\alpha} L''^\alpha (1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$ , we have a truncated case of Case II.3.a, where the economy starts and remains in Regime 2 of Case II.3.a.

**Proof.** See the Appendix. ■

Like Proposition 1, Proposition 2 states that History was either a transition from the life-goal of extra-world self-realization to the goal of intra-world self-realization, or, alternatively, only involved the goal of intra-world self-realization. However, in comparison to Proposition 1, the dynamics involves more cases. Whereas it is not possible here to summarize all cases, Proposition 2 suggests that the rise in the working time is due either to a shift of life-goals, like in Cases II.2.a or II.3.a, or, alternatively, took place as a mere consequence of the unique goal of intra-world self-realization, like in Cases II.1.b and II.2.b.

Consider now the dynamics under  $\Gamma > 0$ , jointly with Conditions 1 and 2.

**Proposition 3 (long-run dynamics under Conditions 1 and 2 under  $\Gamma > 0$ )**

Assume Conditions 1 and 2 as well as  $\Gamma > 0$ . Denote:

$$\begin{aligned}
L''' &\equiv \left[ \frac{\Gamma}{ZX^{1-\beta}} \right]^{\frac{1}{\beta}} < L'''' \equiv \left[ \frac{\Xi}{ZX^{1-\beta}} \right]^{\frac{1}{\beta}} \\
L^\# &\equiv \left[ \frac{AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} + \delta \frac{(1-\bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{ZX^{1-\beta}(1-\bar{\ell})} \right]^{\frac{1}{\beta}} \\
L^{\#\#} &\text{ such that } \left[ \begin{aligned} & ZX^{1-\beta} L^{\#\#\beta} \left( \frac{\varepsilon + ZX^{1-\beta} L^{\#\#\beta}}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta} L^{\#\#\beta}}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta} L^{\#\#\beta}}{\delta + \varepsilon} \right)^2}{2} \\ & = AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} \end{aligned} \right] \\
L^{\#\#\#} &\equiv \left[ \frac{AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} + \delta \frac{(\bar{m})^2}{2} + \varepsilon \frac{(1-\bar{m})^2}{2}}{ZX^{1-\beta} \bar{m}} \right]^{\frac{1}{\alpha}}
\end{aligned}$$

The dynamics of the economy belongs to one of the following cases:

*Case III.1.a* If  $L_0 \leq L^\# < L''' < L''''$  and  $ZX^{1-\beta} L''''^\beta (1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \leq AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}$ , the economy exhibits 2 regimes:

- Regime 1: when  $L_t \leq L^\# < L''' < L''''$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = y_0 = A\bar{\ell}X$  and  $s_t = Z(1-\bar{\ell})X^{1-\beta}L_t^\beta \leq s_0$ .
- Regime 2: when  $L^\# < L_t < L''' < L''''$ , there is IWSR,  $\ell_t = 1-\bar{\ell}-\bar{m}$ ,  $y_t = A(1-\bar{m})X > y_0$  and  $s_t = Z\bar{m}X^{1-\beta}L_t^\beta < s_0$ .

*Case III.1.b* If  $L^\# < L_0 < L''' < L''''$  and  $ZX^{1-\beta} L''''^\beta (1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \leq AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}$ , we have a truncated case of Case III.1.a, where the economy starts and remains in Regime 2 of Case III.1.a.

*Case III.2.a* If  $L_0 \leq L''' < L^{\#\#} < L''''$  and  $ZX^{1-\beta} L''''^\beta \left( \frac{\varepsilon + ZX^{1-\beta} L''''^\beta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta} L''''^\beta}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta} L''''^\beta}{\delta + \varepsilon} \right)^2}{2} < AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} < ZX^{1-\beta} L''''^\beta (1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$ , the economy exhibits 3 regimes:

- Regime 1: when  $L_t \leq L''' < L^{\#\#} < L''''$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = y_0 = A\bar{\ell}X$  and  $s_t = Z(1 - \bar{\ell})X^{1-\beta}L_t^\beta \leq s_0$ .
- Regime 2: when  $L''' < L_t \leq L^{##} < L''''$ , there is EWSR,  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(\bar{\ell} + \ell_t)X > y_0$  and  $s_t = Z(1 - \bar{\ell} - \ell_t)X^{1-\beta}L_t^\beta < s_0$ .
- Regime 3: when  $L''' < L^{##} < L_t < L''''$ , there is IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1 - \bar{m})X > y_0$  and  $s_t = Z\bar{m}X^{1-\beta}L_t^\beta < s_0$ .

Case III.2.b If  $L''' < L_0 \leq L^{##} < L''''$  and  $ZX^{1-\beta}L''''^\beta \left( \frac{\varepsilon + ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right) - \delta \left( \frac{\varepsilon + ZX^{1-\beta}L''''^\beta}{2} \right)^2 - \varepsilon \left( \frac{\delta - ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right)^2 < AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} < ZX^{1-\beta}L''''^\beta (1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$ , we have a truncated case of Case III.2.a, where the economy starts in Regime 2 of Case III.2.a and exhibits 2 regimes.

Case III.2.c If  $L''' < L^{##} < L_0 < L''''$  and  $ZX^{1-\beta}L''''^\beta \left( \frac{\varepsilon + ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right) - \delta \left( \frac{\varepsilon + ZX^{1-\beta}L''''^\beta}{2} \right)^2 - \varepsilon \left( \frac{\delta - ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right)^2 < AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} < ZX^{1-\beta}L''''^\beta (1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$ , we have a truncated case of Case III.2.a, where the economy starts and remains in Regime 3 of Case III.2.a.

Case III.3.a If  $L_0 \leq L''' < L'''' \leq L^{###}$  and  $ZX^{1-\beta}L''''^\beta \bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \geq AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$ , the economy exhibits 4 regimes:

- Regime 1: when  $L_t \leq L''' < L'''' \leq L^{###}$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = y_0 = A\bar{\ell}X$  and  $s_t = Z(1 - \bar{\ell})X^{1-\beta}L_t^\beta \leq s_0$ .
- Regime 2: when  $L''' < L_t < L'''' \leq L^{###}$ , there is EWSR,  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(\bar{\ell} + \ell_t)X > y_0$  and  $s_t = Z(1 - \bar{\ell} - \ell_t)X^{1-\beta}L_t^\beta < s_0$ .
- Regime 3: when  $L''' < L'''' < L_t \leq L^{###}$ , there is EWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1 - \bar{m})X > y_0$  and  $s_t = Z\bar{m}X^{1-\beta}L_t^\beta < s_0$ .
- Regime 4: when  $L''' < L'''' < L^{###} < L_t$ , there is IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1 - \bar{m})X > y_0$  and  $s_t = Z\bar{m}X^{1-\beta}L_t^\beta < s_0$ .

Case III.3.b If  $L''' < L_0 < L'''' \leq L^{###}$  and  $ZX^{1-\beta}L''''^\beta \bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \geq AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$ , we have a truncated case of Case III.3.a, where the economy starts in Regime 2 of Case III.3.a and exhibits 3 regimes.

Case III.3.c If  $L''' < L'''' < L_0 \leq L^{###}$  and  $ZX^{1-\beta}L''''^\beta \bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \geq AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$ , we have a truncated case of Case III.2.a, where the economy starts in Regime 3 of Case III.2.a and exhibits 2 regimes.

Case III.3.d If  $L''' < L'''' < L^{###} < L_0$  and  $ZX^{1-\beta}L''''\bar{m} - \delta\frac{(\bar{m})^2}{2} - \varepsilon\frac{(1-\bar{m})^2}{2} \geq AX(1-\bar{m}) - \delta\frac{(\bar{m})^2}{2} - \varepsilon\frac{(1-\bar{m})^2}{2}$ , we have a truncated case of Case III.2.a, where the economy starts and remains in Regime 4 of Case III.2.a.

**Proof.** See the Appendix. ■

Proposition 3 shows that, like in Proposition 2, the model can replicate the rise of working time either as the outcome of a transition from the Ancient Man to the Modern Man, or, alternatively, without a transition in the pursued life-goals. However, the key difference is that the scenario without a transition, which is here Case III.3.a, is a case where the rise in working time occurs while individuals pursue the goal of extra-world self-realization, instead of intra-world self-realization (in Proposition 2). The transition that finally occurs to Regime 4 within Case III.3.a only changes the pursued life-goal, but has no effect at all on time allocation (maximal extra labor was already reached within Regime 3, under which extra-world self-realization is pursued). Thus Proposition 3 provides an alternative possible explanation for the rise of working time: this could be, under Conditions 1 and 2 and  $\Gamma > 0$ , explained as a strategy aimed at pursuing extra-world self-realization.

**Proposition 4 (long-run dynamics under Conditions 1 and 3 under  $\Gamma > 0$ )**

Assume Conditions 1 and 3 as well as  $\Gamma > 0$ . Denote:

$$\begin{aligned} L^\circ &\equiv \left[ \frac{ZX(1-\bar{\ell}) - \delta\frac{(1-\bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2} + \delta\frac{(\bar{m})^2}{2} + \varepsilon\frac{(1-\bar{m})^2}{2}}{AX^{1-\alpha}(1-\bar{m})} \right]^{\frac{1}{\alpha}} \\ L^{\circ\circ} &\equiv \left[ \frac{ZX\left(\frac{\varepsilon+ZX}{\delta+\varepsilon}\right) - \delta\frac{\left(\frac{\varepsilon+ZX}{\delta+\varepsilon}\right)^2}{2} - \varepsilon\frac{\left(\frac{\delta-ZX}{\delta+\varepsilon}\right)^2}{2} + \delta\frac{(\bar{m})^2}{2} + \varepsilon\frac{(1-\bar{m})^2}{2}}{AX^{1-\alpha}(1-\bar{m})} \right]^{\frac{1}{\alpha}} \\ L^{\circ\circ\circ} &\equiv \left[ \frac{ZX\bar{m} - \delta\frac{(\bar{m})^2}{2} - \varepsilon\frac{(1-\bar{m})^2}{2} + \delta\frac{(\bar{m})^2}{2} + \varepsilon\frac{(1-\bar{m})^2}{2}}{AX^{1-\alpha}(1-\bar{m})} \right]^{\frac{1}{\alpha}} \end{aligned}$$

The dynamics of the economy belongs to one of the following cases:

Case IV.1.a If  $ZX \geq \Gamma$  and  $L_0 \leq L^\circ$ , the economy exhibits two regimes:

- Regime 1: when  $L_t \leq L^\circ$ , there is EWSR,  $\ell_t = 0$ ,  $y_t = A\bar{L}X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = s_0 = ZX(1-\bar{\ell})$ .
- Regime 2: when  $L_t > L^\circ$ , there is IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1-\bar{m})X^{1-\alpha}L_t^\alpha > y_0$  and  $s_t = ZX\bar{m} < s_0$ .

Case IV.1.b If  $ZX \geq \Gamma$  and  $L_0 > L^\circ$ , we have a truncated case of Case IV.1.a, where the economy starts and remains in Regime 2 of Case IV.1.a.

Case IV.2.a If  $\Xi < ZX < \Gamma$  and  $L_0 \leq L^{\circ\circ}$ , the economy exhibits two regimes:

- Regime 1: when  $L_t \leq L^{\circ\circ}$ , there is EWSR,  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(\bar{\ell} + \ell_t)X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = ZX(1 - \bar{\ell} - \ell_t) < s_0$ .
- Regime 2: when  $L_t > L^{\circ\circ}$ , there is IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1 - \bar{m})X^{1-\alpha}L_t^\alpha > y_0$  and  $s_t = ZX\bar{m} < s_0$ .

Case IV.2.b If  $\Xi < ZX < \Gamma$  and  $L_0 > L^{\circ\circ}$ , we have a truncated case of Case IV.2.a, where the economy starts and remains in Regime 2 of Case IV.2.a.

Case IV.3.a If  $ZX \leq \Xi$  and  $L_0 \leq L^{\circ\circ}$ , the economy exhibits two regimes:

- Regime 1: when  $L_t \leq L^{\circ\circ}$ , there is EWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1 - \bar{m})X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = s_0 = ZX\bar{m}$ .
- Regime 2: when  $L_t > L^{\circ\circ}$ , there is IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$ ,  $y_t = A(1 - \bar{m})X^{1-\alpha}L_t^\alpha \geq y_0$  and  $s_t = s_0 = ZX\bar{m}$ .

Case IV.3.b If  $ZX \leq \Xi$  and  $L_0 > L^{\circ\circ}$ , we have a truncated case of Case IV.3.a, where the economy starts and remains in Regime 2 of Case IV.3.a.

**Proof.** See the Appendix. ■

Like in Propositions 1, 2 and 3, History exhibits, under  $\Gamma > 0$  and Conditions 1 and 3, two possible patterns: either a transition from the life-goal of extra-world self-realization to the life-goal of intra-world self-realization, or, alternatively, only the pursuit of intra-world self-realization. Regarding time allocation, History has exhibited either a fixed time allocation (in the absence of shift in life-goal), or, at most, two levels of extra labor time, from either zero, interior or maximal extra labor time to maximal extra labor time.<sup>37</sup>

Propositions 1 to 4 can be used to make several observations about the (possible) emergence of Modern Man and its relations with the Industrious Revolution. Let us first abstract from historical changes in time allocation, and focus only on the selection of preferences. Our results are summarized in Corollary 4: provided one adheres to Condition 1 and to Condition 2 or 3, it follows that the history of humanity is either characterized by the replacement of the Ancient Man (looking for extra-world self-realization) by the Modern Man (looking for intra-world self-realization), or, alternatively, only includes the Modern Man. But it is not possible, within our model, that the entire human history would consist in a quest for extra-world self-realization.

**Corollary 4 (Patterns for life-goals along History)** *Assume Condition 1 with Condition 2 or 3. Along History taken as a whole (from  $t = 0$  to  $t = +\infty$ ), it is either the case that individuals shift, at one point in time, from the goal of extra-world self-realization (Ancient Man) to the goal of intra-world self-realization (Modern Man), or, alternatively, that individuals pursue intra-world self-realization (Modern Man) during the entire History.*

<sup>37</sup>A major difference with respect to Proposition 1 is here that material output per worker grows during the entire history, unlike in Proposition 1 where it was only at the time of regime shift that there was some jump in material output per worker.

**Proof.** Corollary 4 is obtained by observing that in all cases of Propositions 1 to 4, it is never true that an economy would remain, from  $t = 0$  to  $t = +\infty$ , in the situation where agents pursue EWSR forever. ■

Corollary 4 excludes a History where humans would have been pursuing extra-world self-realization only. The intuition behind that result goes as follows. Condition 1 and Condition 2 or 3 imply that individuals initially pursuing extra-world self-realization will, sooner or later, shift towards intra-world self-realization. The reason is that population growth tends, for a given time allocation, either to reduce the marginal spiritual product of meditation time for a fixed marginal material product of labor (under Condition 2) or to increase the marginal material product of labor for a fixed marginal spiritual product of meditation time (under Condition 3). Each of those tendencies will sooner or later encourage individuals to shift towards the quest for intra-world self-realization.

Consider now the issue of the rationalization of the Industrious Revolution. In order to identify different microeconomic explanations of the Industrious Revolution, we select in the 30 historical patterns of Propositions 1 to 4 the cases that exhibit a rise in working time from  $t$  to  $t' > t$ . As we shall now see, the rise in working time can take place *within a given regime* or, alternatively, can take place *as the outcome of a regime shift*.

**Corollary 5 (Theoretical explanations of the Industrious Revolution)**

*Assume Condition 1 and either Condition 2 or 3. A historical rise in working time from period  $t$  to period  $t' > t$  admits three types of explanations:*

*E1 The pursuit of extra-world self-realization (Ancient Man):*

- *Case III.2.a.R1+R2, Case III.3.a.R1+R2+R3, Case III.3.b.R1+R2*

*E2 The pursuit of intra-world self-realization (Modern Man):*

- *Case II.1.b.R1+R2+R3, Case II.1.c.R1+R2, Case II.2.b.R1+R2.*

*E3 A transition from the pursuit of extra-world self-realization to the pursuit of intra-world self-realization (from Ancient Man to Modern Man):*

- *Case I.2.a.R1+R2, Case I.3.a.R1+R2,*
- *Case II.1.a.R1+R2+R3+R4, Case II.1.a.R1+R2+R3, Case II.2.a.R1+R2+R3,*  
*Case II.2.a.R1+R2, Case II.3.a.R1+R2,*
- *Case III.1.a.R1+R2, Case III.2.a.R1+R2+R3, Case III.2.b.R1+R2,*
- *Case IV.1.a.R1+R2, Case IV.2.a.R1+R2.*

**Proof.** We excluded, within all cases of Propositions 1 to 4, the cases where  $\ell_t$  is a corner (zero or maximal) during the entire History. Then, we collected in E1 all (possibly truncated) cases where the rise in  $\ell_t$  prevails while the economy remains in the pursuit of EWSR. We collected in E2 all (possibly truncated) cases where the rise in  $\ell_t$  prevails without any initial period in the pursuit of

EWSR. Explanation E3 collects all other cases where a transition in life-goals was necessary to achieve the rise in  $\ell_t$ . This excludes cases where the shift in life-goals took place after the maximal  $\ell_t$  was reached. ■

Corollary 5 states that our model provides three distinct explanations of the Industrious Revolution. The Industrious Revolution could have occurred as the outcome of the Ancient Man’s self-realization (Explanation E1), as the outcome of the Modern Man’s self-realization (Explanation E2), or as the outcome of a transition from the Ancient Man looking for extra-world self-realization to the Modern Man looking for intra-world self-realization (Explanation E3).

Explanations E1 and E2 require distinct assumptions on preferences (either  $\Gamma < 0$  or  $\Gamma > 0$ ), in combination with assumptions on production (either Condition 2 or 3). On the contrary, Explanation E3 is compatible with various assumptions on preferences and with various assumptions on production. But even if Explanations 1 and 2 require more restrictive hypotheses, these cannot be excluded *a priori*. Hence, Corollary 5 delivers a key message regarding the interpretation of the Industrious Revolution. *From a theoretical perspective, the historical rise in working time does not necessarily involve the transition from the Ancient Man (looking for extra-world self-realization) to the Modern Man (looking for intra-world self-realization). It cannot be excluded, in theory, that the rise in working time has taken place without the emergence of a New Man: either within the quest for extra-world self-realization (Ancient Man), or within the quest for intra-world self-realization (Modern Man).*

These results suggest that, contrary to what is stated in Tilgher’s hypothesis, the reorientation of efforts towards the outside world does not necessarily reveal the emergence of Modern Man (that is, a shift of life-goals, as in Explanation E3), but can possibly have taken place either within the Ancient Man’s era (Explanation E1) or within the Modern Man’s era (Explanation E2), without a change of life-goals. Hence, while Explanation E3 involves a shift of life-goals, and, as such, is compatible with Tilgher’s hypothesis, this is not the case of Explanations E1 and E2, which contradict Tilgher’s hypothesis. As a consequence, our results provide a mixed support for Tilgher’s hypothesis: on purely theoretical grounds, one cannot be certain that the reorientation of efforts is equivalent to the emergence of a New Man.

## 6 A case study: religious holidays in France

As we showed in Section 5, a rise in observed working time may or may not coincide with the replacement of the Ancient Man (looking for extra-world self-realization) by the Modern Man (looking for intra-world self-realization). The goal of this section is to use a particular case study - the decline of the number of religious holidays or *fêtes chômées* in old-regime France - to cast light on the plausibility of the different explanations for the rise in working time.

The reason why we focus on that historical case is that the decline of religious holidays under the *Ancient Regime* is an episode of secularization that was studied in details by Shusterman (2009), who calculated the number of holidays

and working days over 1642-1789. Moreover, the French Industrious Revolution has been the object of debates regarding the causal mechanisms at work (Voth 2010, Grenier 2012). As such, this case is most relevant to provide an empirically-based comparison of the different explanations of the rise in working time, and, hence, to assess the validity of Tilgher’s hypothesis.

At this stage, some clarifications are needed concerning the relation between Tilgher’s hypothesis and the case under study. First, Tilgher’s hypothesis concerns *spiritual exercises in general* and not a particular religion. Thus, the secularization in France concerns only one facet of Tilgher’s hypothesis, but does not capture it entirely. Second, this section will rely on Shusterman’s (2009) estimates of the number of religious holidays, which quantify *objective* (or institutionalized) secularization, which can only be taken as a proxy for the study of Tilgher’s hypothesis, which concerns *subjective* secularization.

**The decline of religious holidays in France (1640-1780)** In the early 17th century, there were, according to Shusterman (2009), on average 33 weekdays per year devoted to official *fêtes chômées* in France. Any paid labor activity carried out to earn one’s life was strictly prohibited during these official religious holidays (like for all Sundays).<sup>38</sup> Examples of these official religious holidays include the Easter Monday, Christmas, the All Saints’ Day, but go far beyond these days, to include other celebrations like the Conception of Mary and the Saint John.<sup>39</sup> The number of official religious holidays vary across dioceses. The large number of official religious holidays per year tended to limit the total number of days available for work.<sup>40</sup>

From the middle of the 17th century onwards, French bishops started to reduce the number of official religious holidays. According to Shusterman (2009), bishops could, after some resistance, successfully impose a significant reduction in the number of official religious holidays. At the end of the 18th century, the number of weekdays devoted to *fêtes chômées* was less than 20 in most French dioceses, that is, a reduction of about 40 % of the number of official religious holidays. This reduction in the number of religious holidays had an impact on the number of days available for work, as shown on Figure 4.

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<sup>38</sup>As such, these *fêtes chômées* were distinct from the *fêtes de dévotion*, during which some paid labor is allowed. On this distinction, see Grenier (2012), p. 609.

<sup>39</sup>For a detailed list of all holidays, see Shusterman (2009, Figure 2 on p. 297).

<sup>40</sup>Given that some of these official religious holidays could fall on a Sunday, the total number of days unavailable for work was less than the number of *fêtes chômées* plus the 52 Sundays.

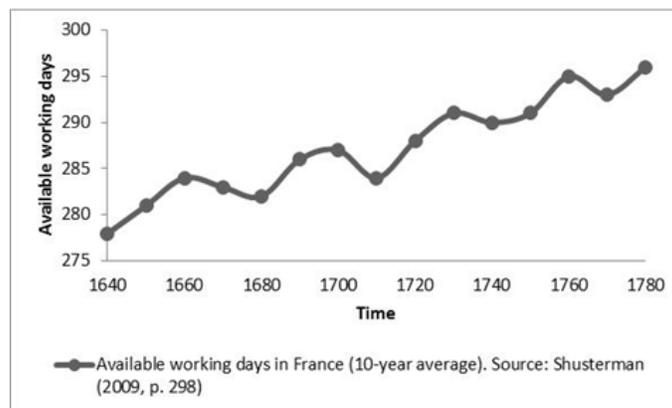


Figure 4. Available working days, France, 1640-1780.

Using official religious documents as historical sources, Shusterman (2009) argued that distinct reasons were given by bishops to justify the reduction of the number of religious holidays, and that the general problem with the *fêtes chômées* was in the way these holidays were used by citizens.<sup>41</sup> According to bishops, religious holidays were sometimes used for leisure activities such as drinking, gambling and idleness. By reducing their number, bishops hoped that the remaining religious holidays would be celebrated in a more pious manner. Another problem was that the prohibition of paid labor during official holidays was not always respected. This leads to another reason evoked by bishops: with the large number of holidays, it was difficult for fathers to make a sufficient amount of money. Thus concern for poor families was also among the explanations for the reform of the ecclesiastical calendar.<sup>42</sup>

The reduction in the number of *fêtes chômées* and the rise in the number of days available for work are part of the same general process of the reallocation of time: the Industrious Revolution. No consensus exists among economic historians regarding the causes at work behind the Industrious Revolution. According to Voth (2000), the Industrious Revolution is mainly explained by a greater interest for consumption. Strengthened desires for consumption goods would thus explain why there was increasing working time during religious holidays, and, also, why French bishops decided, as a consequence of this rise, to reduce the number of *fêtes chômées*. Against Voth's explanation, Grenier (2012) argued that the decline of the number of religious holidays is primarily a religious phenomenon, with purely religious explanations. According to Grenier, the reduction of the number of *fêtes chômées* is part of an older, long-lasting, process of limitation of religious holidays. Three major causes - internal to the Church - have been at work. First, the Church was increasingly suspicious of the celebration of local saints, and wanted religious activities to be re-centered around the

<sup>41</sup> See Shusterman (2009), p. 305.

<sup>42</sup> See Shusterman (2009), p. 305.

Christ. This tendency has led to a revaluation of Sundays (in comparison with weekdays devoted to other saints). Second, the Church wanted, by the reform of the calendar, to have a stronger spatial coherence: the goal was a uniformization of practices across all dioceses, to achieve a more united Church. Third, there was within the Church a growing adhesion to the idea that each human should be able to live in conformity with his own status. Cancelling some *fêtes chômées* was a way to allow persons to escape from poverty.<sup>43</sup>

**Four explanations** Back to Corollary 5, our model provides three general explanations of the rise in working hours: either extra-world self-realization, or intra-world self-realization or a transition from the former to the latter. Each of these explanations includes various subcases. Leaving aside all explanations of the bang-bang style, and introducing a distinction between transitions across life-goals under  $\Gamma > 0$  or  $\Gamma < 0$ , four explanations emerge:

**E1 Ancient Man’s self-realization.** This is Case III.2.a.R1+R2 ( $\Gamma > 0$ ), where optimal extra labor  $\ell_t$  under extra-world self-realization shifts from zero to an interior solution that is increasing over time.

**E2 Modern Man’s self-realization.** This is Case II.1.b.R1+R2 ( $\Gamma < 0$ ), where optimal extra labor  $\ell_t$  under intra-world self-realization is an interior solution that is increasing over time.

**E3a From Ancient to Modern Man (from interior to corner extra labor).** This is Case III.3.b.R1+R2 ( $\Gamma > 0$ ), where optimal extra labor  $\ell_t$  rises from an interior  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$  to the maximal  $\ell_t = 1 - \bar{\ell} - \bar{m}$ .

**E3b From Ancient to Modern Man (from corner to interior extra labor).** This is Case II.2.a.R1+R2 ( $\Gamma < 0$ ), where optimal extra labor  $\ell_t$  rises from  $\ell_t = 0$  to an interior  $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ .

Voth’s (2000) explanation of the rise in the number of work hours, which consists of a reinforced desire for the consumption of material goods, is compatible with E3a and E3b (‘From Ancient to Modern Man’), which both involve a major reorientation of human desires towards material goods. On the contrary, Grenier’s (2012) explanation, which explains the rise in the number of work hours on the basis of purely religious factors, does not involve a change of Man’s life-goals. If one interprets the re-centering of the Church towards the Christ as a contraction of spiritual production in intensive terms, Explanation E1 provides a possible formalization of Grenier’s explanation.

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<sup>43</sup>In some sense, this concern for poverty reduction has always been present. According to Grenier (2012), the French Church has always been flexible and tolerant in the application of the prohibition of paid labor during holidays. There is a long list of special authorizations of paid labor during an official religious holiday, for instance during the harvest season for farmers, and during celebration days for merchants.

**Calibration of structural parameters** Given that the four explanations rely on distinct parametrizations (different signs for  $\Gamma$  and for  $\alpha, \beta$ ), our numerical explorations cannot rely on a unique set of values for all parameters. But at the same time, the only way to assess the plausibility of the four explanations consists of examining how each of these can ‘match’ the data under plausible values for structural parameters. For that purpose, this section will rely on the following strategy. On the one hand, parameters  $\{n, \pi, X, \bar{\ell}, \bar{m}\}$  are calibrated once and for all cases, on the basis of stylized facts. On the other hand, elasticities  $\{\alpha, \beta\}$  are calibrated once for Explanations E1 and E3a based on Case II (where  $\alpha = 0, \beta < 0$ ) and once for Explanations E2 and E3b based on Case III (where  $\alpha > 0, \beta = 0$ ). Then, preferences parameters  $\{\delta, \varepsilon\}$  - and thus  $\Gamma$  - are calibrated specifically in each case, in order to replicate the number of days available for work in the initial year (1640) and in the final year (1780).<sup>44</sup>

Demographic parameters  $n$  (number of children per adult) and  $\pi$  (proportion of children surviving to adulthood) can be calibrated on the basis of demographic history. We use values for 1740 taken from Dupâquier (1995):  $n$  is set to 2.350, implying 4.7 children per women, whereas  $\pi$  is set to 0.500 (half of each cohort could not survive to adulthood).

Regarding the calibration of  $\bar{\ell}$ , economic anthropologists argue that mere biological survival requires between 100 and 160 days of labor per year (Sahlins 1972, p. 22). This implies a minimum quantity of labor equal to between  $\bar{\ell} = 0.273$  and  $\bar{\ell} = 0.438$ . However, adopting those values for  $\bar{\ell}$  would rule out Explanation E3b, by making the initial total labor before the regime shift far below the observed total labor. To avoid ruling out *a priori* that explanation, we will fix  $\bar{\ell}$  to the minimum level of working hours over the period under study, that is, 278 available days for working in 1640, which yields:  $\bar{\ell} = \frac{278}{365} = 0.761$ .

Concerning the calibration of  $\bar{m}$ , the minimum number of official holidays observed in France can be found just after the French Revolution. According to Vovelle (1986), the Sunday was, just after the Revolution, abolished and replaced by the *decadi*, that is, one free day every *décade* (10 days, thus 3 *decadi* per month). There were also the *Sansculottides*, which amounted to 5 days per year. This gives a relative number of official holidays equal to  $\frac{41}{365} = 0.112$ . However, imposing such a low value for  $\bar{m}$  would exclude Explanation E3a, by making the simulated labor time jump to a level far higher than the maximal observed labor over 1640-1780. Hence, to give a chance to that explanation, we will fix  $\bar{m}$  to the minimum observed spiritual time over 1640-1780, that is, to

<sup>44</sup>Thus the calibrated values of  $\delta$  and  $\varepsilon$  solve, under EWSR, the following two equations:

$$\ell_{1640}^* = \frac{\delta(1 - \bar{\ell}) - \varepsilon\bar{\ell} - ZX^{1-\beta}L_{1640}^\beta}{\delta + \varepsilon} \text{ and } \ell_{1780}^* = \frac{\delta(1 - \bar{\ell}) - \varepsilon\bar{\ell} - ZX^{1-\beta}L_{1780}^\beta}{\delta + \varepsilon}$$

when extra labor is interior, and corner solutions otherwise.

The calibrated values of  $\delta$  and  $\varepsilon$  solve, under IWSR, the following two equations:

$$\ell_{1640}^{**} = \frac{AX^{1-\alpha}L_{1640}^\alpha + \delta(1 - \bar{\ell}) - \varepsilon\bar{\ell}}{\delta + \varepsilon} \text{ and } \ell_{1780}^{**} = \frac{AX^{1-\alpha}L_{1780}^\alpha + \delta(1 - \bar{\ell}) - \varepsilon\bar{\ell}}{\delta + \varepsilon}$$

when extra labor is interior, and corner solutions otherwise.

365 – 296 = 69 days per year. This leads us to  $\bar{m} = \frac{69}{365} = 0.189$ .

As in Lagerlöf (2006), we normalize the surface of land  $X$  to 1. Lagerlöf (2006) sets the elasticity of material output to labor to 0.600. We will thus take  $\alpha = 0.600$  as a benchmark value for explanations E2 and E3b based on Case III. Concerning the parameter  $A$ , note that the land-to-output ratio is, in the production of material goods, equal to  $\frac{X_t^\ell}{Y_t} = \frac{X}{A(X)^{1-\alpha}L_t^{1+\alpha}}$ , which, given  $X = 1$ , is equal to  $\frac{1}{AL_t^{1+\alpha}}$ . Hence, if one normalizes the initial population size to 1, the initial value of the land-to-output ratio equals  $\frac{1}{A}$ . According to Ingram (1980), the land-to-output ratio equals 0.77. This implies that  $A = 1.298$ .

By symmetry, we adopt, as a proxy, the same value for the land-to-output ratio in the production of spiritual development, which leads to  $Z = 1.298$ . The calibration of  $\beta$  is based on the specificities of immaterial production activities, in line with Becker and Murphy (1992), who highlighted that productivity gains obtained by increasing the labor force depend on the nature of the production activity. Spiritual activities - like the production of immaterial goods - are *ceteris paribus* more difficult to carry out when the group is large, because of congestion effects. To account for congestion costs, we will take  $\beta = -0.100$  as a benchmark value for explanations E1 and E3a.

Parameters	Values	Sources
$n$	2.350	4.7 children per family in 1740: Dupâquier (1995).
$\pi$	0.500	Half of cohorts dead before age 17 in 1740: Dupâquier (1995).
$X$	1.000	Standard normalization: Lagerlöf (2006).
$\bar{\ell}$	0.761	278 available days for working in 1640: Shusterman (2009).
$\bar{m}$	0.189	296 available days for working in 1780: Shusterman (2009).
$A$	1.298	land-to-output ratio equal to 0.77: Ingram (1980).
$Z$	1.298	land-to-output ratio equal to 0.77: Ingram (1980).
$\alpha$ (upper bound)	0.600	Elasticity of material output wrt labor equal to 0.600: Lagerlöf (2006).
$\beta$ (lower bound)	-0.100	Elasticity of spiritual output wrt labor equal to -0.100.

Table 1: Calibration of demographic and production parameters.

**Assessing the 4 explanations** In order to assess the plausibility of the 4 theoretical explanations of the observed pattern in the number of days available for work, we proceed as follows. Normalizing initial variables  $\{A_0, N_0, Z_0\}$  to 1, and taking the values of structural parameters  $\{n, \pi, X, \alpha, \beta, \bar{\ell}, \bar{m}\}$  of Table 1, we look for the pairs of values of preference parameters  $\{\delta, \varepsilon\}$  that can replicate the number of working days for the initial year 1640. Then, we select, out of all these pairs  $(\delta, \varepsilon)$ , the one that can best replicate the final number of days available for work, that is, the one for 1780.

Our results are synthesized on Figure 5. A first thing to notice is that, given our initial conditions and values for structural parameters, we could not replicate numerically the explanation E3b.<sup>45</sup> The three other explanations -

<sup>45</sup>Our initial conditions imply  $L_0 > L^{++}$ , so that the economy must start in Regime 2 of

E1, E2 and E3a - are unequal in their capacity to match the observed pattern for the number of days available for work (which is, on Figure 5, normalized between 0 and 1, in line with the model). The explanation that best fits the data is E2 (Figure 5b): the rise in working time is caused by the Modern Man's pursuit of intra-world self-realization.<sup>46</sup> The second-best explanation is E3a, which explains the rise in working time as the outcome of a shift from the Ancient Man's pursuit of extra-world self-realization to the Modern Man's pursuit of intra-world self-realization.<sup>47</sup> However, although Explanation E3a can replicate the observed labor for years 1640 and 1780, the general quality of the fit is here less good than under Explanation E2, which relies solely on the Modern Man's life-goal. Indeed, that variant of the model involves a 'jump' that does not fit the relatively smooth pattern of observed labor time. The worst fit prevails under E1: the calibrated values for preference parameters  $\{\delta, \varepsilon\}$  that can replicate labor time in 1640 lead to a pattern for working time that is too sluggish, and which underestimates the rise in the working time.<sup>48</sup>

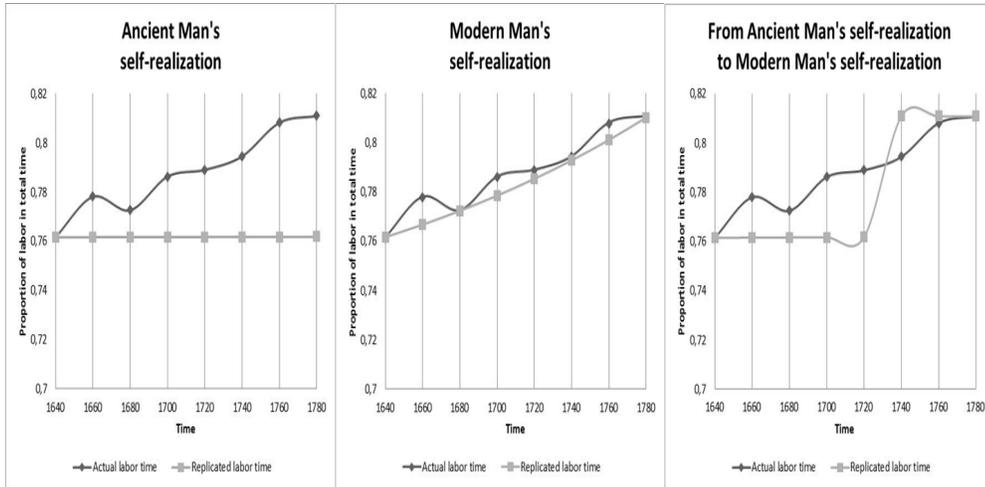


Figure 5a: Explanation E1. Figure 5b: Explanation E2. Figure 5c: Explanation E3a.

All in all, conditionally on our calibrations, our numerical explorations suggest that the most plausible explanation is E2: the rise in the number of days available for work was the mere outcome of the Modern Man's pursuit of the goal of intra-world self-realization, without any transition from the Ancient Man to the Modern Man. Thus the Ancient Man would be of no help to explain the French Industrious Revolution.

Case II.2.a, and, hence, falls under Case II.2.b, where there is no regime shift from EWSR to IWSR.

<sup>46</sup> Figure 5b relies on  $\delta = 18.42$  and  $\varepsilon = 7.47$ .

<sup>47</sup> Figure 5c relies on  $\delta = 518.27$  and  $\varepsilon = 160.49$ .

<sup>48</sup> Figure 5a relies on  $\delta = 526.80$  and  $\varepsilon = 163.16$ .

In order to check for the robustness of our results, we extend our numerical explorations and study how the assessment of the four explanations varies once one considers different values for parameters  $\bar{\ell}$ ,  $\bar{m}$ ,  $\beta$  and  $Z$ . It is shown in the Appendix that, under all parametrizations considered, it remains the case that the theoretical explanation that best matches the observed rise in the number of days available for work in old-regime France is E2: the Modern Man's pursuit of intra-world self-realization.

Back to Tilgher's hypothesis of a fundamental conversion of human-beings, it should be stressed that our numerical explorations do not corroborate Tilgher's hypothesis: from a quantitative perspective, the best microeconomic explanation of the French Industrious Revolution is Explanation E2 based only on the Modern Man's pursuit of intra-world self-realization, without any role for a transition from the Ancient Man to the Modern Man. Thus the reallocation of time during the French Industrious Revolution does not, based on our empirical analysis, reveal a change in the underlying life-goals, contrary to the general conversion process described in Tilgher's hypothesis.<sup>49</sup>

Note also that, by showing that the decline in religious holidays in old-regime France is best explained by a continuous quest of the Modern Man for intra-world self-realization, our numerical results do not corroborate Voth's (2000) explanation of the Industrious Revolution, which involves a change of human desires, something incompatible with E2. At the same time, our numerical results provide a limited support for Grenier's (2012) view of the Industrious Revolution as the outcome of a dynamics that is purely internal to religions. Indeed, the assessment of Explanation E1 suggests that a purely religious explanation of the Industrious Revolution leaving aside the role of productivity gains in the production of material goods would have implied an adjustment of working time that would have been too slow to match the observed pattern.

## 7 Concluding remarks

The emergence of Modern Man is most challenging for economic historians. While major transformations - such as urbanization and the rise of the knowledge economy - have been shown to take place during the Pre-Industrial era, there remains a missing piece in the puzzle: how could Man - even urbanized and better educated - have incentives allowing him to be responsive to technological and institutional changes taking place during the Industrial Revolution?

Tilgher's hypothesis may bring the missing piece in the puzzle: according to Tilgher (1922), the birth of the bourgeois society during the pre-Industrial era is due to a *change of life-goals*, from the flourishing of the inner self towards the control of the outside world. According to Tilgher, that shift of life-goals is necessary to explain how humans could, at one point in history, become navigators, explorers and aviators. Humans wishing to be detached from the outside world

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<sup>49</sup>It should be stressed that this negative conclusion is true conditionally on the assumption that the dynamics of official religious holidays (objective secularization) is a sufficiently good proxy of the dynamics of real time allocation (subjective secularization).

could hardly have occupied - or even imagined - such jobs. Tilgher's hypothesis accounts for this fundamental conversion of human-beings. It describes also a major transformation in human incentives to work and produce material goods.

At the microeconomic level, a reallocation of time/efforts does not necessarily reveal a change of preferences. Hence, contrary to Tilgher's hypothesis, the reorientation of efforts towards the outside world might not be associated with the emergence of a New Man. To examine whether the Industrious Revolution reveals a change of life-goals, this paper developed a unified growth model with endogenous preferences and time allocation choices, where individuals first choose whether they pursue extra-world or intra-world self-realization, and, then, based on these preferences, allocate time between spiritual development and the production of material goods.

We showed that, in the absence of information on preferences, one cannot infer the pursued life-goal from the time allocation prevailing at the temporary equilibrium. We also showed that, from an intertemporal perspective, *a rise in working time does not necessarily reveal a shift from extra-world to intra-world self-realization, but could, in theory, occur as a result of pursuing extra-world self-realization, or, alternatively, of pursuing intra-world self-realization.*

In order to assess these different explanations of the Industrious Revolution, we calibrated the model so as to replicate numerically the decline of religious holidays in old-regime France (1640-1780). Our results suggest that *the French Industrious Revolution is best explained, within our model, by a continuous quest of the Modern Man for intra-world self-realization.* As such, our analysis does not corroborate Tilgher's hypothesis, which associates the reorientation of efforts towards the outside world with the transition from an Ancient to a Modern Man. The rise in working time can be better rationalized without such a transition, by the mere persistence of the Modern Man across History. Hence, our findings do not support the existence of a major change in the structure of human incentives.

One should be cautious before interpreting our results as suggesting that a transition from the Ancient Man to the Modern Man cannot have any explanatory role for the rise of the bourgeois society. Our results suggest merely that the smoothly increasing pattern of working time during the Industrious Revolution is not compatible with a regime shift involving a transition from a Man valuing spiritual development only to a Man valuing material standards of living only. In other words, *our results do not exclude the emergence of a Modern Man, but only the emergence of a Modern Man that would be so different from the Ancient Man, in the way that Tilgher described these historical ideal-types.*

To conclude, it should be stressed that Tilgher's hypothesis was studied while abstracting from major transformations that took place during the Pre-Industrial era, such as the institutional change towards democratization (Cervellati and Sunde 2014, 2018, Buonanno et al 2022), the demographic transition (Cervellati and Sunde, 2011, 2013, 2015) and the rise of a 'knowledge economy' (Mokyr 2002, 2005, 2016, de la Croix et al 2018, de la Croix and Goni, 2024, de la Croix et al 2024). It would be promising to examine how Tilgher's hypothesis could be articulated with those transformations. Much work remains to be done to better understand the pre-conditions for the Industrial Revolution.

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## 9 Appendix

### 9.1 Proof of Corollary 1

Given that  $s_t \equiv ZX^{1-\beta}L_t^\beta(\bar{m}+m_t)$  and that the optimal time allocation  $(\ell_t^*, m_t^*)$  depends only on  $L_t$ , the three arguments of  $U^S(s_t^*, \ell_t^*, m_t^*)$  are functions of  $L_t$ . We can thus rewrite  $U^S(s_t^*, \ell_t^*, m_t^*)$  as a function having  $L_t$  as a unique argument, that is,  $W^S(L_t)$ . We have, when  $\Gamma > 0$ :

$$W^S(L_t) = \begin{cases} ZX^{1-\beta}L_t^\beta(1-\bar{\ell}) - \delta\frac{(1-\bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2} & \text{when } ZX^{1-\beta}L_t^\beta \geq \Gamma \\ ZX^{1-\beta}L_t^\beta\left(\frac{\varepsilon+ZX^{1-\beta}L_t^\beta}{\delta+\varepsilon}\right) - \delta\frac{\left(\frac{\varepsilon+ZX^{1-\beta}L_t^\beta}{\delta+\varepsilon}\right)^2}{2} - \varepsilon\frac{\left(\frac{\delta-ZX^{1-\beta}L_t^\beta}{\delta+\varepsilon}\right)^2}{2} & \text{when } \Xi < ZX^{1-\beta}L_t^\beta < \Gamma, \\ ZX^{1-\beta}L_t^\beta\bar{m} - \delta\frac{(\bar{m})^2}{2} - \varepsilon\frac{(1-\bar{m})^2}{2} & \text{when } ZX^{1-\beta}L_t^\beta \leq \Xi \end{cases}$$

Moreover, when  $\Gamma \leq 0$ , we have:

$$W^S(L_t) = ZX^{1-\beta}L_t^\beta(1-\bar{\ell}) - \delta\frac{(1-\bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2}$$

The proof thus consists in showing that  $W^S(L_t)$  is continuous and differentiable over the entire interval of values for  $L_t > 0$ .

Consider first the case where  $\Gamma \leq 0$ . We then have:

$$W^S(L_t) = ZX^{1-\beta}L_t^\beta(1-\bar{\ell}) - \delta\frac{(1-\bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2}$$

which is continuous and differentiable in  $L_t$ .

Consider now the case where  $\Gamma > 0$ . From Lemma 1, we know that  $W^S(L_t)$  can take three distinct forms, depending on whether  $ZX^{1-\beta}L_t^\beta \geq \Gamma$ ,  $\Xi < ZX^{1-\beta}L_t^\beta < \Gamma$  or  $ZX^{1-\beta}L_t^\beta \leq \Xi$ . Within each of the three intervals for  $L_t$ ,  $W^S(L_t)$  is continuous and differentiable in  $L_t$ . Hence, in order to show that  $W^S(L_t)$  is continuous and differentiable over the entire interval of values for  $L_t$ , we need to show that, at each threshold for  $L_t$ , that is, at  $L_t = \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}$  and at  $L_t = \left[\frac{\Xi}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}$ , (i) there is no ‘jump’ or discontinuity of  $W^S(L_t)$  (that is, same level of utility on the two sides of each critical threshold) and (ii) there is no kink (that is, same slope on the two sides of each critical threshold).

Consider the first threshold. Note that, when  $L_t \rightarrow \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}$ , we have:

$$\begin{aligned}
& \lim_{L_t \rightarrow \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}} W^S(L_t) \Big|_{\Xi < ZX^{1-\beta} L_t^\beta < \Gamma} \\
&= \lim_{L_t \rightarrow \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}} ZX^{1-\beta} L_t^\beta \left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right)^2}{2} \\
&= ZX^{1-\beta} \frac{\Gamma}{ZX^{1-\beta}} \left( \frac{\varepsilon + \Gamma}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + \Gamma}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - \Gamma}{\delta + \varepsilon} \right)^2}{2} \\
&= \Gamma (1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} = W^S(L_t) \Big|_{ZX^{1-\beta} L_t^\beta \geq \Gamma}
\end{aligned}$$

Hence  $W^S(L_t)$  exhibit no ‘jump’ or discontinuity at  $L_t = \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}$ .

When  $\Gamma > 0$  and  $ZX^{1-\beta} L_t^\beta \geq \Gamma$ , we have:

$$\frac{\partial W^S(L_t)}{\partial L_t} \Big|_{ZX^{1-\beta} L_t^\beta \geq \Gamma} = ZX^{1-\beta} \beta L_t^{\beta-1} (1 - \bar{\ell}) \geq 0 \iff \beta \geq 0.$$

Moreover, when  $\Xi < ZX^{1-\beta} L_t^\beta < \Gamma$ , we have:

$$\begin{aligned}
\frac{\partial W^S(L_t)}{\partial L_t} \Big|_{\Xi < ZX^{1-\beta} L_t^\beta < \Gamma} &= ZX^{1-\beta} \beta L_t^{\beta-1} \left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right) + ZX^{1-\beta} L_t^\beta \left( \frac{\beta ZX^{1-\beta} L_t^{\beta-1}}{\delta + \varepsilon} \right) \\
&\quad - \delta \frac{2 \left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right) \frac{\beta ZX^{1-\beta} L_t^{\beta-1}}{\delta + \varepsilon}}{2} - \varepsilon \frac{2 \left( \frac{\delta - ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right) \frac{-\beta ZX^{1-\beta} L_t^{\beta-1}}{\delta + \varepsilon}}{2} \\
&= ZX^{1-\beta} \beta L_t^{\beta-1} \left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right) \geq 0 \iff \beta \geq 0
\end{aligned}$$

Note that:

$$\begin{aligned}
\lim_{L_t \rightarrow \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}} \frac{\partial W^S(L_t)}{\partial L_t} \Big|_{ZX^{1-\beta} L_t^\beta \geq \Gamma} &= ZX^{1-\beta} \beta \left[ \frac{\Gamma}{ZX^{1-\beta}} \right]^{\frac{\beta-1}{\beta}} (1 - \bar{\ell}) \\
\lim_{L_t \rightarrow \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}} \frac{\partial W^S(L_t)}{\partial L_t} \Big|_{\Xi < ZX^{1-\beta} L_t^\beta < \Gamma} &= ZX^{1-\beta} \beta \left[ \frac{\Gamma}{ZX^{1-\beta}} \right]^{\frac{\beta-1}{\beta}} \frac{\varepsilon + \Gamma}{\delta + \varepsilon} = ZX^{1-\beta} \beta \left[ \frac{\Gamma}{ZX^{1-\beta}} \right]^{\frac{\beta-1}{\beta}} (1 - \bar{\ell})
\end{aligned}$$

Hence there is no kink at  $L_t = \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}$ : the slope of  $W^S(L_t)$  is uniquely defined at  $L_t = \left[\frac{\Gamma}{ZX^{1-\beta}}\right]^{\frac{1}{\beta}}$ .

Consider now the second threshold. When  $L_t \rightarrow [\frac{\Xi}{ZX^{1-\beta}}]^\frac{1}{\beta}$ , we have:

$$\begin{aligned}
\lim_{L_t \rightarrow [\frac{\Xi}{ZX^{1-\beta}}]^\frac{1}{\beta}} W^S(L_t) \Big|_{\Xi < ZX^{1-\beta} L_t^\beta < \Gamma} &= ZX^{1-\beta} L_t^\beta \left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right)^2}{2} \\
&= \Xi \left( \frac{\varepsilon + \Xi}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + \Xi}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - \Xi}{\delta + \varepsilon} \right)^2}{2} \\
&= \Xi \bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} = W^S(L_t) \Big|_{ZX^{1-\beta} L_t^\beta \leq \Xi}
\end{aligned}$$

Hence  $W^S(L_t)$  exhibit no ‘jump’ or discontinuity at  $L_t = [\frac{\Xi}{ZX^{1-\beta}}]^\frac{1}{\beta}$ .

Moreover, we have also:

$$\begin{aligned}
\lim_{L_t \rightarrow [\frac{\Xi}{ZX^{1-\beta}}]^\frac{1}{\beta}} \frac{\partial W^S(L_t)}{\partial L_t} \Big|_{ZX^{1-\beta} L_t^\beta \leq \Xi} &= ZX^{1-\beta} \beta \left[ \frac{\Xi}{ZX^{1-\beta}} \right]^\frac{\beta-1}{\beta} \bar{m} \\
\lim_{L_t \rightarrow [\frac{\Xi}{ZX^{1-\beta}}]^\frac{1}{\beta}} \frac{\partial W^S(L_t)}{\partial L_t} \Big|_{\Xi < ZX^{1-\beta} L_t^\beta < \Gamma} &= ZX^{1-\beta} \beta \left[ \frac{\Xi}{ZX^{1-\beta}} \right]^\frac{\beta-1}{\beta} \bar{m}
\end{aligned}$$

Hence there is no kink at  $L_t = [\frac{\Xi}{ZX^{1-\beta}}]^\frac{1}{\beta}$ : the slope of  $W^S(L_t)$  is uniquely defined at  $L_t = [\frac{\Xi}{ZX^{1-\beta}}]^\frac{1}{\beta}$ .

This completes the proof of Corollary 1.

## 9.2 Proof of Corollary 2

Note first that, given that  $y_t \equiv AX^{1-\alpha} L_t^\alpha (\bar{\ell} + \ell_t)$  and that the optimal time allocation  $(\ell_t, m_t)$  depends only on  $L_t$ , the three arguments of the indirect utility function  $U^Y(s_t^*, \ell_t^*, m_t^*)$  are functions of  $L_t$ . We can thus rewrite  $U^Y(s_t^*, \ell_t^*, m_t^*)$  as a function having  $L_t$  as a unique argument, that is,  $W^Y(L_t)$ .

When  $\Gamma < 0$ , we have:

$$W^Y(L_t) = \begin{cases} AX^{1-\alpha} L_t^\alpha \bar{\ell} - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} & \text{when } AX^{1-\alpha} L_t^\alpha \leq -\Gamma \\ AX^{1-\alpha} L_t^\alpha \left( \frac{AX^{1-\alpha} L_t^\alpha + \delta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon - AX^{1-\alpha} L_t^\alpha}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{AX^{1-\alpha} L_t^\alpha + \delta}{\delta + \varepsilon} \right)^2}{2} & \text{when } -\Gamma < AX^{1-\alpha} L_t^\alpha < -\Xi \\ AX^{1-\alpha} L_t^\alpha (1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} & \text{when } -\Xi \leq AX^{1-\alpha} L_t^\alpha \end{cases}$$

and, when  $\Gamma \geq 0$ :

$$W^Y(L_t) = AX^{1-\alpha} L_t^\alpha (1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$$

The proof thus consists in showing that  $W^Y(L_t)$  is continuous and differentiable over the entire interval of values for  $L_t > 0$ .

Assume  $\Gamma \geq 0$ . we have that  $W^Y(L_t)$  is continuous and differentiable in  $L_t$ . Consider now the case where  $\Gamma < 0$ . From Lemma 2, we know that  $W^Y(L_t)$  can take three distinct forms, depending on whether  $AX^{1-\alpha}L_t^\alpha \leq -\Gamma$ ,  $-\Gamma < AX^{1-\alpha}L_t^\alpha < -\Xi$  or  $AX^{1-\alpha}L_t^\alpha \geq -\Xi$ . Within each of the three intervals for  $L_t$ ,  $W^Y(L_t)$  is continuous and differentiable in  $L_t$ . Hence, in order to show that  $W^Y(L_t)$  is continuous and differentiable over the entire interval of values for  $L_t$ , we need to show that, at each threshold for  $L_t$ , that is, at  $L_t = \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$  and at  $L_t = \left[\frac{-\Xi}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ , (i) there is no ‘jump’ or discontinuity of  $W^Y(L_t)$  (that is, same level of utility on the two sides of each critical threshold) and (ii) there is no kink (that is, same slope on the two sides of each critical threshold).

Consider the first threshold. Note that, when  $L_t \rightarrow \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ , we have:

$$\begin{aligned}
& \lim_{L_t \rightarrow \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}} W^Y(L_t) \Big|_{-\Gamma < AX^{1-\alpha}L_t^\alpha < -\Xi} \\
&= \lim_{L_t \rightarrow \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}} AX^{1-\alpha}L_t^\alpha \left( \frac{AX^{1-\alpha}L_t^\alpha + \delta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon - AX^{1-\alpha}L_t^\alpha}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{AX^{1-\alpha}L_t^\alpha + \delta}{\delta + \varepsilon} \right)^2}{2} \\
&= -\Gamma \left( \frac{-\Gamma + \delta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + \Gamma}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{-\Gamma + \delta}{\delta + \varepsilon} \right)^2}{2} \\
&= -\Gamma \bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} = W^Y(L_t) \Big|_{AX^{1-\alpha}L_t^\alpha \leq -\Gamma}
\end{aligned}$$

Hence  $W^Y(L_t)$  exhibit no ‘jump’ or discontinuity at  $L_t = \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ . When  $\Gamma < 0$  and  $AX^{1-\alpha}L_t^\alpha \leq -\Gamma$ , we have:

$$\frac{\partial W^Y(L_t)}{\partial L_t} \Big|_{AX^{1-\alpha}L_t^\alpha \leq -\Gamma} = AX^{1-\alpha} \alpha L_t^{\alpha-1} \bar{\ell} \geq 0 \iff \alpha \geq 0.$$

Moreover, when  $-\Gamma < AX^{1-\alpha}L_t^\alpha < -\Xi$ , we have:

$$\begin{aligned}
\frac{\partial W^Y(L_t)}{\partial L_t} \Big|_{-\Gamma < AX^{1-\alpha}L_t^\alpha < -\Xi} &= AX^{1-\alpha} \alpha L_t^{\alpha-1} \left( \frac{AX^{1-\alpha}L_t^\alpha + \delta}{\delta + \varepsilon} \right) + AX^{1-\alpha} L_t^\alpha \left( \frac{AX^{1-\alpha} \alpha L_t^{\alpha-1}}{\delta + \varepsilon} \right) \\
&\quad - \delta 2 \frac{\left( \frac{\varepsilon - AX^{1-\alpha}L_t^\alpha}{\delta + \varepsilon} \right) \left( \frac{-AX^{1-\alpha} \alpha L_t^{\alpha-1}}{\delta + \varepsilon} \right)}{2} - \varepsilon \frac{2 \left( \frac{AX^{1-\alpha}L_t^\alpha + \delta}{\delta + \varepsilon} \right) \left( \frac{AX^{1-\alpha} \alpha L_t^{\alpha-1}}{\delta + \varepsilon} \right)}{2} \\
&= AX^{1-\alpha} \alpha L_t^{\alpha-1} \left( \frac{AX^{1-\alpha}L_t^\alpha + \delta}{\delta + \varepsilon} \right) \geq 0 \iff \alpha \geq 0
\end{aligned}$$

Note that:

$$\begin{aligned}
\lim_{L_t \rightarrow \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}} \frac{\partial W^Y(L_t)}{\partial L_t} \Big|_{AX^{1-\alpha}L_t^\alpha \leq -\Gamma} &= AX^{1-\alpha} \alpha \left[ \frac{-\Gamma}{AX^{1-\alpha}} \right]^{\frac{\alpha-1}{\alpha}} \bar{\ell} \\
\lim_{L_t \rightarrow \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}} \frac{\partial W^Y(L_t)}{\partial L_t} \Big|_{-\Gamma < AX^{1-\alpha}L_t^\alpha < -\Xi} &= AX^{1-\alpha} \alpha \left[ \frac{-\Gamma}{AX^{1-\alpha}} \right]^{\frac{\alpha-1}{\alpha}} \left( \frac{-\Gamma + \delta}{\delta + \varepsilon} \right) \\
&= AX^{1-\alpha} \alpha \left[ \frac{-\Gamma}{AX^{1-\alpha}} \right]^{\frac{\alpha-1}{\alpha}} \bar{\ell}
\end{aligned}$$

Hence there is no kink at  $L_t = \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ : the slope of  $W^Y(L_t)$  is uniquely defined at  $L_t = \left[\frac{-\Gamma}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ .

Consider now the second threshold. When  $L_t \rightarrow \left[\frac{-\Xi}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ , we have:

$$\begin{aligned}
&\lim_{L_t \rightarrow \left[\frac{-\Xi}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}} W^Y(L_t) \Big|_{-\Gamma < AX^{1-\alpha}L_t^\alpha < -\Xi} \\
&= AX^{1-\alpha} L_t^\alpha \left( \frac{AX^{1-\alpha} L_t^\alpha + \delta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon - AX^{1-\alpha} L_t^\alpha}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{AX^{1-\alpha} L_t^\alpha + \delta}{\delta + \varepsilon} \right)^2}{2} \\
&= -\Xi \left( \frac{-\Xi + \delta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + \Xi}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{-\Xi + \delta}{\delta + \varepsilon} \right)^2}{2} \\
&= -\Xi(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} = W^Y(L_t) \Big|_{AX^{1-\alpha}L_t^\alpha \geq -\Xi}
\end{aligned}$$

Hence  $W^Y(L_t)$  exhibit no ‘jump’ or discontinuity at  $L_t = \left[\frac{-\Xi}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ . Moreover, we have also:

$$\begin{aligned}
\lim_{L_t \rightarrow \left[\frac{-\Xi}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}} \frac{\partial W^Y(L_t)}{\partial L_t} \Big|_{AX^{1-\alpha}L_t^\alpha \geq -\Xi} &= AX^{1-\alpha} \alpha \left[ \frac{-\Xi}{AX^{1-\alpha}} \right]^{\frac{\alpha-1}{\alpha}} (1 - \bar{m}) \\
\lim_{L_t \rightarrow \left[\frac{-\Xi}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}} \frac{\partial W^Y(L_t)}{\partial L_t} \Big|_{-\Gamma < AX^{1-\alpha}L_t^\alpha < -\Xi} &= AX^{1-\alpha} \alpha L_t^{\alpha-1} \left( \frac{AX^{1-\alpha} L_t^\alpha + \delta}{\delta + \varepsilon} \right) \\
&= AX^{1-\alpha} \alpha \left[ \frac{-\Xi}{AX^{1-\alpha}} \right]^{\frac{\alpha-1}{\alpha}} (1 - \bar{m})
\end{aligned}$$

Hence there is no kink at  $L_t = \left[\frac{-\Xi}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ : the slope of  $W^Y(L_t)$  is uniquely defined at  $L_t = \left[\frac{-\Xi}{AX^{1-\alpha}}\right]^{\frac{1}{\alpha}}$ .

This completes the proof of Corollary 2.

### 9.3 Proof of Proposition 1

Under Condition 2, and using Lemma 3, we have:

$$\begin{aligned}
W^S(L_t) &= ZX^{1-\beta} L_t^\beta (1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \\
&\geq W^Y(L_t) = \left\{ \begin{array}{l} AX\bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \text{ when } AX \leq -\Gamma \\ AX \frac{(AX + \delta)}{\delta + \varepsilon} - \delta \frac{(\frac{\varepsilon - AX}{\delta + \varepsilon})^2}{2} - \varepsilon \frac{(\frac{AX + \delta}{\delta + \varepsilon})^2}{2} \text{ when } -\Gamma < AX < -\Xi \\ AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \text{ when } -\Xi \leq AX \end{array} \right\}
\end{aligned}$$

Note that the LHS is decreasing in  $L_t$  because of  $\beta < 0$  (Corollary 2), whereas the RHS does not depend on  $L_t$ . Hence, depending on conditions about  $AX$ , the relevant critical threshold at which  $W^S(L_t) = W^Y(L_t)$  is:

$$\begin{aligned}
L^* &\equiv \left[ \frac{AX\bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} + \delta \frac{(1 - \bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{ZX^{1-\beta} (1 - \bar{\ell})} \right]^{\frac{1}{\beta}} \text{ when } AX \leq -\Gamma \\
L^{**} &\equiv \left[ \frac{AX \frac{(AX + \delta)}{\delta + \varepsilon} - \delta \frac{(\frac{\varepsilon - AX}{\delta + \varepsilon})^2}{2} - \varepsilon \frac{(\frac{AX + \delta}{\delta + \varepsilon})^2}{2} + \delta \frac{(1 - \bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{ZX^{1-\beta} (1 - \bar{\ell})} \right]^{\frac{1}{\beta}} \text{ when } -\Gamma < AX < -\Xi \\
L^{***} &\equiv \left[ \frac{AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} + \delta \frac{(1 - \bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{ZX^{1-\beta} (1 - \bar{\ell})} \right]^{\frac{1}{\beta}} \text{ when } -\Xi \leq AX
\end{aligned}$$

Note that:  $\lim_{L_t \rightarrow 0} W^S(L_t) = +\infty > \lim_{L_t \rightarrow 0} W^Y(L_t)$ . Hence, for extremely low population sizes, the economy is such that individuals prefer EWSR over IWSR. Moreover, since  $W^S(L_t)$  is decreasing in  $L_t$  whereas  $W^Y(L_t)$  is a constant, and since  $\lim_{L_t \rightarrow +\infty} W^S(L_t) < 0$ , it must be the case that  $W^S(L_t)$  and  $W^Y(L_t)$  must intersect, and they must intersect only once.

Hence, the economy falls in only one of the following cases:

- Case I.1: when  $AX \leq -\Gamma$ ,  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^*$ ,
- Case I.2: when  $-\Gamma < AX < -\Xi$ ,  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{**}$ ,
- Case I.3: when  $-\Xi \leq AX$ ,  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{***}$ .

Those conditions are the ones that appear in Proposition 1. Since  $L_t$  is the unique latent variable, the remainder of the proof consists of identifying all possible cases, based on the initial condition  $L_0$ , and of deriving the associated regimes.

Let us first consider Case I.1, where  $AX \leq -\Gamma$ . The relevant critical threshold is here  $L^*$ . There are two possible subcases, based on the initial condition  $L_0 > 0$ :

- Case I.1.a:  $L_0 \leq L^*$ ,
- Case I.1.b:  $L^* < L_0$ .

Take Case I.1.a. When  $L_0 \leq L^*$ , we know that individuals look for EWSR, there is, based on Lemma 3, no extra labor time ( $\ell_t = 0$ ) and output per worker is constant and equal to  $y_0 = A\bar{\ell}X$ . This is Regime 1.

However,  $L_t$  grows over time, and crosses sooner or later the threshold  $L^*$ . This is Regime 2: when  $L_t > L^*$ , individuals look for IWSR, there is, based on Lemma 3, no extra labor time ( $\ell_t = 0$ ) and output per worker is constant and equal to  $y_0 = A\bar{\ell}X$ . The economy remains in that regime forever. Indeed, the condition  $AX \leq -\Gamma$  remains true forever, and thus, once  $L_t \geq L^*$  there has to be IWSR with zero extra labor time.

The Case I.1.b, where  $L^* < L_0$ , is a truncated case of Case I.1.a, where the economy initially starts in Regime 2.

Consider now Case I.2, where  $-\Gamma < AX < -\Xi$ . The relevant threshold is now  $L^{**}$ . There are two possible subcases, based on the initial condition  $L_0 > 0$ :

- Case I.2.a:  $L_0 \leq L^{**}$ ,
- Case I.2.b:  $L^{**} < L_0$ .

Take Case I.2.a. When  $L_0 \leq L^{**}$ , we know that individuals look for EWSR, there is, based on Lemma 3, no extra labor time ( $\ell_t = 0$ ) and output per worker is constant and equal to  $y_0 = A\bar{\ell}X$ . This is Regime 1.

However,  $L_t$  grows over time, and crosses sooner or later the threshold  $L^{**}$ . This is Regime 2: when  $L_t > L^{**}$ , individuals look for IWSR, there is, based on Lemma 3, interior extra labor time ( $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ), but which is time-invariant. Hence, output per worker is constant but higher than in Regime 1, and is now equal to  $y_t = A(\bar{\ell} + \ell_t)X$ . The economy remains in that regime forever. Indeed, the condition  $-\Gamma < AX < -\Xi$  remains true forever, and thus, once  $L_t \geq L^{**}$  there has to be IWSR with interior (fixed) extra labor time.

The Case I.2.b, where  $L^{**} < L_0$ , is a truncated case of Case I.2.a, where the economy initially starts in Regime 2.

Consider now Case I.3, where  $AX \geq -\Xi$ . The relevant threshold is now  $L^{***}$ . There are two possible subcases, based on the initial condition  $L_0 > 0$ :

- Case I.3.a:  $L_0 \leq L^{***}$ ,
- Case I.3.b:  $L^{***} < L_0$ .

Take Case I.3.a. When  $L_0 \leq L^{***}$ , we know that individuals look for EWSR, there is, based on Lemma 3, no extra labor time ( $\ell_t = 0$ ) and output per worker is constant and equal to  $y_0 = A\bar{\ell}X$ . This is Regime 1.

However,  $L_t$  grows over time, and crosses sooner or later the threshold  $L^{***}$ . This is Regime 2: when  $L_t > L^{***}$ , individuals look for IWSR, there is, based on Lemma 3, maximal extra labor time ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ), but which is time-invariant. Hence, output per worker is constant but higher than in Regime 1,

and is now equal to  $y_t = A(1 - \bar{m})X$ . The economy remains in that regime forever. Indeed, the condition  $AX \geq -\Xi$  remains true forever, and thus, once  $L_t \geq L^{***}$  there has to be IWSR with maximal (fixed) extra labor time.

The Case I.3.b, where  $L^{***} < L_0$ , is a truncated case of Case I.3.a, where the economy initially starts in Regime 2.

This completes the proof of Proposition 1.

## 9.4 Proof of Proposition 2

Under Condition 3, and using Lemma 3, we have:

$$\begin{aligned}
W^S(L_t) &= ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \\
&\geq W^Y(L_t) = \begin{cases} AX^{1-\alpha} L_t^\alpha \bar{\ell} - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} & \text{when } L_t \leq L' \\ AX^{1-\alpha} L_t^\alpha \left( \frac{AX^{1-\alpha} L_t^\alpha + \delta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon - AX^{1-\alpha} L_t^\alpha}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{AX^{1-\alpha} L_t^\alpha + \delta}{\delta + \varepsilon} \right)^2}{2} & \text{when } L' < L_t < L'' \\ AX^{1-\alpha} L_t^\alpha (1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} & \text{when } L'' \leq L_t \end{cases}
\end{aligned}$$

where  $L' \equiv \left[ \frac{-\Gamma}{AX^{1-\alpha}} \right]^{\frac{1}{\alpha}} < L'' \equiv \left[ \frac{-\Xi}{AX^{1-\alpha}} \right]^{\frac{1}{\alpha}}$ .

A first, key observation is that under Condition 3, the utility of EWSR  $W^S(L_t)$  is a constant, which does not vary with  $L_t$ , whereas the utility of IWSR  $W^Y(L_t)$  is increasing in  $L_t$  (Corollary 3).

Therefore, if there is an intersection of  $W^Y(L_t)$  and  $W^S(L_t)$ , that intersection must be unique. In other words, there can be no re-switching from one life-goal to another: the transition from EWSR to IWSR is unique and irreversible.

Given that the utility of intra-world self-realization is necessarily lower than the utility of EWSR when  $L_t \rightarrow 0$ , that is,  $\lim_{L_t \rightarrow 0} W^Y(L_t) = -\delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} < \lim_{L_t \rightarrow 0} W^S(L_t) = ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$ , EWSR dominates for very low population levels, and thus the economy must fall in only one of the following three cases:

- Case II.1:  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^+ \leq L'$ ;
- Case II.2:  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{++}$  with  $L' < L^{++} < L''$ ;
- Case II.3:  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{+++}$  with  $L'' \leq L^{+++}$ .

where

$$\begin{aligned}
L^+ &\equiv \left[ \frac{ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} + \delta \frac{(1-\bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{AX^{1-\alpha}\bar{\ell}} \right]^{\frac{1}{\alpha}} \\
L^{++} &\text{ such that } \left[ \begin{aligned} & ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \\ & = AX^{1-\alpha}L^{++\alpha} \left( \frac{AX^{1-\alpha}L^{++\alpha} + \delta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon - AX^{1-\alpha}L^{++\alpha}}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{AX^{1-\alpha}L^{++\alpha} + \delta}{\delta + \varepsilon} \right)^2}{2} \end{aligned} \right] \\
L^{+++} &\equiv \left[ \frac{ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} + \delta \frac{(\bar{m})^2}{2} + \varepsilon \frac{(1-\bar{m})^2}{2}}{AX^{1-\alpha}(1-\bar{m})} \right]^{\frac{1}{\alpha}}
\end{aligned}$$

Note that the critical threshold  $L^+$  is relevant only in Case II.1 where  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L_t \leq L'$ , but not when the intersection takes place at  $L_t > L'$ . Moreover, the threshold  $L^{++}$  is relevant only in Case II.2 where  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L' < L_t < L''$ , but not when the intersection takes place at  $L_t \leq L'$  or at  $L_t \geq L''$ . Finally, the threshold  $L^{+++}$  is relevant only in Case II.3 where  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L'' \leq L_t$ , but not when the intersection takes place at  $L_t < L''$ .

Regarding Case II.1, the condition about the intersection of  $W^Y(L_t)$  and  $W^S(L_t)$  takes the form of  $W^S(L') \leq W^Y(L')$ , that is:

$$ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \leq AX^{1-\alpha}L'^\alpha \bar{\ell} - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}$$

Regarding Case II.2, the condition about the intersection of  $W^Y(L_t)$  and  $W^S(L_t)$  takes the form of  $W^Y(L') < W^S(L') = W^S(L'') < W^Y(L'')$ , that is:

$$\begin{aligned}
& AX^{1-\alpha}L'^\alpha \bar{\ell} - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \\
< & ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \\
< & AX^{1-\alpha}L''^\alpha \left( \frac{AX^{1-\alpha}L''^\alpha + \delta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon - AX^{1-\alpha}L''^\alpha}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{AX^{1-\alpha}L''^\alpha + \delta}{\delta + \varepsilon} \right)^2}{2}
\end{aligned}$$

Regarding Case II.3, the condition about the intersection of  $W^Y(L_t)$  and  $W^S(L_t)$  takes the form of  $W^S(L'') \geq W^Y(L'')$ , that is:

$$ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \geq AX^{1-\alpha}L''^\alpha (1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}$$

Those conditions are the ones that appear in Proposition 2.

Since  $L_t$  is the unique latent variable of the model, the remainder of the proof consists of identifying all possible cases, based on the initial condition  $L_0$ , and of deriving the associated regimes.

Let us first consider Case II.1. There are four possible subcases, based on the initial condition  $L_0 > 0$ :

- Case II.1.a:  $L_0 \leq L^+ < L' < L''$ ,
- Case II.1.b:  $L^+ < L_0 < L' < L''$ ,
- Case II.1.c:  $L^+ < L' \leq L_0 < L''$ ,
- Case II.1.d:  $L^+ < L' < L'' \leq L_0$ .

Actually, one can see that Cases II.1.b, II.1.c and II.1.d are truncated versions of Case II.1.a, where the first regime is skipped.

Let us thus first resolve Case II.1.a:  $L_0 \leq L^+ < L' < L''$ . Since  $L_t$  grows over time due to Condition 1, the economy exhibits 4 regimes.

When  $L_t \leq L^+ < L' < L''$ , individuals look for EWSR, we know from Lemma 3 that there is no extra labor time ( $\ell_t = 0$ ) and output per worker is equal to  $y_t = A\bar{\ell}X^{1-\alpha}L_t^\alpha$  and is growing. This is Regime 1.

As  $L_t$  grows, sooner or later it will reach the critical threshold  $L^+$ . The economy then enters Regime 2. When  $L^+ < L_t < L' < L''$ , individuals shift from EWSR to IWSR. However, since  $L_t < L'$ ,  $\ell_t = 0$  and output per worker is equal to  $y_t = A\bar{\ell}X^{1-\alpha}L_t^\alpha$  and is growing.

Since  $L_t$  grows, sooner or later it will reach the critical threshold  $L'$ : then, when  $L^+ < L' \leq L_t < L''$ , individuals still look for IWSR, but there is now interior extra labor time ( $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ) and output per worker is equal to  $y_t = A(\bar{\ell} + \ell_t)X^{1-\alpha}L_t^\alpha$  and is growing. This is Regime 3.

Finally,  $L_t$  will, by growing, reach the critical threshold  $L''$ . Then, when  $L^+ < L' < L'' \leq L_t$ , individuals still look for IWSR, but there is now maximal extra labor time ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ) and output per worker is equal to  $y_t = A(1 - \bar{m})X^{1-\alpha}L_t^\alpha$  and is growing. This is Regime 4. Since the population size will keep on increasing, the economy will remain in that regime without turning back to previous regimes.

This completes the proof of Case II.1.a.

Case II.1.b is a truncated case of Case II.1.a, where Regime 1 of Case II.1.a is skipped, the economy starting initially in Regime 2 in Case II.1.a. Similarly, Case II.1.c is also a truncated case, where Regimes 1 and 2 of Case II.1.a are skipped: the economy starts immediately in Regime 3 of Case II.1.a. Finally, Case II.1.d is a truncated case, where Regimes 1, 2 and 3 of Case II.1.a are skipped: the economy then starts immediately in Regime 4 of Case II.1.a.

Let us now consider Case II.2. Given the condition:

$$\begin{aligned}
& AX^{1-\alpha}L'^\alpha\bar{\ell} - \delta\frac{(1-\bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2} \\
< & ZX(1-\bar{\ell}) - \delta\frac{(1-\bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2} \\
< & AX^{1-\alpha}L''^\alpha\left(\frac{AX^{1-\alpha}L''^\alpha + \delta}{\delta + \varepsilon}\right) - \delta\frac{\left(\frac{\varepsilon - AXL''^\alpha}{\delta + \varepsilon}\right)^2}{2} - \varepsilon\frac{\left(\frac{AX^{1-\alpha}L''^\alpha + \delta}{\delta + \varepsilon}\right)^2}{2}
\end{aligned}$$

we know that the shift from EWSR to IWSR takes place when intra-world self-realization recommends an interior extra labor time. Thus the relevant critical threshold is now  $L^{++}$ .

If  $L_0 \leq L^{++} < L''$ , the economy is initially in a state where individuals look for EWSR, there is no extra labor time ( $\ell_t = 0$ ) and output per worker is equal to  $y_t = A\bar{\ell}X^{1-\alpha}L_t^\alpha$  and is growing. This is Regime 1.

As  $L_t$  grows, sooner or later it will cross the threshold  $L^{++}$ . When  $L^{++} < L_t < L''$ , individuals shift to IWSR, and, due to Lemma 3, there is interior extra labor time ( $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ). This is Regime 2. Output per worker is equal to  $y_t = A(\bar{\ell} + \ell_t)X^{1-\alpha}L_t^\alpha$  and is growing.

As  $L_t$  keeps on growing,  $L_t$  will reach the critical threshold  $L''$ . When  $L^{++} < L'' \leq L_t$ , individuals look for IWSR, but there is maximal extra labor time ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ) and output per worker is equal to  $y_t = A(1 - \bar{m})X^{1-\alpha}L_t^\alpha$  and is growing. This is Regime 3. The economy will remain forever in that regime.

Case II.2.b is a truncated case of Case II.2.a, where Regime 1 of Case II.2.a is skipped, the economy starting initially in Regime 2 in Case II.2.a. Similarly, Case II.2.c is also a truncated case, where Regimes 1 and 2 of Case II.2.a are skipped: the economy starts in Regime 3 of Case II.2.a.

Let us now consider Case II.3. Given the condition:

$$ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \geq AX^{1-\alpha}L''^\alpha(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$$

we know that the shift from EWSR to IWSR will take place at  $L_t \geq L''$ , that is, when IWSR recommends maximal extra labor time. Hence the relevant critical threshold is here  $L^{+++}$ .

Consider Case II.3.a. If  $L_0 \leq L^{+++}$  and  $ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \geq AX^{1-\alpha}L''^\alpha(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$ , based on Lemma 3, the economy is initially in a situation where individuals look for EWSR, there is no extra labor time ( $\ell_t = 0$ ) and output per worker is equal to  $y_t = A\bar{\ell}X^{1-\alpha}L_t^\alpha$  and is growing. This is Regime 1.

Then, as  $L_t$  grows, the economy reaches the stage where  $L^{+++} < L_t$ , at which individuals start looking for IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$  and output per worker is equal to  $y_t = A(1 - \bar{m})X^{1-\alpha}L_t^\alpha$  and is growing. This is Regime 2, where the economy will remain forever.

Note that Case II.3.b, where  $L_0 > L^{+++}$  and  $ZX(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \geq AX^{1-\alpha}L''^\alpha(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$ , is just a truncated case of Case II.3.a, where the economy starts initially in Regime 2 and remains there forever.

This completes the proof of Proposition 2.

## 9.5 Proof of Proposition 3

We have:

$$\begin{aligned}
W^S(L_t) &= \begin{cases} ZX^{1-\beta} L_t^\beta (1 - \bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}, & \text{when } L_t \leq \left[ \frac{\Gamma}{ZX^{1-\beta}} \right]^{\frac{1}{\beta}} \\ ZX^{1-\beta} L_t^\beta \left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta} L_t^\beta}{\delta + \varepsilon} \right)^2}{2}, & \text{when } \left[ \frac{\Gamma}{ZX^{1-\beta}} \right]^{\frac{1}{\beta}} < L_t < \left[ \frac{\bar{\Xi}}{ZX^{1-\beta}} \right]^{\frac{1}{\beta}} \\ ZX^{1-\beta} L_t^\beta \bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}, & \text{when } \left[ \frac{\bar{\Xi}}{ZX^{1-\beta}} \right]^{\frac{1}{\beta}} \leq L_t \end{cases} \\
&\cong W^Y(L_t) = AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}
\end{aligned}$$

A first, key observation is that the utility of EWSR  $W^S(L_t)$  is decreasing in  $L_t$  (see Corollary 2), whereas the utility of IWSR  $W^Y(L_t)$  is a constant, which does not vary with  $L_t$ .

Therefore, if there is an intersection of  $W^Y(L_t)$  and  $W^S(L_t)$ , that intersection must be unique. In other words, there can be no re-switching from one life-goal to another: the transition from EWSR to IWSR is unique and irreversible.

Given that the utility of IWSR is lower than the utility of EWSR when  $L_t \rightarrow 0$ , that is,  $\lim_{L_t \rightarrow 0} W^Y(L_t) < \lim_{L_t \rightarrow 0} W^S(L_t) = +\infty$ , EWSR dominates for very low population levels, and thus the economy must fall in only one of the following three cases:

- Case III.1:  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^\# \leq L'''$ ;
- Case III.2:  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{\#\#}$  with  $L''' < L^{\#\#} < L''''$ ;
- Case III.3:  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{\#\#\#}$  with  $L'''' \leq L^{\#\#\#}$ .

where

$$\begin{aligned}
L^\# &\equiv \left[ \frac{AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} + \delta \frac{(1-\bar{\ell})^2}{2} + \varepsilon \frac{(\bar{\ell})^2}{2}}{ZX^{1-\beta} (1 - \bar{\ell})} \right]^{\frac{1}{\beta}} \\
L^{\#\#} &\text{ such that } \left[ \begin{aligned} & ZX^{1-\beta} L^{\#\#\beta} \left( \frac{\varepsilon + ZX^{1-\beta} L^{\#\#\beta}}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta} L^{\#\#\beta}}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta} L^{\#\#\beta}}{\delta + \varepsilon} \right)^2}{2} \\ & = AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} \end{aligned} \right] \\
L^{\#\#\#} &\equiv \left[ \frac{AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} + \delta \frac{(\bar{m})^2}{2} + \varepsilon \frac{(1-\bar{m})^2}{2}}{ZX^{1-\beta} \bar{m}} \right]^{\frac{1}{\alpha}}
\end{aligned}$$

Note that the critical threshold  $L^\#$  is relevant only in Case III.1 where  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L_t \leq L'''$ , but not when the intersection takes place at  $L_t > L'''$ . Moreover, the threshold  $L^{\#\#}$  is relevant only in Case III.2 where  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L''' < L_t < L''''$ , but not when the intersection takes place at  $L_t \leq L'''$  or at  $L_t \geq L''''$ . Finally, the threshold  $L^{\#\#\#}$  is relevant only in Case III.3 where  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L'''' \leq L_t$ , but not when the intersection takes place at  $L_t < L''''$ .

Regarding Case III.1, the condition about the intersection of  $W^Y(L_t)$  and  $W^S(L_t)$  takes the form of  $W^S(L''') \leq W^Y(L''')$ , that is:

$$ZX^{1-\beta}L'''\beta(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \leq AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}$$

Regarding Case III.2, the condition about the intersection of  $W^Y(L_t)$  and  $W^S(L_t)$  takes the form of  $W^S(L''') < W^Y(L''') < W^S(L''')$ , that is:

$$\begin{aligned} & ZX^{1-\beta}L'''\beta \left( \frac{\varepsilon + ZX^{1-\beta}L'''\beta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta}L'''\beta}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta}L'''\beta}{\delta + \varepsilon} \right)^2}{2} \\ < & AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} \\ < & ZX^{1-\beta}L'''\beta(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \end{aligned}$$

Regarding Case III.3, the condition about the intersection of  $W^Y(L_t)$  and  $W^S(L_t)$  takes the form of  $W^S(L''') \geq W^Y(L''')$ , that is:

$$ZX^{1-\beta}L'''\beta\bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} \geq AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}$$

Those conditions are the ones that appear in Proposition 3.

Since  $L_t$  is the unique latent variable of the model, the remainder of the proof consists of identifying all possible cases, based on the initial condition  $L_0$ , and of deriving the associated regimes.

Let us first consider Case III.1. There are four possible subcases, based on the initial condition  $L_0 > 0$ :

- Case III.1.a:  $L_0 \leq L^\# < L''' < L''''$ ,
- Case III.1.b:  $L^\# < L_0 < L''' < L''''$ ,
- Case III.1.c:  $L^\# < L''' \leq L_0 < L''''$ ,
- Case III.1.d:  $L^\# < L''' < L'''' \leq L_0$ .

Actually, one can see that Cases III.1.b, III.1.c and III.1.d are truncated versions of Case III.1.a, where the first regime is skipped.

Let us thus first resolve Case III.1.a:  $L_0 \leq L^\# < L''' < L''''$ . Since  $L_t$  grows over time due to Condition 1, the economy exhibits 2 regimes.

When  $L_0 \leq L^\# < L''' < L''''$ , and  $ZX^{1-\beta}L'''\beta\bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} \geq AX(1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}$ , we know from Lemma 3 that individuals look for EWSR, and that there is no extra labor time. As a consequence, output per worker is equal to  $y_0 = A\bar{\ell}X$  and is constant.

Note that  $L_t$  grows over time. Hence sooner or later it will reach the critical level  $L^\#$ . From Lemma 3, we know that individuals shift then to IWSR, with

maximal extra labor ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ). This is Regime 2. As a consequence of the rise of labor time, output per worker is now equal to  $y_t = A(1 - \bar{\ell})X$ , but remains constant. Note that further rises of  $L_t$  will have no impact any more, so that the economy will remain in Regime 2 forever.

Note that Case III.1.b, where  $L^\# < L_0 < L''' < L''''$  and  $ZX^{1-\beta}L''''^\beta(1 - \bar{\ell}) - \delta\frac{(1-\bar{\ell})^2}{2} - \varepsilon\frac{(\bar{\ell})^2}{2} \leq AX(1 - \bar{m}) - \delta\frac{(\bar{m})^2}{2} - \varepsilon\frac{(1-\bar{m})^2}{2}$ , is just a truncated case of Case III.1.a, where the economy is immediately in Regime 2: individuals look for IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$  and  $y_t = A(1 - \bar{\ell})X$ .

Consider now Case III.2.a, where  $L_0 \leq L''' < L^{\#\#} < L''''$  and

$$\begin{aligned} & ZX^{1-\beta}L''''^\beta \left( \frac{\varepsilon + ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right)^2}{2} \\ < & AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \\ < & ZX^{1-\beta}L''''^\beta(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \end{aligned}$$

From Lemma 3, we know that initially, individuals look for EWSR,  $\ell_t = 0$  and  $y_t = A\bar{\ell}X$ . This is Regime 1.

However,  $L_t$  grows over time, and will reach  $L'''$ .

When  $L''' < L_t \leq L^{\#\#} < L''''$ , individuals look for EWSR, there is interior extra labor time ( $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ) and output per worker is equal to  $y_t = A(\bar{\ell} + \ell_t)X$  and is growing. This is Regime 2.

But Regime 2 is not the end of history: as  $L_t$  grows, it will reach the threshold  $L^{\#\#}$ . From Lemma 3, we know that individuals then shift to IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$  and  $y_t = A(1 - \bar{m})X$ . This is Regime 3, where the economy will remain.

Case III.2.b is a truncated case of Case III.2.a, where Regime 1 is skipped. Thus there are only two regimes.

When  $L''' < L_t \leq L^{\#\#} < L''''$ , and

$$\begin{aligned} & ZX^{1-\beta}L''''^\beta \left( \frac{\varepsilon + ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta}L''''^\beta}{\delta + \varepsilon} \right)^2}{2} \\ < & AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \\ < & ZX^{1-\beta}L''''^\beta(1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \end{aligned}$$

we know from Lemma 3 that individuals look for EWSR, there is interior extra labor time ( $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ). This is Regime 1, where output per worker is equal to  $y_t = A(\bar{\ell} + \ell_t)X$  and is growing.

As  $L_t$  grows, sooner or later it will reach  $L^{\#\#}$ . The economy enters Regime 2, where, on the basis of Lemma 3, individuals look for IWSR, there is maximal

extra labor time ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ) and output per worker is equal to  $y_t = A(1 - \bar{m})X$  and is constant.

Case III.2.c is a truncated case of Case III.2.a, where the economy starts immediately in Regime 3. Thus, when  $L''' < L^{###} < L_0 < L''''$ , and

$$\begin{aligned} & ZX^{1-\beta} L''''^\beta \left( \frac{\varepsilon + ZX^{1-\beta} L''''^\beta}{\delta + \varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon + ZX^{1-\beta} L''''^\beta}{\delta + \varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta - ZX^{1-\beta} L''''^\beta}{\delta + \varepsilon} \right)^2}{2} \\ < & AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \\ < & ZX^{1-\beta} L''''^\beta (1 - \bar{\ell}) - \delta \frac{(1 - \bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} \end{aligned}$$

we know from Lemma 3 that individuals look for IWSR,  $\ell_t = 1 - \bar{\ell} - \bar{m}$  and  $y_t = A(1 - \bar{m})X$ .

Consider now the Case III.3.a, where  $L_0 \leq L''' < L'''' \leq L^{###}$  and  $ZX^{1-\beta} L''''^\beta \bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \geq AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$ .

From Lemma 3, we know that, in the initial state of the economy, individuals look for EWSR, there is no extra labor time ( $\ell_t = 0$ ) and output per worker is equal to  $y_t = A\bar{\ell}X$  and is constant. This is Regime 1.

But as  $L_t$  is growing, it reaches the threshold  $L''$ , at which EWSR requires interior extra labor time (because of Lemma 3). Hence, once  $L''' < L_t < L'''' \leq L^{###}$ , individuals look for EWSR, there is interior extra labor time ( $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ) and output per worker is equal to  $y_t = A(\bar{\ell} + \ell_t)X$  and is growing. This is Regime 2.

$L_t$  keeps on growing, and at one point we have  $L''' < L'''' < L_t \leq L^{###}$ . By Lemma 3, individuals still look for EWSR, but there is now maximal extra labor time ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ) and output per worker is equal to  $y_t = A(1 - \bar{\ell})X$  and is constant. This is Regime 3.

As  $L_t$  keeps on growing, it will finally cross the threshold  $L^{###}$ . This is Regime 4. When  $L''' < L'''' < L^{###} < L_t$ , individuals look for IWSR, but there is still maximal extra labor time ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ) and output per worker is still equal to  $y_t = A(1 - \bar{\ell})X$  and is constant. Thus Regime 4 differs from Regime 3 only in terms of the pursued life-goals, whereas the means remain the same. The economy will remain forever in Regime 4.

Note that Case III.3.b where  $L''' < L_0 < L'''' \leq L^{###}$  and  $ZX^{1-\beta} L''''^\beta \bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \geq AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$  is a truncated version of Case III.3.a, where Regime 1 is skipped. Thus History is made of three regimes. Case III.3.c where  $L''' < L'''' < L_0 \leq L^{###}$  and  $ZX^{1-\beta} L''''^\beta \bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2} \geq AX(1 - \bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1 - \bar{m})^2}{2}$  is a truncated version of Case III.3.a, where both Regimes 1 and 2 are skipped. Hence only two regimes remain. Finally, Case III.3.d is also a truncated version of Case III.3.a, where Regimes 1, 2 and 3 are skipped. There remains thus only one regime, Regime 4 in Case III.3.a.

This completes the proof of Proposition 3.

## 9.6 Proof of Proposition 4

Under Condition 3, and using Lemma 3, we have:

$$\begin{aligned}
W^S(L_t) &= \left\{ \begin{array}{l} ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2}, \text{ when } ZX \geq \Gamma \\ ZX \left( \frac{\varepsilon+ZX}{\delta+\varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon+ZX}{\delta+\varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta-ZX}{\delta+\varepsilon} \right)^2}{2}, \text{ when } \Xi < ZX < \Gamma \\ ZX\bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}, \text{ when } ZX \leq \Xi \end{array} \right\} \\
&\geq W^Y(L_t) = AX^{1-\alpha} L_t^\alpha (1-\bar{m}) - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}
\end{aligned}$$

Note that the LHS of the condition does not vary with  $L_t$ , and is a constant. The RHS is increasing in  $L_t$  (Corollary 3).

Hence, depending on conditions about  $ZX$ , the relevant critical threshold at which  $W^S(L_t) = W^Y(L_t)$  is:

$$\begin{aligned}
L^\circ &\equiv \left[ \frac{ZX(1-\bar{\ell}) - \delta \frac{(1-\bar{\ell})^2}{2} - \varepsilon \frac{(\bar{\ell})^2}{2} + \delta \frac{(\bar{m})^2}{2} + \varepsilon \frac{(1-\bar{m})^2}{2}}{AX^{1-\alpha}(1-\bar{m})} \right]^{\frac{1}{\alpha}} \text{ when } ZX \geq \Gamma \\
L^{\circ\circ} &\equiv \left[ \frac{ZX \left( \frac{\varepsilon+ZX}{\delta+\varepsilon} \right) - \delta \frac{\left( \frac{\varepsilon+ZX}{\delta+\varepsilon} \right)^2}{2} - \varepsilon \frac{\left( \frac{\delta-ZX}{\delta+\varepsilon} \right)^2}{2} + \delta \frac{(\bar{m})^2}{2} + \varepsilon \frac{(1-\bar{m})^2}{2}}{AX^{1-\alpha}(1-\bar{m})} \right]^{\frac{1}{\alpha}} \text{ when } \Xi < ZX < \Gamma \\
L^{\circ\circ\circ} &\equiv \left[ \frac{ZX\bar{m} - \delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2} + \delta \frac{(\bar{m})^2}{2} + \varepsilon \frac{(1-\bar{m})^2}{2}}{AX^{1-\alpha}(1-\bar{m})} \right]^{\frac{1}{\alpha}} \text{ when } ZX \leq \Xi
\end{aligned}$$

Note that  $\lim_{L_t \rightarrow 0} W^S(L_t) > \lim_{L_t \rightarrow 0} W^Y(L_t) = -\delta \frac{(\bar{m})^2}{2} - \varepsilon \frac{(1-\bar{m})^2}{2}$ . For extremely low population sizes, individuals prefer EWSR over IWSR. Moreover, since  $W^Y(L_t)$  is increasing in  $L_t$  whereas  $W^S(L_t)$  is a constant, and since  $\lim_{L_t \rightarrow +\infty} W^S(L_t) = +\infty$ , it must be the case that  $W^S(L_t)$  and  $W^Y(L_t)$  must intersect, and they must intersect only once.

Hence the economy belongs to one of the following three cases:

- Case IV.1: when  $ZX \geq \Gamma$ ,  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^\circ$ ,
- Case IV.2: when  $\Xi < ZX < \Gamma$ ,  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{\circ\circ}$ ,
- Case IV.3: when  $ZX \leq \Xi$ ,  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{\circ\circ\circ}$ .

Those conditions are the ones that appear in Proposition 4. Since  $L_t$  is the unique latent variable, the rest of the proof consists of identifying all possible cases, based on the initial condition  $L_0$ , and of deriving the associated regimes.

Let us first consider Case IV.1, where  $ZX \geq \Gamma$ . The relevant critical threshold is here  $L^\circ$ . There are two possible subcases, depending on  $L_0 > 0$ :

- Case IV.1.a:  $L_0 \leq L^\circ$ ,

- Case IV.1.b:  $L^\circ < L_0$ .

Consider first Case IV.1.a, where  $ZX \geq \Gamma$  and  $L_0 \leq L^\circ$ . By Lemma 3, we know that, in the initial period, individuals look for EWSR, and choose zero extra labor time ( $\ell_t = 0$ ). Hence the output per worker is  $AX^{1-\alpha}\bar{\ell}L_t^\alpha$  and is growing over time, as  $L_t$  grows. This is Regime 1.

But as  $L_t$  grows, sooner or later it will reach  $L^\circ$ . The economy enters Regime 2: individuals now look for IWSR, and by Lemma 3  $\ell_t = 1 - \bar{\ell} - \bar{m}$ . Output per worker is now equal to  $AX^{1-\alpha}(1 - \bar{m})L_t^\alpha$  and is growing over time. The economy will remain forever in that regime.

Note that Case IV.1.b:  $L^\circ < L_0$  is a truncated version of Case IV.1.a, where Regime 1 is skipped. Thus the economy starts and remains forever in the Regime 2, where  $\ell_t = 1 - \bar{\ell} - \bar{m}$ . Output per worker is now equal to  $AX^{1-\alpha}(1 - \bar{m})L_t^\alpha$  and is growing over time.

Consider now Case IV.2, where , and where  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{\circ\circ}$ . The threshold  $L^{\circ\circ}$  is the only relevant threshold. Thus the economy belongs to two cases:

- Case IV.2.a:  $L_0 \leq L^{\circ\circ}$ ,
- Case IV.2.b:  $L^{\circ\circ} < L_0$ .

Let us start with Case IV.2.a. By Lemma 3, we know that initially individuals pursue EWSR, and that there is interior (fixed) extra labor ( $0 < \ell_t < 1 - \bar{\ell} - \bar{m}$ ). This is Regime 1. Output per worker is equal to  $AX^{1-\alpha}(\bar{\ell} + \ell_t)L_t^\alpha$  and grows over time as  $L_t$  grows.

When  $L_t$  reaches  $L^{\circ\circ}$ , the economy enters Regime 2. Indeed, by Lemma 3, we know that individuals now pursue IWSR, and  $\ell_t = 1 - \bar{\ell} - \bar{m}$ . Output per worker is now equal to  $AX^{1-\alpha}(1 - \bar{m})L_t^\alpha$  and is growing over time.

Note that Case IV.2.b:  $L^{\circ\circ} < L_0$  is a truncated version of Case IV.2.a, where Regime 1 is skipped. Thus the economy starts and remains forever in the Regime 2, where  $\ell_t = 1 - \bar{\ell} - \bar{m}$ . Output per worker is now equal to  $AX^{1-\alpha}(1 - \bar{m})L_t^\alpha$  and is growing over time.

Consider now Case IV.3, where  $\Xi < ZX < \Gamma$ , and where  $W^Y(L_t)$  and  $W^S(L_t)$  intersect at  $L^{\circ\circ\circ}$ . The threshold  $L^{\circ\circ\circ}$  is the only relevant threshold. Thus the economy belongs to two cases:

- Case IV.3.a:  $L_0 \leq L^{\circ\circ\circ}$ ,
- Case IV.3.b:  $L^{\circ\circ\circ} < L_0$ .

Let us start with Case IV.3.a. By Lemma 3, we know that initially individuals pursue EWSR, and that there is maximal extra labor ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ). This is Regime 1. Output per worker is equal to  $AX^{1-\alpha}(1 - \bar{m})L_t^\alpha$  and grows over time as  $L_t$  grows.

When  $L_t$  reaches  $L^{\circ\circ\circ}$ , the economy enters Regime 2. Indeed, by Lemma 3, we know that individuals now pursue IWSR, and that there is maximal extra

labor ( $\ell_t = 1 - \bar{\ell} - \bar{m}$ ). Output per worker is now equal to  $AX^{1-\alpha}(1 - \bar{m})L_t^\alpha$  and is growing over time.

Case IV.3.b:  $L^{\circ\circ\circ} < L_0$  is a truncated version of Case IV.3.a, where Regime 1 is skipped. Thus the economy starts and remains forever in the Regime 2, where  $\ell_t = 1 - \bar{\ell} - \bar{m}$ . Output per worker is now equal to  $AX^{1-\alpha}(1 - \bar{m})L_t^\alpha$  and is growing over time.

This completes the proof of Proposition 4.

## 9.7 Numerical explorations: robustness checks

In order to check for the robustness of our results, let us now reconsider the four explanations under some deviations from the baseline values for structural parameters. For that purpose, we will rely on the scenarios shown on Table 2 (other parameters keeping the same values as in the benchmark scenario).

Parameters	lower bound	intermediate value	upper bound
$\bar{\ell}$	0.273	0.438	0.761
$\bar{m}$	0.001	0.112	0.189
$\beta$	-0.300	-0.200	-0.100
$Z$	1.000	1.298	1.600

Table 2. Alternative calibrations for key parameters.

Let us first consider the robustness of our simulations to the level of  $\bar{\ell}$ . Note first that, when  $\bar{\ell}$  is fixed below the level of working time in year 1640, both explanations E3a and E3b are rejected, because none of these variants can, under these low levels of  $\bar{\ell}$ , replicate the number of days available for working observed in 1640.<sup>50</sup> Moreover, as shown on Figure 6a, considering lower levels for  $\bar{\ell}$  does not improve the quality of the fit under explanation E1 based on the Ancient Man's self-realization. Figure 6b shows that modifying the level of  $\bar{\ell}$  does not affect the quality of the fit under Explanation E2.

Figures 6a and 6b suggest that our previous findings are robust to the level of  $\bar{\ell}$ : assuming a lower  $\bar{\ell}$  does not affect our previous result: the rise in working time is best explained as a mere outcome of the Modern Man's pursuit of IWSR, without any historical role for the Ancient Man.

Let us now examine the robustness of our results to the parameter  $\bar{m}$ . Note first that, as in the benchmark case, explanation E3b is excluded. Moreover, adopting lower values for  $\bar{m}$  excludes also E3a, because E3a involves a regime shift that would here exhibit, after the regime shift, a (corner) level of total labor that is far above the observed values.<sup>51</sup> Hence, under lower values for  $\bar{m}$ , there remain only two explanations: E1 and E2. As shown on Figures 7a

<sup>50</sup>Indeed, under these alternative calibrations, these two explanations imply that the total labor before the regime shift, equal to  $\bar{\ell}$ , is much smaller than the observed number of days available for working in 1640. Hence explanations E3a and E3b cannot replicate the labor time prevailing in the initial period.

<sup>51</sup>Indeed, the corner total labor  $\bar{\ell} + \ell_t$  equals 0.999 under  $\bar{m} = 0.001$ , and equals 0.888 under  $\bar{m} = 0.112$ . Those values exceed the observed proportion of time dedicated to labor in 1780, equal to 0.810.

and 7b, adopting a lower value for  $\bar{m}$  improves slightly the quality of the fit under E1, but has no effect at all on the quality of the match under E2. The underlying intuition goes as follows. Since the optimal extra labor depends on  $\bar{m}$  only under EWSR, the Modern Man's conduct is invariant to the selected value of  $\bar{m}$ . This explains why E2 is unaffected by variations in  $\bar{m}$ . However, since the optimal extra labor under EWSR is decreasing in  $\bar{m}$ , a lower  $\bar{m}$  reinforces the replicated growth of the working time. This explains why adopting a lower value for  $\bar{m}$  tends to improve - slightly - the fit of explanation E1.

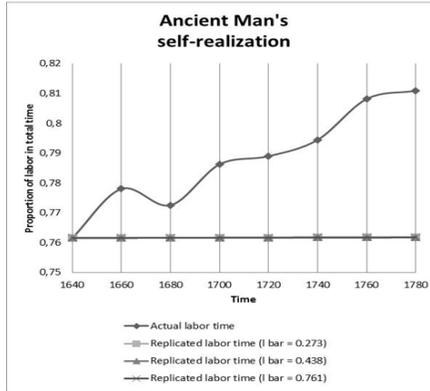


Figure 6a. Explanation E1 under various values for  $\bar{\ell}$ .

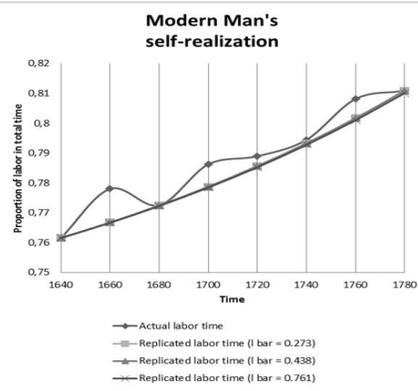


Figure 6b: Explanation E2 under various values for  $\bar{\ell}$ .

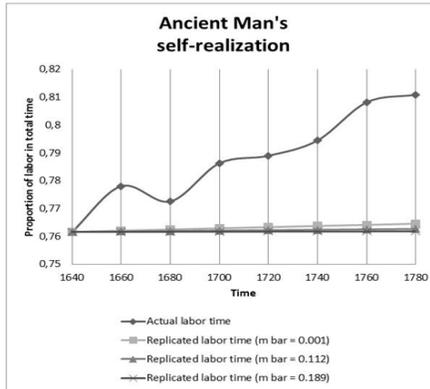


Figure 7a. Explanation E1 under various values for  $\bar{m}$ .

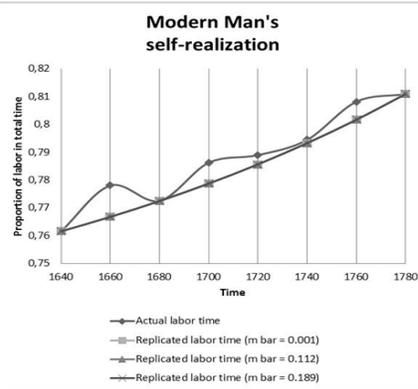


Figure 7b: Explanation E2 under various values for  $\bar{m}$ .

Another robustness check concerns the parameter  $\beta$ . In the benchmark case, we assumed either  $\beta = -0.100$  (under explanations E1 and E3a) or  $\beta = 0$  (under explanations E2 and E3b). In order to check whether our negative results concerning explanations E1 and E3a are robust to the postulated value of  $\beta$ ,

we examine here what the fit of these explanations would become under lower values for  $\beta$ , equal to  $-0.200$  and  $-0.300$ . Figures 8a and 8b show that reducing  $\beta$  has no significant effect on Explanations E1 and E3a. Our results are thus robust to the selected value of  $\beta$ .

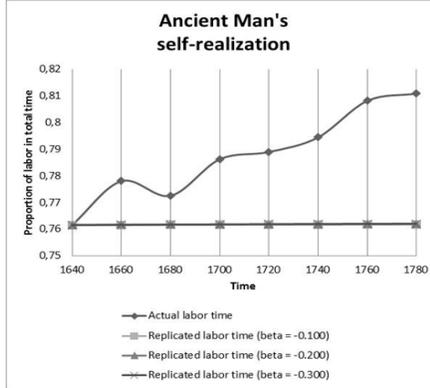


Figure 8a. Explanation E1 under various values for  $\beta$ .

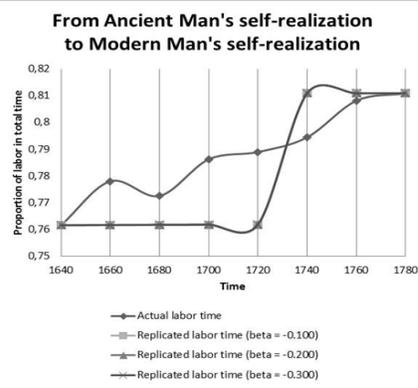


Figure 8b: Explanation E3a under various values for  $\beta$ .

Finally, in order to study the robustness of our results to the parameter  $Z$ , which was initially calibrated by assuming the same land-to-output ratio under spiritual and material production, let us now recompute the different explanations under alternative values for  $Z$ , such as  $Z = 1.000$  and  $Z = 1.600$ . As shown on Figures 9a, 9b and 9c, changing the level of  $Z$  has little impact on the quality of the fit under explanation E1, and no effect at all on explanations relying on the Modern Man's self-realization.

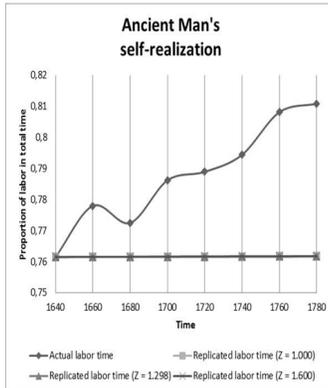


Figure 9a. Explanation E1 under various values for  $Z$ .

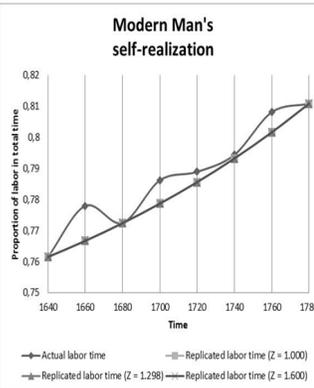


Figure 9b: Explanation E2 under various values for  $Z$ .

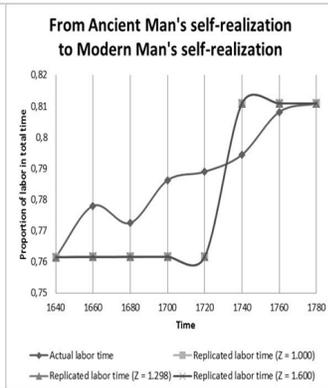


Figure 9c: Explanation E3a under various values for  $Z$ .