**UNIVERSITÀ DI GENOVA**
**SCUOLA DI SCIENZE SOCIALI**
**DIPARTIMENTO DI ECONOMIA**



Tesi di Laurea Magistrale

in

Management for Energy

and Environmental

Transition

# Growth, Resources, Systems of Production and Consumption: The Age of Limits and the Toyota Method

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**anno accademico 2025/2026**

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**Abstract (Italian)**

Il presente elaborato esamina la transizione storico-economica dal modello industriale fordista, fondato sull'illusione post-bellica di un'abbondanza illimitata di risorse energetiche e materiali, alla necessità attuale di un paradigma produttivo ed ecologico basato sulla sostenibilità biofisica e sulla circolarità. Partendo dalla formazione della Golden Age e dal suo cedimento nei primi anni Settanta, analizzato sia sul piano monetario (il collasso di Bretton Woods) sia su quello ecologico (il rapporto MIT sui limiti dello sviluppo), il lavoro indaga la duplice natura della scarsità: le fonti che alimentano il sistema economico e i pozzi che ne assorbono gli scarti. La ricerca analizza poi il primo shock petrolifero del 1973 e il più ampio quadro di cambiamento che investì mercato, consumatori e cultura occidentale. Su questo sfondo si innesta il Toyota Production System (TPS), nato dalla scarsità strutturale del Giappone del dopoguerra come alternativa storica autonoma al fordismo. La tesi dimostra che l'applicazione dei principi *lean* (eliminazione dello spreco, logica pull, qualità totale e altri) consente di superare l'obsolescenza programmata e altre esternalità negative tipiche della produzione di massa. Infine, il pensiero snello viene integrato con l'economia circolare e la slow consumption, nel quadro di un passaggio da un'economia della crescita a un'economia del benessere, in cui la durabilità dei prodotti sostituisce la loro rapida sostituzione e la vendita della proprietà lascia spazio alla fornitura di servizi. Il contributo della tesi consiste nel proiettare il Toyotismo, inteso sia come metodo produttivo sia come filosofia, oltre la sua dimensione storica, presentandolo come ossatura di un nuovo paradigma economico di decrescita e di accettazione dei limiti alla crescita continua.

**Abstract (English)**

This dissertation examines the historical and economic transition from the Fordist industrial model, founded on the post-war illusion of an unlimited abundance of energy and material resources, to the present-day need for a productive and ecological paradigm grounded in biophysical sustainability and circularity. Starting from the rise of Golden Age and its collapse in the early 1970s, analysed from both a monetary perspective (the breakdown of Bretton Woods) and an ecological one (the MIT report on the limits to growth), the work investigates the dual nature of scarcity: the sources that supply the economic system and the sinks that absorb its waste. It then analyses the first oil shock of 1973 and the broader picture of change that affected the market, consumers and Western culture. Against this backdrop, the Toyota Production System (TPS) emerges from the structural scarcity of post-war Japan as an independent historical alternative to Fordism. The dissertation shows that the application of *lean* principles (elimination of waste, pull logic, total quality and others) makes it possible to overcome planned obsolescence and other negative externalities typical of mass production. Finally, lean thinking is integrated with the circular economy and slow consumption, within a shift from an economy of growth to an economy of well-being, in which product durability replaces rapid replacement and the sale of ownership gives way to the provision of services. The contribution of this dissertation lies in projecting Toyotism, understood both as a production method and as a philosophy, beyond its historical dimension, presenting it as the backbone of a new economic paradigm of degrowth and acceptance of the limits to continuous growth.

## Introduction

The extraordinary economic expansion of the West after the Second World War, known as the Golden Age, was not a spontaneous phenomenon but the result of a precise institutional and geopolitical architecture. In the aftermath of the conflict, the world order consolidated around the economic, technological and military supremacy of the United States, the only country to emerge from the war years with an industrial apparatus that was not merely intact but strengthened. The convergence of specific factors made that quarter-century of unprecedented growth possible: a stable monetary situation, international trade fostered by the removal of customs barriers, the Marshall Plan and a general stability across the Western bloc (known as the Pax Americana); on this foundation worked citizens whose wages rose in step with productivity and who were able to consume, alongside the economies of scale inherent in Fordist mass production: high profits for firms, great purchasing power for the masses. This mechanism was constantly sustained by Keynesian-style public intervention, aimed at maintaining full employment and demand on the one hand, and productive capacity, profits and the reinvestment of capital on the other; last but not least, there was oil at rock-bottom prices. However, the system's need to avoid a crisis of overproduction at all costs led to a progressive institutionalisation of the culture of waste: Western consumers were re-educated towards the incessant replacement of goods through the planned use of obsolescence techniques or the stimulation of induced needs, all devices serving to keep the economy in a regime of permanent growth. This model rested on the tacit (and false) assumption that the biosphere could serve, simultaneously and without any difficulty, both as an inexhaustible reservoir of low-cost resources entering the "industrial metabolism" and as an infinite dump for the polluting by-products leaving it. The first cracks in this structure appeared as early as the late 1960s: growing awareness of the ecological damage caused by chemical and industrial pollution was accompanied by a first scientific formalisation of the impossibility of perpetuating such material and economic growth on a planet that is biophysically limited. With the opening of the 1970s, the equilibrium of the Golden Age collapsed as a result of several factors: the end of the dollar's convertibility into gold was the prime example, but it was joined by the saturation of mass markets, ever-increasing wage demands and a slowdown in marginal

productivity. The system had lost its driving force, and onto this already unstable picture was grafted the first oil shock of 1973, triggered by the Arab–Israeli conflict. The energy crisis made public consciousness and governments perceive, for the first time, the idea of scarcity and of the vulnerability of the entire economic system: the presumed invincibility of the Western industrial apparatus collapsed. Before proceeding, a methodological clarification of a geographical and structural nature is necessary. This research deliberately adopts an analytical perspective focused on the advanced Western economies (Japan being the sole exception), and it is exclusively to these realities that the considerations regarding the need to slow down the economic and productive metabolism and material consumption are addressed. Western nations completed their industrial transition decades ago, a transition that brought about the construction of infrastructure, urbanisation and mass motorisation; they have reached a stage of maturity at which it is not obvious that economic and material growth can generate real progress in subjective or collective well-being, whereas its negative effects are certain. A radically different condition characterises the emerging economies, first and foremost China and India, but also the so-called *Least Developed Countries* (countries concentrated in areas such as sub-Saharan Africa and South or Central Asia: Chad, Niger, Mali, Burundi, Somalia, the Central African Republic, Afghanistan, Yemen and others). First of all, it is neither certain nor obvious that *every* nation wishes to undergo the process of industrialisation, and this must in any case be respected (some countries choose to focus on tourism or finance, skipping the industrial phase precisely in order to protect their resources and their identity). Secondly, where this process has been set in motion, the expansion of energy consumption, polluting emissions and the extraction of raw materials represents a historically legitimate stage. As Maugeri (2006) observes, the enormous voracity of an expanding country such as China, which has become the world's second-largest consumer of oil and a great devourer of steel and cement to sustain its continuous urbanisation, conceals a profound disparity in per capita consumption, which remains far below Western levels (in terms of energy). At the same time, owing to politically administered domestic prices and plants still undergoing modernisation, many Asian economies record energy intensity indices per unit of output far higher than those of the West. This gap anticipates a fundamental methodological conclusion: the ecological transition may not present itself as a single, uniform solution, the same for everyone. For emerging countries,

the priority still lies in material growth, so a form of sustainability closer to technological decoupling (green growth, if you will, or growth as green as possible) could be a good path. For the industrialised West, the transition might more closely resemble a deeper change in the economic model, and thus a selective and conscious reduction in the physical volumes of goods produced and traded, the overcoming of obsolescence, and a reorientation towards leisure time, education, ecological regeneration and community and social ties.

The theoretical architecture of this dissertation rests on a multidisciplinary integration of economic history, the history of economic thought, and elements of ecology, management engineering and environmental economics. The entire bibliographical apparatus is organised around four fundamental macro-themes or core areas: the first of these encompasses the Golden Age, its structure, its premises and its collapse, together with the themes of abundance and growth. This first core area reconstructs the rise, functioning and crisis of those years: Hobsbawm's work (1994) provides an excellent historical account of the short twentieth century, offering an overview of the institutional, monetary and economic foundations of the Golden Age as well, and allowing it to be framed as an exceptional interlude in the history of capitalism. Marglin and Schor, with "The Golden Age of Capitalism: Reinterpreting the Postwar Experience" (1990), enable us to delve much more deeply into the theoretical apparatus that underpinned the era in question, above all with regard to political institutions, economic theories and economic and industrial equilibria: they explain how prosperity rested on a rigid alignment between productivity gains and wage growth, mediated by the stabilising action of the State. The material, quantitative scale of the expansion of that quarter-century is provided by Maddison (2001) and his compilation of historical series, above all in terms of growth (both of individual countries and in comparative terms) and of specific related indicators. It is Maugeri (2006), by contrast, who accounts in particular for the dizzying growth in energy consumption. His investigation of the "Age of Oil" reveals the crucial role played by the abundant availability of cheap oil as the lifeblood of the entire system, and exposes its fragility, which culminated in the oil shock of 1973. Vance Packard's essay (1960), meanwhile, is used to address the years of the economic boom and the Fordist production machine in terms of its negative effects, above all

unbridled consumerism, planned obsolescence and the resulting waste and generation of refuse.

The second macro-theme of this dissertation concerns the concept of limits, that is, the biophysical limits of the planet and the ecological crisis caused by economic growth: this marks the conceptual break with the economic and productive mentality described above. The reference work for this theme, and the pivot of the entire dissertation, is without doubt "The Limits to Growth" by Meadows et al. (1972): the study shows that exponential growth in population, the economy and industrial production is mathematically unsustainable within a closed, finite biophysical system such as our planet. Carson's denunciation (1962) of chemical contamination by pesticides and other industrial substances is cited as an example of a crack in the technocratic paradigm of human dominion over the planet, as a recognition, by the general public, of the toxic and negative side of industrial growth. The contribution of Nicholas Georgescu-Roegen, through his work "The Entropy Law and the Economic Process", is valuable because, whereas other authors analyse physical and ecological limits on a systemic scale, here the current economic model and its limits are described from a different perspective: the author applies the laws of thermodynamics, viewing the economic process as a degenerative and irreversible physical transformation that inevitably draws reserves of matter and energy from the environment in a state of "low entropy" and returns them in a state of "high entropy", that is, as waste and pollution. The United Nations report (1973) on the 1972 Stockholm Conference is used to mark the entry of awareness of our planet's finiteness (in terms both of resource scarcity and of the production of pollutants and waste) into global law and diplomacy. Furthermore, the topicality of certain problems and their present-day consequences is borne out by contemporary scientific data, in particular the historical series provided by NASA (2026) on the atmospheric accumulation of greenhouse gases and the rise in global temperature, while the World Economic Forum's (2026) findings on Earth Overshoot Day confirm what earlier studies had anticipated, namely a consumption of global resources greater than the Earth can sustain: we are already drawing on resources (and have been for decades) at a rate that is unsustainable for the planet that is our home.

The third macro-theme centres on the Toyota Production System, examining it from several angles: the TPS is analysed as a historical alternative to Fordist production, some

of its ecologically virtuous aspects are highlighted, and it becomes part of a set of other possible solutions for the economy of the future. This conceptual block sets out to investigate the industrial response to scarcity. The work of Taiichi Ohno (1978), the creator of the Toyota method, is unquestionably the founding text and the primary source for understanding the practical functioning and original philosophy of the Japanese system: it offers a complete overview of the production logics and principles governing the Toyota factory, its genesis and its advantages. The historical rationale of the TPS, including in terms of comparative performance, is provided by Michael Cusumano (1985), who, in "The Japanese Automobile Industry", helps us to understand why and how the Toyota model prevailed not only over the American giants but also over other players in the Japanese industrial context, making the best of the stifling conditions of post-war Japan. Schonberger (1982) succeeds in extracting from the Japanese example principles applicable to Western management, and is one of the first to argue for the universal applicability of the TPS outside the cultural context in which it was born and grew; Robert E. Cole (1981), on the other hand, focusing more narrowly on the automotive industry, analyses and describes the trauma suffered by the American production apparatus in the face of the Japanese challenge, identifying the strengths and innovations that led consumers to choose Toyota increasingly often. It is, however, with the research of John Krafcik (1988), also from MIT, that the TPS acquired its Western name, "lean production"; in his thesis, Krafcik provides important figures and standardised metrics proving the superiority of the Toyota method in terms of parsimony, man-hours, inventories and floor space. The parsimony of the TPS is further borne out by data from the Aerospace Corporation (1974), in particular the report "Passenger Car Weight Trend Analysis", which confirm that American car models had become increasingly heavy, whereas Japanese imports favoured a less impactful approach, keeping their cars at considerably lower values of mass and size (and thus requiring fewer materials and less energy for production). Scholars such as Womack, Jones and Roos (1990) go on to document the technical and operational superiority of lean production in its capacity to dismantle the hidden costs of the Fordist model, while the first two, Womack and Jones, in their 1996 work "Lean Thinking: Banish Waste and Create Wealth in Your Corporation", extend the lessons learnt over years of study across sectors, from manufacturing to services, providing a number of lean operating principles applicable

anywhere, even in contexts quite different from the automotive industry. The bibliography also includes works that link the theme of Toyota-style lean production to certain ecological virtues, offering a different perspective: Florida (1996) shows empirically that lean firms display a greater propensity towards ecological innovation; King and Lenox (2001), in "Lean and Green? An Empirical Examination of the Relationship between Lean Production and Environmental Performance", provide scientific and statistical evidence of the link between industrial efficiency and environmental sustainability, emphasising how plants that adopt lean practices generate less waste and fewer emissions, partly through a preventive approach. Stuart Hart (1995) places the Toyota method as a valuable managerial element within his "natural-resource-based view of the firm": he argues that the management of environmental sustainability should cease to be seen as a bureaucratic cost and be regarded instead as an opportunity for competitive advantage. Similarly, though with a different agenda from Hart's, P. Hawken, A. Lovins and L. Hunter Lovins (1999), in "Natural Capitalism: Creating the Next Industrial Revolution", introduce the Toyota method and some of its key principles into their project and paradigm of "Natural Capital", which, unlike traditional industrial capitalism, recognises and values natural resources as scarce rather than infinite. Here the TPS makes a leap in scale: the focus is no longer on the production system, but its logics are extended from the factory to the entire economic system. Finally, other sources show not only how Toyota was able to produce with great energy and material parsimony, but also how much the defect prevention typical of that way of producing meant, in practical terms, a durable and long-lasting product. Reliability reports such as those of J.D. Power attest to the durability of Toyota vehicles, as do web resources provided by the manufacturer itself, or destructive tests carried out by the BBC (2003): these sources allow us to look not only at the production system but also to appreciate its positive effects directly on the product itself.

The final thematic block comprises the new paradigms of production and consumption, the proposals identified in the research that aim to resolve the contradiction between the ecological and physical limits of the planet and the industrial and economic needs of mature Western societies. Packard's 1960 work "The Waste Makers" is taken up again in a programmatic sense: the criticisms the author levels at consumer society define precisely the perimeter of business, economic and industrial practices that this dissertation seeks to overturn. Overcoming the society of unbridled consumption, waste and

obsolescence typical of the economic boom of the Golden Age, through the exploration of a range of practices, is precisely the aim of this new thematic section. To this end, Cooper (2005) provides an initial perspective with his concept of *slow consumption*, arguing that extending the lifespan of physical products is a necessary condition for curbing the flows of matter and energy in the economic process. The same author, in his 2010 work "Longer Lasting Products", consolidates his vision, refining its details and extending it to operational policy proposals; in addition, a number of product design strategies (repairability, modularity, longevity and others) are brought together and put forward to counter the throwaway society. In the sources just presented, the need to slow down the economic and industrial metabolism begins to emerge: the work does not yet address the question of degrowth, but it does raise the problem of the recession and fall in employment that might follow from such a slowdown, and the overcoming of obsolescence through the increased lifespan of goods is presented as an excellent solution. Nancy Bocken and co-authors (2016) continue on the same theme with a text of hybrid and interdisciplinary character, combining product engineering and design (again with the aim of extending product life) with economic models such as the circular economy and business strategy. The goal remains that of slowing down flows of materials and energy; in particular, the production process is here examined with great subtlety, and both slowing and closing are applied to it (in line with the principles of the circular economy); but the fundamental focus remains on product design, on the production of goods conceived in perfect harmony with slowed-down, circular and closed economic cycles (that is, products designed for durability, repairability, reuse, upgrading and disassembly). The dimension of corporate economic profit remains very much alive (how does the company make money?), as does the proposal of business models such as Product-as-a-Service; thus, the position still does not dare to challenge the concept of economic growth. The discussion moves onto more macroeconomic ground with Tim Jackson's "Prosperity without Growth", which represents the goal and teleological horizon of this dissertation: the originality of his proposal lies in its courageous dismantling of the concept of technological decoupling between economic growth (in terms of GDP) and its negative externalities, and hence in a critique of the myth of infinite growth and of its identification with progress and human happiness. The essay precisely identifies the dilemma, the vice in which the modern economy is caught, trapped between

unsustainable growth and unstable degrowth; it argues for the need to free economic stability from the obligation of continuous expansion, and overturns the common view by proposing a reorientation or restructuring of the ends of the economy and of the labour market, the so-called Cinderella Economy. Jackson's proposal is complemented by Kate Raworth's "Doughnut Economics", which offers a vision along the same lines as Jackson's in its critique of growth for its own sake, but from a different angle: the goal of the economy should no longer be merely to increase macroeconomic figures, but to thrive in balance between two limits, an inner one (a social foundation, made up of human rights and minimum needs to be met for all) and an outer ecological ceiling that economic growth must not exceed: it is within this space that the economy should operate. Further considerations on the slowing of growth and on the emerging value of new "forms" of economy, based more on care, on the renegotiation of social time and on different forms of consumption, are offered by the online source "Il Tascabile" (2026a; 2026b).

The fundamental theoretical hypothesis of this research is that Toyotism (a term used deliberately to denote both the economic-industrial organisational method and the mentality or philosophy that produces it), if stripped of purely expansionary and accumulative logics and placed within a different economic framework, can serve as a useful tool for the transition of Western societies towards a post-growth phase (as well as bringing those still growing closer to greater sustainability). The Toyota system has in fact proved to work most effectively precisely in contexts of scarcity and limits: the very conditions that must now be wholeheartedly accepted. In a context in which the circular economy demands that the useful life of products be extended and slow consumption requires a marked contraction in material sales, the frugality of the TPS allows organisations to remain operational, more sustainable (and profitable), thanks to the elimination of waste and the maximum compression of fixed costs. By converting the business model from the sale of the good to the provision of its use (the shift towards a service economy), the absolute quality and proverbial durability of which Japanese-style manufacturing is capable become a competitive advantage for the service provider, and a benefit for the consumer and for the environment. Toyotism can be part of a larger change, combined with other solutions. To test the soundness of these propositions, the dissertation is structured in three chapters that follow a logical progression, moving from the historical and macroeconomic reconstruction of the Golden Age, through the

microeconomic analysis and functioning of the Toyota method, to a forward-looking synthesis for the future. The first chapter, “The Breakdown of the Cultural Paradigm and the First Doubts of the Real Economy”, reconstructs the historical framework in which the crisis of abundance took place: after an analysis of the formation, glory and decline of the Golden Age (monetary, wage-related and productive), compounded by the impact of the first oil shock, it describes the birth of ecological awareness and the first scientific formalisation of the concept of an ecological and material limit to economic growth. Section 1.1 (“The Dual Nature of Scarcity”) addresses the conceptual dimension of the end of the period of growth and abundance and is divided into two subsections: the first examines the shock represented by the 1972 report “The Limits to Growth”, which shattered the illusion of continuous and indefinite material growth, while the second breaks down, into its two facets, the very concept of limit that the work compelled readers to recognise: on the one hand, the scarcity, or finiteness, of natural resources; on the other, the possibility of saturating the environment with the waste of economic processes. The second section, 1.2, “The First Doubts of the Real Economy: Growth, Inflation and the 1973 Shock”, analyses the concrete manifestation of these constraints in the real economy, addressing the crisis of the Golden Age and the onset of stagflation and showing the vulnerability of an industrial apparatus (hungry for materials and energy) in the face of the oil shock. Section 1.3, “The Shift in Demand, the Institutions and the Bridge to the Lean Model”, examines society’s cultural and institutional response to the externalities of the Fordist mode of production, as well as, in its second subsection, the saturation of mass markets and the change in demand, transformations that would make the Japanese production model increasingly attractive. The second chapter, “The Genesis of the Lean System and the Architecture of Non-Waste”, shifts the inquiry from the historical framework to the inside of the factory: having established the crisis of the Fordist model, it investigates how Japanese industry responded to the limited availability of resources. A first section examines the responses of Western consumer countries to the oil crisis, while the rest of the chapter turns to a full understanding of the TPS, from the conditions of its birth to its functioning and the economic, industrial and ecological advantages it is able to generate. Finally, the third chapter, “Global Sustainability, Eco-Efficiency and New Models of Consumption”, provides the forward-looking synthesis of the entire work: the tools and advantages of the Toyota system are rethought, extended and integrated with

other solutions at different levels, ranging from product longevity to the current frontiers of the circular economy and post-growth economic paradigms. Whereas the first section recognises the rationality of the TPS as an ideal managerial and productive infrastructure suited (and functional) to modern ecological challenges, and as the right philosophy, the second section brings about the actual intersection between the TPS and various economic solutions or theories: it first shows how the principles of Toyotism can guide the design of products that are durable, easy to disassemble, repair and upgrade (and thus in line with the circular economy); it then puts the Japanese system to the test by placing it within economic solutions or paradigms that challenge the consumption model and even the very concept of growth.

Beyond the macro-themes addressed and the way they unfold within the structure of the dissertation, this work centres on a number of research questions: following the course of the work, the first question concerns how the post-war illusion of infinite abundance and continuous growth, built up during the Golden Age, entered into crisis during the 1970s. Secondly, it asks whether the Toyota Production System, born of the scarcity and deprivation of defeated Japan, can demonstrate that it is possible to combine maximum efficiency, the elimination of waste, high product quality and, above all, environmental sustainability. Can Toyotism free itself from the accumulative logics of capitalism and serve as an industrial and managerial infrastructure supporting the circular economy, *slow consumption* and post-growth theories? Alongside these more direct questions within a narrower field, the study will inevitably open onto broader questions touching on economic doctrines and paradigms: can there be a genuine decoupling between economic growth and increasing environmental impact, or must we resign ourselves to degrowth? Finally, is a society without growth, or with a deliberately lower growth rate, sustainable in economic and financial, cultural and also institutional terms? How can an entire macroeconomy function in degrowth when all its key institutions (the welfare state, pension systems, public debt, the banking and credit system) are structurally designed around perpetual economic expansion? These are the questions that drive and motivate this research, and to which it seeks to provide answers: this work certainly does not claim to offer a definitive solution to *all* the problems and questions just set out (some of them are among the most fundamental and complex of our time), but rather to contribute to some of them and to try to understand others as fully as possible.

# CHAPTER I: The breakdown of the cultural paradigm and the first doubts of the real economy

## 1.1: The dual nature of scarcity

### 1.1.1: The illusion of abundance and the shock of "The Limits to Growth"

After the end of the Second World War, the United States emerged not merely as one of the victorious powers but as the dominant state, the only one left with a production system described as «enhanced» by Marglin S.A. et al. (1990); while several areas of Europe and Japan were reduced to ash and their productive apparatus wiped out, the United States suffered no damage on its own soil, increased its GDP by two-thirds and ended the war with two-thirds of the world's productive capacity (Hobsbawm E.J., 1994). For the United States, therefore, this period was simply a continuation of wartime expansion, which in fact slowed slightly compared with the war years, whereas all the other major players (Europe and Japan) had to start again from scratch. This favourable position allowed the USA to abandon its old isolationism and adopt a hegemonic and strongly internationalist stance, which led to the construction of a new world order, the so-called «Pax Americana» (Marglin S.A. et al., 1990), resting on pillars such as, to name but one, the Bretton Woods monetary agreements. The first fruit of Washington's new stance was the Marshall Plan of 1948, the largest programme of economic aid granted by the United States between 1948 and 1952, which injected several *billions* of US dollars into the European system in various forms and essentially triggered Europe's economic and industrial revival, exporting the American model of production and consumption across the Atlantic. It is hardly surprising that the period immediately following American aid saw first the United States, and then the rest of the Western countries, enter a period of such great economic and productive (and consumer) flourishing that it came to be known as «The Golden Age». This was a period of significant economic and institutional solidity, which saw economics and politics intertwined in the creation of a global system that was predictable, stable and geared towards uninterrupted growth. Clearly, none of

this solidity was accidental; on the contrary, it was a deliberate institutional architecture built on the ashes of, and from the lessons learnt during, the period that Hobsbawm (1994) calls «the Age of Catastrophe», marked by two world wars and a great depression between them. The fundamental components of the Golden Age were undoubtedly solid macroeconomic figures and performance, an interventionist rather than a bystander State, and the export abroad of American momentum and of the American model, helped by the backdrop of the new international system. The average growth figures of the ACCs (Advanced Capitalist Countries, namely the six largest industrial countries of the time: Japan, Germany, Italy, France, the United Kingdom and the United States) over the period 1950–1973, even taken simply as an overall snapshot of different countries with very different growth rates and situations, are astonishing: total GDP grew at an annual average of 4.9% (compared with growth below 2% in the roughly 40 preceding years), and GDP "per head" by 3.8%. Export volumes exploded, with overall growth of 8.6% (the figures for the catch-up economies were even more spectacular, reaching 15.4% a year for Japan and 12.4% for Germany), against an average unemployment rate across the six economies at historic lows, a mere 3% (with some cases in which unemployment practically *vanished*). These figures are striking and undoubtedly confirm that quarter-century as one of the most prosperous periods in the history of the world economy, but on their own they do not provide a complete picture of those years; according to Marglin S.A. et al. (1990), beyond the individual percentages, strong growth was made possible by certain key elements, in particular by two relationships: first, the rapid and parallel growth of elements such as *capital stock per worker* and productivity, and second, an adequate growth in the real purchasing power of wages. The existence of these relationships guaranteed high production on the one hand and high consumption on the other, thus avoiding crises of overproduction while ensuring that firms were able to generate high profits. Since this system worked and firms maintained high and stable profits, the level of reinvestment (expressed in rates of accumulation), which in turn allowed the pattern to perpetuate itself by reinvesting the capital generated in further machinery and means of production, could be described as high. None of this would have been possible without calm and favourable political conditions and, above all, without State intervention in economic matters: deflationary American policies were used in the immediate post-war period to stamp out inflation and "discipline" the economy, and, more generally, State

intervention in the various countries aimed at maintaining full employment and stability. Keeping demand at a certain level in order to ensure consumption was the key objective that drove the various countries, in different ways and each according to its own model, to create and maintain the Welfare State (through the provision of pensions, subsidies, allowances and services) and to intervene through public spending, even accepting deficit spending, since income stability was the key to reassuring consumers and firms, the latter always confident that they could count on a market constantly ready to absorb their output. This extraordinary economic boom generated a climate of blind euphoria, together with the feeling that material growth could continue unchanged indefinitely (Hobsbawm, 1994). For the first time, the masses in the various developed countries finally gained access to a standard of living never seen before. The psychological context of this phase is perfectly summed up by the electoral slogan coined in 1959 by the British Prime Minister Harold Macmillan: «You've never had it so good». The industrial engine of the Golden Age was founded on the consolidation and expansion of the Taylorist and Fordist production model (Hobsbawm, 1994; Marglin S.A. et al., 1990): the rigid division of labour and the assembly line that implemented it ensured the mass production of goods, including durables such as household appliances and cars, but this productive power *had* to be matched by demand in order to avoid, as had already happened in the past, a crisis of overproduction; and the State's efforts to keep consumption and demand going (through certain policies, public spending, etc.) were not the only means: to keep demand high, the system institutionalised the culture of waste and consumption, including through techniques such as so-called "obsolescence". According to Packard (1960), the market was flooded with products subject in some way to an obsolescence that was not natural but artificial: this might be obsolescence of quality (that is, consumer products deliberately designed to break or fail within a predetermined period), or «psychological» obsolescence, induced by marketing, advertising and constant changes of style, which made products that were still fully functional appear outdated (there are many examples, such as annual model changes and variations in colour and style). The inevitable consequence of the efforts made to keep this machine of forced production and consumption running was a conceptual view of the natural environment as an infinite reservoir of raw materials at rock-bottom prices; the entire economic boom was based on oil consumption that tripled between 1950 and 1973, at a price that remained consistently

below two dollars a barrel throughout the period. The by-product of such a productive explosion was inevitably ecological deterioration, pollution and the blind exploitation of every resource, phenomena that were largely ignored during the Golden Age, except by a few, because «the dominant ideology of progress took it for granted that the growing domination of nature by man was the very measure of humanity's advance». (Hobsbawm, 1994). The prevailing ideology was the one summed up by the old motto of nineteenth-century capitalists, «where there's muck, there's brass», according to which man's domination over nature was considered the very measure of human success. This paradigm suffered an irreversible cultural and psychological trauma in the early 1970s. In 1972, the report "The Limits to Growth" (1972), commissioned by the Club of Rome from researchers at MIT, demonstrated for the first time, on a scientific basis, that the illusion of abundance was bound to be shattered. The message of the text was disruptive: *infinite growth is physically impossible on a finite planet*. By analysing the exponential growth curves of five critical factors, namely population, agricultural production, depletion of non-renewable resources, industrial output and pollution, the researchers showed that the global system would soon reach its physical limits. Beyond the specific data it provided, the importance of the text lies in the fact that, for the first time, awareness of the concepts of finiteness and scarcity took hold. The report warned that, if growth trends in consumption and pollution were not altered, human society would face a sudden and uncontrollable «overshoot and collapse» within the following century. "The Limits to Growth" destroyed the assumption that technological progress could raise the ceilings imposed by nature indefinitely, marking the psychological end of the Golden Age and, in effect, calling for a deliberate and controlled halt to the consumerist euphoria that had defined the preceding decades.

### 1.1.2: Breaking down the limit: economic constraints and environmental saturation

The very concepts of scarcity and finiteness demand that we abandon the mentality of economic progress as human dominion over the globe and its ecosystems, a mentality that sees the planet as a container to be emptied of its resources in order to feed the economic machine, and then to be filled with its by-products or waste. The concept of scarcity requires a new ontological status to be assigned to the industrial economy, which must no longer be seen as a closed circuit isolated from the planet, but as part of it, almost as one of its organisms (Jackson, 2009). Having understood the cultural shock of the 1970s, which confronted us with a finite world, we must now understand scarcity by analysing its anatomy, and observe how far the economy and industrial production are unable to escape a profound relationship with the planet and its limits; this is precisely what the economist Tim Jackson attempts to do in his essay "Prosperity without Growth" (2009): in the very foreword to the work, Prof. Daly (University of Maryland) introduces the concept of *throughput*, namely «the metabolic flow of useful matter and energy from environmental sources, through the economic subsystem (production and consumption), and back to environmental sinks as waste». This new concept compels, or at least pushes, economists, who have always focused on growth in terms of GDP, towards a certain level of ecological literacy, towards the full integration of ecology into economic reasoning and its mathematics. The aim is to create a new macroeconomics (known as ecological macroeconomics) «ending the folly of separating economy from society and environment». The author obliges us to think of the economy as a living and operating subset, yet one that is entirely dependent on (and contained within) a finite set, the planet Earth, and as such cannot disregard respect for its limits, its scarcity. The idea of decoupling economic growth from its direct physical impact is merely a myth: however much technological efficiency may loosen this link, a concept of continuous economic growth that manages to escape the need to consume natural resources and produce waste is therefore physically impossible. This is precisely the dual view of scarcity held by Jackson (2009): on the one hand, a problem of «sources» (the sources and resources entering the economic metabolism), and on the other, a problem of «sinks» (the

sinks or reservoirs that assimilate its outgoing by-products). The first front of scarcity concerns the limit imposed by incoming sources: a world economy aiming at continuous growth is hungry for new raw materials. This is not only a matter of energy, but also of fertile land for producing food, clean water and minerals (iron, aluminium, copper, rare earths), and the fact that these resources are all finite and exhaustible can lead to rising prices or even conflicts over their proper and fair use, both within nations and between different countries. Optimists, according to Jackson, take advantage of falling prices to play down the question of scarcity, but the author warns us that price volatility cannot give us a real measure of the remaining quantity of resources, and that «Through both peak and trough, the under-lying physical resource base moved inexorably towards exhaustion» The fundamental point is not the extent to which volatility tracks our approach to the limit of commodity use; *the point is that we are inexorably heading towards their exhaustion, regardless of price movements*. The second front of scarcity concerns the saturation of sinks, that is, of natural reservoirs of assimilation, and this aspect is even more worrying: even before we exhaust oil or other raw materials, «we're running out of planet». According to Carson (1962), the economic system is exhausting the planet's capacity to absorb its polluting by-products: the profound biological reasons why the environment cannot tolerate industrial waste indefinitely have to do with the *speed* with which industry releases hundreds of harmful chemicals into the biosphere; certain substances not only have no counterparts in nature, but also overload the slow natural processes of adaptation and absorption, effectively poisoning the planet and living beings. The rapidity of the changes imposed by modern civilisation no longer follows «the deliberate pace of nature», but responds solely to the impetuous and reckless rhythm of man and of an economic machine of which he himself is a slave. The industrial and economic system is therefore caught in the grip of a dual scarcity: on the one hand, the physical quantity of natural resources available for extraction is inexorably shrinking; on the other, the Earth's capacity to absorb waste is coming to an end. A fundamental and insurmountable principle must therefore be reaffirmed: it is simply impossible for a subsystem (the economy) to grow indefinitely in physical terms within a finite ecological system (the planet) (Jackson, 2009).

## 1.2: The first doubts of the real economy: growth, inflation and the 1973 shock

### 1.2.1: The end of the economic boom and the first signs of instability

Although collective memory tends to equate the moment the Golden Age came to a halt with the oil shock of 1973, it should be noted that the economic and institutional architecture that held it up had begun to show signs of strain some years earlier. Hobsbawm (1994) explains clearly that, from the late 1960s onwards, while the military, and therefore political, strength of the United States remained considerable, it was offset by the fact that its economic predominance was gradually being eroded by the Japanese and European economies. During that decade, dollars «had flowed out of the USA in a growing torrent», accelerated by Keynesian deficit spending, which was needed to finance the enormous costs of the Vietnam War and also the most ambitious social welfare programme in the country's history. In this way the dollar, the cornerstone of the post-war economic system planned by the USA, was growing ever weaker, and although it was backed by a quarter of the world's gold reserves (held at Fort Knox), it increasingly consisted of «floods of paper or book-entries». Since, under the Bretton Woods system, the stability of the dollar was guaranteed by its convertibility into gold, some (cautious) European economies, such as France, preferred to exchange their paper dollars for solid and reassuring gold bars. And as Fort Knox was emptied of its gold, the stability of the dollar for much of the 1960s relied less and less on *actual* American gold reserves and more and more on the goodwill of European central banks (at the request of the United States) to refrain from asking for their dollars to be converted, and indeed to join together in a "Gold Pool" with the aim of keeping the price of gold stable by selling and buying it back (when gold exceeded a certain price, the European central banks sold it, massively increasing supply and lowering its price, and then bought it back once the price had fallen: this mechanism acted as a buffer to keep the value of the dollar pegged to that of gold bullion) . In practice, Bretton Woods was no longer working, and when the Gold Pool was also dissolved in 1968, its reserves drained, it was only a matter of a few years before the formal abandonment, in 1971, of the dollar's convertibility into gold, and with it the stability of an entire system

of international payments and its control by the USA. The monetary blow dealt to the world system by the Nixon administration's abandonment of the gold standard had, among other effects, that of devaluing the currency: according to Maugeri (2006), the separation from gold itself took place «to remedy the overvaluation of the currency» (money was in effect artificially worth too much relative to actual gold reserves) , all against the background of inflation caused by the continuous printing of money to finance public spending and the war, together with domestic price caps aimed at keeping the prices of petroleum products under control. While Nixon, on the one hand, tried to calm the domestic situation (at least for a few months, until the next election) by freezing wages, prices and interest rates, one of the president's mistakes, among others, was to underestimate the effect that a devalued dollar could have on the OPEC countries (the well-known intergovernmental economic cartel formed by the main oil-producing countries, including Saudi Arabia, Iran, Kuwait, Venezuela and Iraq): American inflation hit the real profits of these countries hard, since oil was priced essentially in dollars. The cartel countries were thus being paid in a currency of lesser value, and this was one of the reasons that led, as we shall see, to the oil crisis. Alongside the monetary chaos, the industrial engine of production was slowing down, and the idea that this slowdown was due solely to the oil price rise of 1973 is an oversimplification: in the three main capitalist countries (the USA, Japan and Germany), a decline in the growth rates of hourly labour productivity, as well as of manufacturing productivity, took place between the late 1960s and the early 1970s (Marglin S.A. et al., 1990). Interestingly, in none of these three economies, nor in that of France, was the fall in labour productivity offset by an improvement in the output/capital ratio (that is, capital efficiency), indicating a fall in productivity that was not due simply to lower investment in machinery, but to investment becoming less effective at keeping productivity high: in short, both components of labour productivity, namely capital efficiency (given by the ratio of total output to capital invested) and capital intensity per worker (given by total capital employed divided by the total number of workers), were falling in that period; so less was being invested, and the investments themselves were yielding less (Marglin S.A. et al., 1990). One of the pillars of the Golden Age was that real wages grew in parallel with productivity,

enabling consumers to absorb output and firms to enjoy excellent margins; in this period of declining productivity, however, there was a genuine «worldwide wage explosion», as Hobsbawm (1994) calls it, across all the industrialised countries, owing to the shortage of (and need for) labour, strong trade unions, student revolts and a new generation of workers who began to demand better working conditions, less factory discipline and high wages, even when these were disconnected from production. The perfect relationship between high productivity and real wages rising in parallel with it was coming apart precisely in this period: wages continued to be kept artificially high, or even to rise, in the face of a widespread productive crisis. This process inevitably led to the progressive erosion of firms' profit margins (since the cost of producing a single good rose), and with lower profits, firms began to cut back on investment, further curbing the momentum of economic growth (Marglin S.A. et al., 1990). If we add to all the preceding elements of disorder the alienation inherent in the Fordist production model (which will be discussed in the following sections), no longer suited to satisfying a market by now saturated with products and undergoing profound transformation (Packard, 1960), a worrying macroeconomic picture emerges: stagflation (a paralysing combination of economic stagnation and high inflation) was the final outcome of these cross-pressures, caused essentially by an overheating of the economy owing to rising inflation and to governments which, prompted by the signs of slowdown and by the vast American deficit, kept pumping money into the system to maintain full employment and full consumption. There *was* indeed a brief flare-up: the economies of the OECD countries recorded, between 1972 and 1973, a 7.5% increase in GDP and a 10% increase in real industrial output (Hobsbawm, 1994); but this was not a sign of returning health so much as an engine running at excessively high revs: factories were working at the limit of their remaining capacity, labour was scarce and, with the commodities boom, raw materials were beginning to run short. It was a final effort by the Golden Age system, one that consumed its remaining structural energy and left it dramatically exposed to the oil shock of 1973.

### 1.2.2: The energy crisis and the vulnerability of the industrial model

While the internal cracks in the system had already appeared during the 1960s with the failure of Bretton Woods and the squeeze on profits, the historical event that finally broke the bank was the oil embargo imposed by the Arab OPEC countries in October 1973. The embargo took place in the context of the Yom Kippur War, in which Egypt and Syria launched a surprise attack on Israel, precisely during the Jewish holiday of that name, in order to recapture the territories taken from them by the young Israeli state (Sinai from Egypt and the Golan Heights from Syria) during the earlier Six-Day War of 1967. At the height of the Cold War, the conflict did not go unnoticed and immediately became geopolitical: while the USA supplied Israel with weapons, the USSR supported the Egyptian–Syrian axis. In this context, the Arab oil-producing countries, driven also by the economic and monetary reasons discussed above and acting through OPEC, decided to use crude oil as a weapon of geopolitical pressure: an embargo was declared on the countries supporting Israel (which is why the European allies, concerned about the continuity of their oil supply, refused even to allow the Americans to use their air bases), with the aim of forcing the West to put pressure on Israel to withdraw from the occupied territories. In doing so, the Arab states made a sensational discovery: they realised that they held in their hands the power to multiply the world price of oil, the lifeblood of all Western economies, at will, and the price roughly quadrupled in 1973 (Hobsbawm, 1994). Although the supply cuts did not affect all states equally, the combined effect on Western economies and industries was devastating: they suddenly discovered that they were fragile and extremely dependent on external forces, because the entire edifice of the economic miracle rested, in energy terms, on a historical *anomaly* that had been mistaken for a *constant*, namely the certainty of perpetually abundant and cheap supplies. This had led to the absolute energy dependence of the world's strongest economies on those who in fact controlled the sources: according to MIT's Limits to Growth report, at that time 97% of industrial energy came from fossil fuels; the world ran on oil, and to give an idea of its voracity, it is worth noting that in the Middle East alone there was a frenzied acceleration in extraction, which rose from a "mere" 16 million tonnes in 1937 to 86 million in 1950 , reaching 1,053 million tonnes in 1973, an average increase of

11.5% a year (Maddison, 2001). The United States suddenly found itself strangled, discovering that its military and economic supremacy could do little, while the European economies continued to receive supplies, but at higher prices: this further blow, on top of the problems described above, changed the state of affairs for good, and in 1974 the GNP of the industrialised countries suffered (Hobsbawm, 1994) a substantial collapse, a fall of a magnitude not seen since the end of the Second World War. 1974 was a definitive watershed; indeed, «The world economy did not recover its old stride after the crash. An era was at an end». The deeper meaning of the 1973 oil shock goes beyond mere geopolitical friction or an unfortunate temporary anomaly: it did not simply deal a heavy blow to a system that was already wavering and not in perfect health, nor did it merely reveal its tensions and relationships of dependence; it represented the brutal and sudden (albeit artificial) materialisation of that scarcity or finiteness which some studies and far-sighted scholars had foreseen. Maugeri (2006) argues that there was no real physical shortage of oil: at the height of the crisis, the Arab embargo did not create any actual shortfall (the real deficit was just over 5% of world consumption); rather, it was a collective psychosis, a *fear* of scarcity, that drove prices up, fuelled by the lack of transparent information and by speculation on the newly born spot market, where buyers sought to secure individual cargoes at auction for as much as 17 dollars a barrel. It matters little whether the scarcity was real or not: what is certain is that even the mere idea of a shortage produced disastrous economic and material effects, and this should make us reflect on the anomalous degree of dependence on the idea of continuous growth and of abundant, cheap oil supplies (consistently below two dollars a barrel) that had developed during the Golden Age of Oil. If the response of entire nations and of international markets to the mere spectre of scarcity of a single raw material (however fundamental at the time) produced reactions that were chaotic to say the least, it is worth asking what a *real* shortage might have entailed, and how humanity would be able to respond *today* to similar threats, whether concerning petroleum products or other commodities.

### 1.3 The shift in demand, the institutions and the bridge to the lean model

#### 1.3.1: The Beginning of the Turning Point in the 1970s: from environmental awareness to the first laws

Until the 1960s, the dominant ideology in the industrialised countries took it for granted that the very manifestation and measure of human progress was precisely man's growing domination of nature (Hobsbawm, 1994), and this in some way blinded society to ecological deterioration. The first cultural jolt to that naive and short-sighted optimism coincided with the publication of Rachel Carson's Silent Spring (1962). The work, which essentially denounced the unconditional abuse of chemical pesticides in agriculture and highlighted their harmful effects, in fact had a far greater impact: first of all, it dealt the first major blow to the conception of progress as coercive human domination over nature; in this sense, the alteration of ecosystems ceased to be seen as a normal and linear indicator of development and modernisation. The American biologist overturned that view, essentially arguing for the interconnection between humankind and nature and for the concept of bioaccumulation: she showed that the use of synthetic poisons had effects that went far beyond their initial economic purpose (protecting plants from insects), as these substances travelled through the food chain, polluting and compromising water, plankton, fish and birds, and ultimately reaching human tissue. Nature ceased to be an inert object to be exploited and was rediscovered as a complex and interconnected biosphere, and harming it could only have negative consequences for humankind. Carson's revelations did not remain confined to her book; on the contrary, its effect was to awaken consciences and trigger genuine civic mobilisation: the work itself records that, at the institutional level, there was an immediate positive reaction from the Kennedy administration, which set up a special committee to study the pesticide problem, subsequently leading to environmental legislation at every level of government. Moreover, the biologist documents several cases in which citizens managed to organise themselves to take government agencies and industries to court, and this mass awakening found fertile ground in the climate of intense protest of the late 1960s, in which youth movements acted as a catalyst for social groups (and broader demands), definitively transforming environmental protection into a political and popular cause

(Hobsbawm, 1994). Faced with the evidence of ecological damage and with persistent grassroots demands, institutions acknowledged that free-market mechanisms were unable to regulate themselves, especially with regard to pollution: the benefits of production achieved through pollution were immediate for those who enjoyed and generated them, but far removed in time (and, in some cases, in space) from their ecological and social costs (Meadows et al., 1972). The problem of negative externalities therefore made coercive intervention both necessary and legitimate: in the USA, in 1970 alone, the EPA was created, a central government agency with powers of control, monitoring and sanction over polluting industries, which two years later banned DDT entirely; and the Clean Air Act was passed (imposing very strict standards on industrial emissions and, above all, forcing the car industry to reduce exhaust pollution drastically, which led to the introduction of unleaded petrol and catalytic converters). In various other European states, this was precisely the period of new regulatory initiatives, and it soon became clear that individual national legislative approaches were not enough, because pollution and the exploitation of the planet knew no borders. Scientific evidence of industrial pollutant residues by then present even in the most remote areas of the world, such as the 300% increase in lead in the Greenland ice or the presence of DDT in the body fat of human beings from Alaska to New Delhi (Meadows et al., 1972), was enough to convince people that the problem of pollution and resources, that is, of scarcity in both its senses, was a shared one. All these internal national pressures converged in a major diplomatic and global awakening at the UN Conference on the Human Environment in Stockholm in 1972, which culminated in the Stockholm Declaration (United Nations, 1973). In this document, perhaps the first pillar of international environmental law, the international community did indeed make progress in recognising certain fundamental needs or truths, from several points of view: the environment, which before 1972 had no status in international law, was finally raised to the level of a human right. Furthermore, the Declaration not only seeks to promote greater international cooperation, but also dismantles the idea that a State may exploit its resources while polluting freely: this may happen provided that the State in question also bears «the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other

States or of areas beyond the limits of national jurisdiction». While, on the one hand, raising the environment to an entity linked to human rights, balancing national sovereignty with global responsibility and pushing for growing international collaboration in the institutional, legal and scientific fields were all pioneering achievements, on the other hand the Conference remained immature on other issues. Stockholm stopped at a generic declaration of intentions and principles, which were right but abstract and imprecise, and thus lacking in specific obligations and consequences; furthermore, it retained an outlook that was still very anthropocentric and centred on development, not only because many of its principles focus on the exploitation of resources, but also because development itself was still regarded as essential to humanity's continued well-being on the planet. The Conference did not question the concept of continuous development as harmful or scientifically impossible; on the contrary, it kept alive the paradigm of exploiting natural resources, merely proposing smarter and more far-sighted ways of continuing to pursue it. Only decades later, with the Kyoto Protocol of 1997, would the international diplomatic architecture make the definitive qualitative leap, the genuine identification of a limit, a brake on development, for example through quantifiable obligations on countries regarding maximum ceilings on carbon dioxide emissions.

### 1.3.2: The reversal of the market, the end of Fordism and efficiency as the new global rule

The economic and productive architecture of the Golden Age was founded on the Fordist model and on its spread overseas to new automotive industries and, on American soil, on its expansion into new types of production (from construction to junk food) (Hobsbawm, 1994). However, the abrupt arrival of the 1970s, combined with the problems that had already been accumulating in the previous decade, made the survival of that model increasingly impossible. Gigantic mass-production plants, uninterrupted assembly lines and highly accentuated standardisation increasingly became relics of the past, images that no longer reflected reality. According to Packard (1960), the main reason why the old golden

economies of scale ground to a halt was the physical saturation of the market, the change in its capacity and mode of consumption. Mass production worked very well as long as there was a virgin market to satisfy, a euphoric population that was only just experiencing job security, excellent wages and comforts never seen before, together with new needs and demands. But when the market shifted increasingly from one of "first purchase" to one of "replacement", things changed considerably: in The Waste Makers, Packard (1960) already described the American consumer, stuffed with every desirable product, as «tired, a little jaded, eager for something different»: nine out of ten American homes had a refrigerator, a television set and a stove, while seven out of ten had a vacuum cleaner, a toaster and an electric mixer, and for the first time in history there were more cars than families. And it was precisely in response to this consumer satiety, the key to the whole system, that the production model had to adapt and change, or else it would have kept running idle. In order to keep sales volumes and rates high, producers realised that something had to change: the product had to detach itself from its functional utility, respond to new needs and motivate citizens to consume. There are not many ways of selling again to a family that already owns one of your products: supplying spare parts, selling more than one product, or «you dream up a new or improved product—or one that at least seems new or improved—that will enchant families that already own an "old" model of your product». This, according to Packard, is how obsolescence was reborn as a method of increasing sales volumes. A product becomes obsolescent in a real sense when it is superseded by another that objectively performs that particular function better; this is functional obsolescence, which we all welcome. It is a different matter when obsolescence is artificially forced in order to induce the consumer to replace a product that could otherwise continue to function; and there are two main strategies for doing so: ensuring that the product actually wears out or breaks at a predetermined time (this is known as quality or planned obsolescence), or making the product *appear* worn out to the consumer (psychological obsolescence). The first type of obsolescence, perhaps the most hated and irritating for consumers, could carry risks, and by the 1960s it was not a new solution: some examples of planned obsolescence date back much earlier; indeed, the author cites the historical example of General Electric, whose engineers

in the 1930s proposed shortening the life of flashlight bulbs so that they would last the life of a single battery instead of three, estimating that this would increase sales by 60%. The second way of forcing obsolescence is described as safer and more widely applicable, and consists in wearing the product out, not physically through precise «death dates» but only «in the owner's mind», so that a product that is still perfectly sound or functional in terms of quality or performance becomes old or outdated because a change of style makes it look so. The author is very clear when he points out that «in fast-paced modern marketing there is very often little new, basically, that can be offered. The manufacturer can't wait for the slow workings of functional obsolescence to produce something really better. Or he feels he can't. So he sets out to offer something new anyhow and hopes that the public will equate newness with betterness. Fortunately for him, mid-century Americans are prone to accept that equation» And it is through changes in design that, when nothing genuinely new can be offered, manufacturers seek to create the illusion of change and improvement: changes of colour, new chrome trims, different levels of ornamentation, evolving styles. And whereas in the history of art changes of this kind took centuries (think of the slow and gradual evolution of Greek columns, ever more detailed in design and ornamentation, or of the time separating the clean lines of Renaissance buildings and furnishings from the curves of the Baroque and, finally, the profusion of frivolities and decorations of the Rococo), modern designers managed instead to push the public through continuous and closely spaced stylistic swings, sometimes only a few years apart. At that time, industry as a whole took its cue from the women's fashion sector, which by 1960 was already worth 12 billion dollars and was the first to implement obsolescence actively (as early as 1950, B. Earl Puckett, one of the most powerful and influential American retail executives of the twentieth century and president of the Allied Stores Corporation, declared that "we must make women so unhappy with what they have that their husbands can find no peace or happiness in their excessive savings"). The same logic was applied to a vast range of other sectors and products. For example, simple agreements between plastics manufacturers to establish the year's «leading colour» (Packard, 1960) could give rise to several product ranges (linked by nothing other than being made of plastic), such as baby baths, waste-paper baskets, bowls

and the like, all coordinated in a particular colour such as pink, yellow or turquoise: this could prompt the public to replace entire household sets so that they would not clash with the new annual fashion. Further examples could be drawn from the automotive sector or from household appliances: the author documents how General Motors used the same basic body shell for millions of different cars across five different brands (Pontiac, Chevrolet, Oldsmobile, Buick and Cadillac), merely changing bodywork details such as chrome trim or tail fins; again, from the late 1950s onwards, refrigerator manufacturers agreed «with impressive unanimity» to change the shape from rounded to angular, or the colour from white to pastel. In this process of continuous planned stylistic changes, which moved consumers now one way and now the other at roughly annual intervals, it should be noted that Fordism still worked (or was made to work): the assembly line and mass production retained their role, because product differentiation was organised, standardised and superficial. The public accepted this new frenzy for novelty because the marketing of the time succeeded perfectly in understanding and exploiting certain psychological, social and even philosophical traits of human nature: material goods ceased to be merely functional objects and became imbued with a «symbolic language» (Jackson, 2009) through which individuals communicated their identity, their status and a sense of belonging to a community. Society itself, which depends on consumption in order to survive, tends to create individuals who develop an «empty self», constantly driven by an anxious craving for novelty in order to belong to it in their own credible way; and the insatiable desire of such individuals is perfectly complementary to the continuous (false) production of novelty through the entrepreneur's «creative destruction». Gradually, however, the Fordist production model had to give way to a number of factors: a replacement market, made up of consumers increasingly seeking originality and self-expression and the expression of their social identity *through* the product, increasingly demanded differentiated, personalised, tailor-made goods; moreover, with the arrival of the 1970s and the problems of actual or feared scarcity described above, there was an ever greater need for a production model whose strengths were flexibility, a lean structure capable of adapting to the rapid changes of the new market, and the avoidance of waste. Fordism, which had been created for an entirely different

purpose, was unable to keep pace, while in Japan, for several years already and without anyone being aware of it, the solution was being prepared. The mass production method was not plunged into crisis by the oil shock (we have just seen that it was already in difficulty); rather, the shock revealed its unsustainable features: in an economic regime with very low energy prices (and low prices for other inputs), the Fordist model could afford to ignore waste of materials, space and heat in its plants and to produce imposing, heavy and highly inefficient cars. Aided by the monetary and macroeconomic disorder associated with inflation and the abandonment of the gold standard, the 1973 shock and the energy efficiency standards that followed as a consequence (which will be discussed later) forced the country to make better use of its energy resources, and the same happened to the large manufacturing industries, such as the car industry. The combination of all the factors described, monetary, energy-related and market-related, led the American consumer to look with different eyes at, or finally to see, the Japanese car and its merits.

## Chapter II: The Genesis of the Lean System and the non-waste architecture

### 2.1 Responses to the Crisis: public policy, diversification and energy geopolitics

Focusing specifically on the first oil shock, and drawing on the work of Maugeri (2006), this section analyses the systematic responses of the West, implemented in order to react immediately to the crisis and reduce its dependence on OPEC. A first concrete response to the 1973 crisis was the creation of the International Energy Agency (IEA) in 1974, strongly championed by the American Secretary of State Henry Kissinger as an instrument of coalition among industrialised, oil-importing countries, intended to counter the economic and bargaining power of the OPEC cartel. The new agency was not born easily or without effort, since the embargo had strained relations between Europe and the USA to such an extent that, at least in the early years, it proved impossible to reach common agreements going beyond the collection of data on energy supply and demand and the proposal or coordination of energy policies and measures. More specifically, the USA, which had been hit hard, reacted to the embargo with specific legislation: in December 1975, the Ford administration enacted the Energy Policy and Conservation Act

(EPCA) , a law that introduced two fundamental innovations: on the one hand, the CAFE (Corporate Average Fuel Economy) standards, which required car manufacturers to double the average efficiency of passenger vehicles within ten years (raising it from 13 to more than 27 miles per gallon), forcing the entire industry into a radical effort of redesign and adaptation; on the other hand, the Strategic Petroleum Reserve was established, a government reserve of around 600 million barrels conceived as a security shield to cushion any new embargoes or supply difficulties. In addition to these legislative measures concerning the conservation of energy in the form of oil and its derivatives, the general thrust of the West was towards the search, wherever possible, for other energy sources: efforts were made to remove oil from all "improper" uses (such as electricity generation or heating), reserving it for transport, and to employ alternatives such as natural gas or nuclear power. The 1970s and 1980s, the author records, were the golden years of nuclear energy, a relatively new way of generating electric power. The first Soviet and American reactors dated back to the 1950s, but the first commercial nuclear power plant began operating in the USA in the 1960s. By the early 1980s, 243 plants were operating worldwide, most of which (as many as 162) had been built precisely in the decade of the first oil crisis. In parallel with the nuclear rush, natural gas and coal began to replace crude oil in thermal power stations and in residential heating. A further response to, and consequence of, the 1973 oil shock was the search for oil resources outside the Arab OPEC countries, and hence the opening of new extractive frontiers through the targeted channelling of capital and investment: it was precisely thanks to this reaction that the exploitation of oilfields in Alaska, Mexico and the North Sea (under British and Norwegian management) was unlocked. The North Sea, in particular, became a sort of "technological school" that enabled the entire industry to take an important step forward in its technical ability to extract crude oil in extremely difficult conditions. Nor should the increasingly significant extractive role of the USSR be forgotten, and all these new solutions led within a few years (towards the end of the 1970s) to an enormous influx of non-OPEC oil onto the market, contributing to overproduction and the consequent collapse of prices in the following decade. While, at the macroeconomic and regulatory level, Western countries responded to the crisis by imposing security reserves and efficiency standards and by seeking to diversify their energy portfolios, at the microeconomic level manufacturing industry inevitably had to rethink its organisational

model and adapt to the new conditions brought about directly by the oil shock, as well as to the responses to it that we have just examined.

## 2.2 The Genesis of the Lean System: Scarcity as a Constraint on Survival

### 2.2.1 The Japanese context: resource poverty and the limits of Fordism

The situation in Japan in the immediate post-war period was tragic from many different points of view: an economy totally devastated by the conflict, lacking capital and foreign currency, and therefore the capacity to purchase Western technologies (Womack et al., 1990). Economic disorder in the aftermath of the war was extreme: hyperinflation was sending prices soaring, and the American occupiers decided to stabilise the situation through severe deflationary measures, such as a fixed exchange rate unfavourable to the yen and very tight credit restrictions. The cure, also known as the "Dodge Plan" after the American banker charged with implementing it, worked to such an extent that it froze the economy excessively and caused a depression: with no liquidity in circulation, domestic demand fell. Scarcity was not confined to the financial sphere but was widespread: the country, keenly aware of its own weakness, lacked all the natural raw materials needed to run a modern economy (Hobsbawm, 1994). The fledgling Toyota found itself right in the midst of these shortages: a deep liquidity crisis, dwindling bank loans, a lack of raw materials and increasingly powerful trade unions (Womack et al., 1990). As regards hardship and scarcity, it may help to imagine a country characterised by a « shortage of everything from crude materials to parts» (Ohno, 1978), in which supply networks had been destroyed and industries were unable to function because the suppliers themselves lacked equipment and manpower, and Toyota could not obtain the parts it needed within the required time: shortages were so severe that factories had to spend half the month collecting materials and concentrate production in the second half. To these severe constraints on capital, materials and labour was added an insurmountable structural limit: the size of the market. The American Fordist model was based on standardised production (and therefore tedious and demotivating for workers, and less varied for consumers) and on vast volumes of identical or very similar products, in order to cut production

costs as far as possible; the Japanese market, by contrast, was tiny in comparison and extremely fragmented (Ohno, 1978). Domestic demand for cars (and for products in general) was very modest, yet extremely varied, ranging from luxury cars for government officials to lorries for transport and small cars for manoeuvring through crowded cities in the face of excessively high fuel prices (Womack et al., 1990). Under these conditions, the Fordist system, although studied by the Japanese (Ohno, 1978), could not succeed or be imported: its premise was abundance, very large production volumes, a continuous flow of raw materials processed and carried along conveyor belts, enormous batches of identical parts and products with little differentiation. Mass production rested essentially on quantitative economies of scale, that is, on a falling ratio between fixed costs and an output that had to grow ever larger (Womack et al., 1990). Such a system had adapted itself, including in terms of machinery, to a certain type of production, and the very objective of Fordism was also the source of waste: if the mass producer reduced costs by producing large numbers of products, it needed machinery (presses, for example) capable of working at very high speeds and without interruption. In order never to stop the gigantic and expensive machinery, the presses were run continuously, generating mountains of stock and semi-finished goods well before any real demand existed (that is, production took place on a massive scale and *preceded* demand). American practice was to dedicate several machines to a single component, stamping it for months or even *years* without ever changing the dies (an extremely costly operation, since it took an entire working day) (Womack et al., 1990). All this made numerous expedients necessary to avoid interrupting the lines and the production flow at all costs, and these were nothing more than further, secondary forms of waste: it was necessary to overproduce deliberately, and overproduction meant having to build large warehouses, hire workers to move goods and manage inventory, buy forklift trucks and employ staff to repair the parts that inevitably rusted or were damaged during storage (Womack et al., 1990). For Toyota, all of this was unsustainable waste; it literally did not have the budget to afford all that machinery and such volumes of stock: Ohno realised that the paradigm had to be reversed; the company had to be able to complete an entire vehicle using a limited number of machines, which required (given also the variety demanded by the

market) changing dies several times a day and reducing changeover times (which came down to just a few minutes in the 1950s) (Ohno, 1968). This drastic reduction in set-up times allowed Toyota to produce only what was necessary and no more, eliminating warehouses, cutting costs and freeing itself from the tyranny of large batches. Resource scarcity had forced the company to reject the mere imitation of Fordism, paving the way for the genesis of a radically new system, flexible and geared to the absolute elimination of all waste.

### 2.2.2 The birth of the "Lean" system and the pull logic

The impossibility of replicating Western volumes, both in terms of abundant resources and of the market's capacity to absorb mass production, combined with a lack of capital to finance expensive machinery and immense warehouses full of stock, forced Toyota to reject the Fordist logic of "Just-in-case", that is, the pre-emptive production of stock to cope with every eventuality and prevent the assembly line from stopping (Schonberger R.J., 1982). In an environment lacking resources, Taiichi Ohno, the mind behind the Toyota method, understood that the only way forward was to produce only and exclusively what needed to be produced, that is, what had been requested by orders. Doing so essentially meant moving beyond the "push" logic that by then dominated factories all over the world: in this traditional method, the quantity to be produced is determined essentially on the basis of market forecasts and inventory availability; production then follows, pushing semi-finished goods towards downstream processes regardless of whether they are needed or not (Ohno, 1968). Clearly, the outcome of a push production process was the generation of mountains of products and semi-finished goods, huge inventories of parts not immediately needed, overproduction, manufacturing errors and scrap: all elements that reduced productivity and profit (Ohno, 1968). And it was precisely here that the Toyota system overturned the prevailing mentality: the productive input was no longer to come from upstream, that is, from analyses seeking to establish the maximum the market could absorb and from the capacity of the machinery, but from downstream, from the real needs and demands of the market. The ingenious solution for overcoming the push logic was devised by Ohno through his observation, during his travels, of a phenomenon new to Japan: the American supermarket. Ohno himself (1968) describes

how the supermarket was a place, a system, in which customers could buy according to their needs, exactly what they required, at the right time and in the right quantity. Likewise, the supermarket manager restocks the shelves only with the goods that customers have bought. This principle was applied to the assembly line in Toyota's factories from 1953 onwards: the upstream process was to be conceived roughly as a supermarket shelf, to which the customer (that is, the downstream, subsequent process) would go to collect only the components needed for its own purposes, and only those parts just withdrawn would be immediately replenished upstream, not one more. Applying the American supermarket's way of operating to the factory gave rise to the "pull" production logic, revolutionary for industrial management: in this model the production flow is reversed, and production no longer takes place blindly, pushing parts and semi-finished goods from upstream processes towards subsequent ones (often relying on heavy overproduction); on the contrary, it is the certainty of the final sale of the car that "pulls" the demand for the part or component leaving the preceding station, which in turn requests parts from the station before it. This triggers a chain reaction of production requests travelling backwards from the car leaving the plant all the way to the arrival of raw materials: in this system physical goods move forwards, but information and production orders travel backwards. The desired goal is for the upstream process to produce precisely the exact quantity withdrawn by the downstream process, eliminating at source the risk of overproduction and all its negative and costly side effects. This pull logic constitutes the backbone of the Just-in-Time system, its very essence: just in time means «that, in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and only in the amount needed » (Ohno, 1968), and this can bring the company closer to the ideal objective of zero inventory. Just in time should not be confused with mere short-sighted speed or haste; it literally denotes the right moment: just as delays in the arrival of parts where they are to be assembled or processed cannot be tolerated, the same applies to early arrivals. But Just in Time was only one of the fundamental pillars of lean production; there were other fundamental pillars and a series of other measures to be implemented to ensure that the factory truly ran smoothly, fluidly and through a pull system: what was needed was what Ohno (1968) called an «autonomic nervous system »**,** known as *kanban***,** capable of transmitting signals and orders from one station to another without central or top-down coordination. To sustain the *pull* logic, it

therefore became essential to build a rigorous operational architecture, capable of communicating production needs in real time and of systematically eliminating every inefficiency, delay or defect that might block such a delicate flow, devoid of protective stocks.

### 2.3 The non-waste architecture: operating logics and the elimination of *muda*

Having conceptualised just in time and the market-driven pull logic, having grasped the enormous differences between the Japanese situation and the American system of mass production and consumption, and having chosen to distance itself from the latter, the time had come for Toyota to turn certain insights into a real, working factory system. The economic and industrial objective was by now crystal clear: to eliminate at all costs every form of waste (as observed in the American model). It was precisely to give a name to this waste, characterising it as «all elements of production that only increase cost without adding value - for example, excess people, inventory, and equipment», that Taiichi Ohno used the term "*muda*". Since the Fordist dogma held that the assembly line must never stop for any reason, precisely because the profit margin was to be sought in maximising volumes, it consequently had to (and could) tolerate a certain percentage of scrap and defects: this philosophy is symbolised by the acronym AQL (acceptable quality level), that is, a level of quality deemed acceptable not with respect to the customer's wishes, but solely with respect to domestic competitors (Cole, 1981). The physiological tolerance of a certain percentage of defects and the total aversion to slowing down the lines went so far that entire cars with flaws were simply sent further down the production line, only to be laboriously reworked at the end of the line in huge dedicated areas (Womack et al., 1990). For Toyota this was an insane approach, and Ohno (1968) identified seven Muda, seven types of waste that had to be avoided at all costs: overproduction, waiting time, unnecessary transport and maintenance, unnecessary or inappropriate processing, excess inventory, unnecessary movement and the production of defective parts. Of these, the most serious was overproduction, which tended to cause the others. These problems had to be solved at the root, but how was this done in operational terms? As anticipated, and as described by Ohno, a first solution for applying the pull logic and eliminating warehouses and overproduction was *kanban*, the "autonomic

nervous system" of the factory inspired by American supermarkets: the downstream process was to go to the upstream process to collect parts only when it held a kanban authorising it to do so; in turn, the upstream process produced *exclusively* the exact quantity indicated on the card. Without a kanban, which served as an order for the withdrawal, transfer and production of a component, it was forbidden (under one of the six rules codified by Ohno) to withdraw or produce goods; it was the only authorised signal to start manufacturing. A small card, an analogue signal, ensured that not a single part could be produced or moved unless it was needed, and thus eliminated at the root the "cardinal" waste of overproduction and all the waste connected with it, such as warehouses and staff dedicated to moving and storing goods. Eliminating overproduction meant, in practice, producing in small batches, in line with the slogan «small lot sizes and quick setups» (Ohno, 1968): but this was anything but easy in terms of organisation and layout, which necessarily had to adapt to and follow that aim. Whereas in the West machines within a factory were grouped by function (for example, all the lathes in one place, all the milling machines in another, all the drilling equipment in yet another), this forced materials to travel from station to station, undergoing one operation at a time. Moreover, this layout forced each operator to perform a single function: a lathe operator knew only how to use a lathe, while a welder did nothing but welding; the result was, of course, further waste, because not only were workers «singleskilled», but as many workers were needed as there were machines, and if a job required a small weld in the lathe department, the entire part would have to travel needlessly from one station to another and back again. Ohno organised the space differently: he placed different machines in sequence (following the order of the processing stages) and arranged for a single worker to operate several machines in sequence, thereby ceasing to be a specialist on one machine and becoming a multi-process operator, and making all the unnecessary movements from one production island to another superfluous. In order to avoid overproducing and building up stock (and to meet the market's demand for variety), production had to be varied continuously; a single part could not be stamped "indefinitely" as in the United States: this required extremely rapid die changes on the presses, perhaps dozens of times a day (we should remember that in America months or years might pass before a die was changed). By training workers and standardising the attachment mechanisms, die changeover time was brought down to around 3 minutes by

1960 (Ohno, 1968). Thanks in part to the possibility of rapid machine set-up changes, it became possible to alternate production and change it continuously according to the needs of the market (which, it should be remembered, was the main driver of production itself in the pull system): production "in blocks" (for example, two thousand units of one model followed by three thousand of another) was abandoned in favour of "levelled" production. Levelled production consisted of alternating different models on the same assembly line several times a day, even for large numbers of cars, enabling highly varied production with zero waste. To understand production levelling better, and how opposed it was to the American model, it may be useful to consider an example given by Ohno himself (1968), in which he supposes that the model to be produced is the Toyota Corona: «suppose we make 10,000 Coronas working 20 days a month. Assume that this breaks down to 5,000 sedans, 2,500 hardtops, and 2,500 wagons. This means that 250 sedans, 125 hardtops, and 125 wagons are made daily. These are arranged on the production line as follows: one sedan, one hardtop, then a sedan, then a wagon, and so on. This way, the lot size and fluctuation in production can be minimized». This constant or levelled production, also known as *Heijunka*, had a number of advantages: first of all, it made the system extremely flexible and responsive to fluctuations in the total volumes required (if, for example, the number of cars demanded had fallen by hundreds or even thousands of units, levelled production would have allowed the company to stop in time, whereas mass production would have produced them all and left them unsold); in addition, keeping production constant made for better relations with suppliers (Womack et al., 1990), in the sense that it spared them sudden changes in volumes (which would have forced them to hold large stocks of parts and materials, or even to manufacture finished parts in anticipation of orders), whose management costs were inevitably passed on in the final price of the part sold to the factory. By guaranteeing stability and long-term contracts, Toyota enabled its suppliers to eliminate their own warehouses in turn, obtaining in exchange components at a lower price and a systemic relationship of trust with its partners. Furthermore, while *kanban* eliminated overproduction, there was a second pillar of the JIT method used to eliminate defects: autonomation with a human touch, or *Jidoka*. The concept of autonomation (as distinct from automation) referred to the machines used at Toyota which, unlike Western ones (which, once switched on, could continue producing continuously and blindly), were able to stop by themselves at the first error. Thus, if a

machine in a mass-production setting were producing defective parts for whatever reason, production would inevitably have continued for at least a certain period, generating a certain number of defective parts. Japanese machines, by contrast, did not allow this, and thus forced the problem (and the waste) to be resolved before it could spread. Moreover, the concept of *Jidoka* was also extended to the human beings involved in production: while in Detroit quality control was entrusted to large numbers of inspectors at the *end of the line* (the ratio was one to twenty, compared with one to thirty at Toyota, significantly more) (Cole, 1981), in Japan quality became the direct responsibility of the worker, who had the duty to stop the entire production line if a defect was detected, so that the problem could be solved at the root (the Andon system) (Ohno, 1968). Ultimately, the Just-in-Time production system, in keeping with the principle of *Kaizen* (continuous improvement), placed great value on the role of the worker: not only were Japanese workers able to operate several machines and free to stop an entire production line, but they could also meet in circles where they learnt to identify and solve "workshop problems"; this was not new compared with all the other car manufacturers, which did exactly the same thing, but to give an idea of the importance of workers' opinions in Japan: «at Toyota, for example, with a total of 47,000 employees, there are 4,200 quality control circles involving almost all production workers. To give you an impression of the significance of these activities, let me note the following: General Motors is generating on the average .84 suggestions per eligible employee per year, with about 22 percent of these suggestions being adopted. In 1980, Toyota Motor reports generating 17.8 suggestions per employee per year—and more importantly, about 90 percent of these suggestions are adopted. This means that not only are they getting more suggestions (20 times as many), but they are also getting better ones.» (Cole, 1981). Finally, for the Japanese company the crusade against Muda did not stop at the factory gates: it was extended beyond them, inevitably involving other stakeholders, such as suppliers. Both in the United States and in several European car companies, suppliers, whether independent external firms or internal to the manufacturers, were subject to short contracts aimed at securing the lowest price: the car manufacturer would summon several producers, providing ready-made designs, a total volume of parts and a minimum level of quality (in terms of defective parts), and would generally promise the contract to whoever guaranteed the lowest price (Womack et al., 1990). Here the logic of mass production was also applied to the (many) suppliers; they

were kept at a certain distance and treated as independent parties through purely contractual relationships, in which each party inevitably pursued its own interest, and the element often sacrificed was the quality of the parts and components supplied (which had an enormous effect on the overall quality of the cars) (Cole, 1981). Toyota, by contrast, thanks in part to the *keiretsu* system (post-war Japanese groupings of companies linked by cross-shareholdings, serving to support one another and to block foreign ownership), succeeded in integrating its suppliers into a system of interdependence (Cole, 1981): the car manufacturer maintained a constant exchange of blocks of shares, capital, employees and information of every kind with its suppliers, encouraging them to do the same among themselves; this kept each party independent (indeed, Toyota itself encouraged them to work for other car manufacturers), but bound their fates together and kept them in a relationship of closeness and collaboration that was unimaginable to the Americans (Womack et al., 1990). The result was not only a higher quality of the components supplied, and therefore a higher overall quality of the Japanese industrial product compared with the American one (Cole, 1981), but also the export of the just-in-time system to suppliers which, almost as an extension of the "parent company", adopted the same production method in a virtuous circle of improvement (Ohno, 1968). There was thus a shift from the slow creation of a production method to its gradual expansion, encouraged by the corporate and financial architecture of the keiretsu, first vertically (between Toyota itself and its suppliers), and then also horizontally, among the suppliers (who also worked for other car companies) and certain competitors, both in the automotive sector (Mazda, Honda) and in other sectors, such as motorcycles, watches, cameras and electronic equipment (Womack et al., 1990).

## 2.4 The materialisation of efficiency: lower material consumption and durable quality

### 2.4.1: The figures of saving: reducing material and energy intensity

The architecture of non-waste and the elimination of muda theorised by Taiichi Ohno did not merely revolutionise the organisation of work at Toyota and, gradually, at other Japanese companies and across the world; they also brought about a major reduction both in waste and in the intensity of the materials and energy used in production. It is

essential to point out that the reduction in consumption at Toyota did not arise from any ecological sensibility as such: it was not that kind of scarcity that caused concern, but rather the grip of economic hardship, the absolute scarcity of materials and capital in which post-war Japan found itself, and later the blow dealt by the oil shock of 1973. The initial aim was certainly not to save the planet, but rather to reduce waste and the absorption of inputs for the sake of pure economic saving: the fight against waste, efficiency as an obsessively careful use of resources, was subordinated to cost reduction, which according to Ohno (1968) was the only way to increase profits and prosper in conditions of scarcity. Nevertheless, this economic imperative translated, as a secondary and almost involuntary effect, into efficiency of an ecological nature. Without dwelling excessively on data, and setting aside the self-evident lower ecological impact that inevitably followed from the reduced use of resources and their intelligent management, a number of studies and works have supported this view. Some write: "*Lean production [...] is 'lean' because it uses less of everything compared with mass production—half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site...*" (Womack et al., 1990), and even without placing our trust in the "rule of half", we can still rely on the basic concept: the categorical imperative of fighting waste for economic purposes ended up coinciding materially with the maximum optimisation of energy and physical inputs, and therefore with a lower environmental impact. Turning to some more precise factory data, we draw on the very close collaboration between the work of Womack et al. (1990) and that of John Krafcik (1988), and on the latter's extensive experience as the engineer tasked by MIT's IMVP (International Motor Vehicle Program) with personally visiting and studying 90 different assembly plants in various parts of the world. In his MBA thesis (Krafcik, 1988), Krafcik focused on several comparative aspects of mass-production and lean-production plants; among the various data testifying to the greater efficiency and parsimony of lean plants, the use of space stands out. According to the engineer, the Japanese made far more efficient use of their space, measured in square feet per unit per year (sq ft/unit/year): according to the graphs in Krafcik's thesis (1988), the Japanese (in plants located in Japan) used an average of just 5.4 square feet per unit per year, the result of the simple calculation 1,080,000 sq ft / 200,000 units per year = 5.4 sq ft/unit/year

(meaning that, on average, a factory of 1,080,000 square feet needed just 5.4 square feet, or about 0.5 square metres, per car produced each year). For American plants in North America, the average is around 8 square feet per unit per year, rising to 10 for European plants in Europe. Much more *space* was therefore needed in Europe and the United States to produce a single car. This simple comparison, which may seem an isolated detail, is in fact highly significant and has many consequences in terms of cost, as well as of energy and material consumption: quoting Shin Ohkubo (executive vice president of Honda America), Krafcik himself (1988) writes «[…] Because land is much cheaper in the U.S. than in Japan, building a large plant here is less difficult. But if a plant has a lot of space, it consumes a larger amount of energy. In a large plant, it takes more time to transport material within the plant, and the larger space is an invitation to create large inventories and stock a large quantity of parts». Leaving aside other very interesting elements addressed in Krafcik's thesis, let us turn to data that give an actual measure of the energy and material savings. The Japanese advantage in reduced consumption of materials and energy, and in particular that of Toyota's factories, was certainly not limited to the production process or to product design, but lay first and foremost in the modernisation of steelmaking techniques: Japan was thus able to produce steel, vital to the automotive sector, using less energy than other countries. According to the World Steel Association (1980) (Table 22, p. 42), Japan consistently maintained a lower level than the USA of energy use (kilograms of coal equivalent) per tonne of crude steel produced (the basic material for car production and for manufacturing industry): Japanese values between 1965 and 1970 range from 674 to 667 kg per tonne, while in the same period American consumption is much higher, rising from 901 kg to 926 kg. Even more interesting, according to the same table, are the values for the two countries between 1973, the year of the oil shock, and 1976: not only did the United States enter the oil crisis with 881 kg of coal equivalent per tonne of steel and emerge from it with 906, but Japan maintained levels of 696 kg and 729 kg respectively, confirming its greater efficiency in steel production. It can therefore be said that the Japanese automotive industry was less energy-intensive even before it began producing the car. In the absence of precise data on the exact quantity of materials or energy needed to produce a Toyota car and an American car in that period, information serving as a "proxy", that is, as substitute data, proves useful. It can certainly be stated with confidence that from the late 1950s to 1973, that is, even

before the impending oil shock, cars imported into the United States (of which the Japanese Toyota and Datsun accounted for a considerable share, and which, together with the German Volkswagen, held 15% of the American market) weighed roughly *half* as much as those produced in the United States, although weight trends were generally rising (EPA, 1974): according to the study, the average weight of imported cars was around 2,000–2,200 pounds (approximately 900–1,000 kg), while the average weight of domestically produced cars remained close to 4,000 pounds, or about 1,800 kg. Although the U.S. Environmental Protection Agency study indicated only the average weight of imported cars actually *sold*, and although almost all the cars imported into the United States were smaller and lighter than the enormous American-made sedans towards which the domestic market was heavily skewed (so that the Americans imported only small cars), this suggests that, in general, the Japanese car was indeed smaller and lighter than the American one, and therefore required fewer materials to produce. As Cole (1981) points out: «Local circumstances forced Japanese manufacturers to produce small, efficient passenger cars and thereby also forced them to learn how to make small vehicles as attractive as possible». As evidence of this, it is hardly surprising that the share of Japanese cars imported into the USA (lighter and far more fuel-efficient than the American *land yachts*) did nothing but increase during the 1970s, owing to two oil shocks and rising fuel prices. It should be remembered that, in addition to the aspects just described, the Japanese product benefited from a production process which, as already mentioned, was geared towards the eradication of waste: not only less waste of materials (as borne out by fewer defects and repairs) and of space, but also fewer labour hours (and therefore less energy used by the machinery) per car produced, which at the end of the 1970s amounted to about 14 per car in Japan and more than 30 in the USA (Krafcik, 1988) (p. 47, Table 4). In the light of these data, a picture emerges of a wide gap between the two types of production process in terms of the use and absorption of materials and energy per unit of output, a gap which, although driven by the constant intention, or necessity, of lowering production costs, ultimately and inevitably had a virtuous effect from an ecological point of view as well (King et al., 2001).

### 2.4.2: Beyond obsolescence: product quality and durability

A “parsimonious” production system such as the Japanese one, which on the one hand paid the utmost attention to the inputs used, was on the other hand able to place on the national and international market products that were anything but shoddy. The idea, the myth typical of American management, that doing things efficiently and spending less was equivalent to doing them worse must therefore be abandoned: in truth, it is clear that there was no serious correlation, at least for Japanese production plants, between effort or productivity, in terms of labour hours per vehicle (and therefore also cost), and quality, understood as the absence of defects (Womack et al., 1990). For Japanese manufacturers such as Toyota, «free quality» was possible, whereas quality cost more only for European and American manufacturers. This should come as no surprise, because the secret of the higher quality of the Japanese product, at least from a strictly industrial point of view (that is, quality understood as the absence of defects), was that it was deliberately pursued as an imperative, as the highest aim, as the method through which waste (and with it cost) was reduced; we know very well, by contrast, that the American philosophy was exactly the opposite: quality higher than that of competitors was not needed in order to take market share from them; all that was needed was an acceptable quality, good enough, so tolerance of waste and defects, and of lower quality, was higher (Cole, 1981). What has just been argued should not, however, give the impression that the Japanese product was always “infallible” and never needed improvement over the course of its history: the prejudice that “quality costs” was indeed borne out in practice, at least until the 1970s, by common American opinion, which, as Cole (1981) admits, long saddled Japanese manufacturing with the stigma of being a producer of «cheap toys» and «inferior» cars. The superior quality of Japanese products was therefore the fruit of years of continuous improvement (this is precisely the concept of *Kaizen*: small and continuous improvements), and it did not become apparent immediately. *Industrial* quality, that is, the absence of defects in the product leaving the factory, must be clearly distinguished from the quality perceived by the customer, a much vaguer and more composite concept; yet in this latter sense too, the Toyota car managed to distinguish itself over time. Cole (1981) argues clearly about the nature of quality. Quality is in some way detached from the engineering calculations carried out within a factory and brought much closer to the

customer's perceptions and emotions: «What do we mean by automotive quality? Quality is the entire collection of activities by which we achieve fitness for use as determined by the final user». The aim here is to stress the importance of the multifaceted nature of this concept, emphasising that it is the customer, the end consumer with his or her needs and tastes, who determines which pool of characteristics or functions makes a car worthy of the term "quality", voting for it and choosing it through the act of purchase. It was precisely from this difference, a philosophical one if you will, in conceiving or understanding two different ideas of quality (made up of different components) that a very practical competitive advantage arose: on one side, quality was understood as "good enough" to beat the competitor; on the other, as the pursuit of perfection in every industrial act and the need to satisfy the customer. And while in Japan "fitness for use", determined by the evident needs of the consumer, was made the main driver of the very conception of the vehicle (we should remember that the starting point was the very demand for products, *in order* to produce them), in America manufacturers, focusing excessively on waging war on one another for profit, had forgotten precisely this fundamental aspect. Into this "distraction" the Asian product made its way, gradually and without being loved at first, progressively taking the lead in the perception of those who actually used cars, to the point of raising the «quality threshhold», the minimum acceptable level. This did not mean, Cole (1981) specifies, that the quality of American cars declined in the 1970s; quite the opposite: in that period American vehicles had several «bright spots», such as «safety, corrosion resistance, structural integrity, and […] durability of the power train»; it was simply that the quality of Japanese cars improved considerably, winning consumers' hearts thanks to superb finishes, excellent fit and obsessive attention to detail. Finally, customer satisfaction was measured not only in terms of fewer defects (an area in which Japanese vehicles were *already* very strong, owing to their production philosophy) or high-quality finishes, but also in terms of reliability. Cole (1981) defines reliability as the «probability that the car will perform without failure—or more operationally, the mean time between failures», and argues that in this field too the Japanese car had by then overtaken the American one. Thus, through industrious and quiet progress, the result was a well-made, well-finished, fuel-efficient and increasingly reliable product, so much so that from the following decade onwards Toyota became ever better known for the reliability of its vehicles: the car "had to start

every morning and never leave the user stranded", eventually matching the German luxury car giants in solidity in terms of the number of defects recorded, especially in years when the growing complexity of on-board technological systems was making it increasingly difficult for the average user to fix a fault (Womack et al., 1990). The lesson taught to the Americans and to their production philosophy was that not only was high quality at a low price possible (provided that production was geared towards eliminating waste), but that it was also an excellent strategy for increasing market share and profit (Cole, 1981). In addition, thanks to the virtues of lean production, Toyota and other Japanese manufacturers were able to maintain high levels of production and sales without having to resort to strategies of planned obsolescence, as was the case with American products. The Toyota production system and the reduction of production and design costs allowed the Japanese manufacturer to offer a wide variety of models and to expand it with relatively modest investment compared with the American giants: in practical terms, whereas on one side changing the features of a model (and thus making it attractive or appealing for sale) took a long time and huge sums of money, this was not the case on the other. Womack et al. (1990) confirm this, arguing that the very way in which Toyota lowered its costs allowed it to achieve profit levels similar to those of the Americans but with lower sales volumes: in order to lower costs, the Japanese *did not need* to chain themselves to production in the order of *millions* of units of a *single model*, keeping it in production for ten years; on the contrary, they could afford a greater variety of models (offering a wide choice) and four-year production cycles, with genuine and frequent innovations. In short, from a certain point of view planned obsolescence was overcome because it was simply rendered superfluous: there was no need whatsoever to produce the same, technologically identical vehicle for years and to alter it in a purely cosmetic way in order to sell it; the lean system made it possible to innovate *genuinely*, and to do so quickly and at low cost (in the 1980s a series of innovations were introduced that were not new but had never been implemented because they were considered too expensive: some examples are double overhead camshafts, electronic fuel injection and multiple valves per cylinder) (Womack et al., 1990). To put it in Packard's (1960) terms, in the Japanese case obsolescence could be described as "functional", whereas in the American case it was purely psychological.

## Chapter III: Global sustainability, eco-efficiency and new models of consumption

### 3.1 From the fight against waste to the protection of the planet: resource saving and global impact

It is clear at this point that the drive towards efficiency and parsimony in the Toyota system arose from the need to survive in conditions of scarce material and financial resources and to adapt to a market that was sluggish in its capacity to absorb output and difficult to satisfy in several respects. The development and success of the JIT system were then also helped by, and achieved through, its encounter with further periods in which the concept of scarcity once again became alive and present; for example, as we have seen, during the 1970s. We can therefore be certain that the ruthless elimination of waste was essentially motivated by an economic, material lack: an extreme attention to efficiency based on a scarcity that Jackson (2009) would locate at the level of «sources», that is, of the inputs and resources entering the economic metabolism. If there was a positive effect from an ecological and environmental point of view, this was certainly not the main objective. It would obviously be an oversimplification to attribute the success of the Toyota production system solely to a scarcity of material and economic resources (whether understood as the condition of its birth or as situations it had to face years or decades later), but this was certainly one of its main drivers. Although awareness of a limit (not well defined, but present) to our planet's capacity to cope with the consequences of endless, exponential growth was already beginning to spread in the 1970s (Meadows et al., 1972), and although certain problems caused by poisons and pollutants had been clearly evident for some years, it can be argued that the industrial position and mentality nonetheless remained (despite the progress made by national legislation and international meetings) not far removed from the way of thinking that was *causing* those very problems: scarcity was treated conceptually as an industrial and economic problem, to be solved in order to get the world's industrial metabolic machine running at full speed again; in other words, the problem of resource scarcity was a concern in terms of prices, supplies and competition, in short, of growth. In sum, the growing awareness of the finiteness of resources caused great alarm, but the way of reasoning remained the same; and if the

"shock" of resource limits was, in a sense, not enough to change course, concern about the planet's capacity to absorb pollutants had even less effect. Armed with decades of history and data, we are much more aware today: if we describe the economy (in stylised terms) as a metabolic flow that draws matter and energy from the environment, transforms them by passing them through an economic process and finally discharges scraps and waste, we know that the real problem today lies indeed in the inability of natural cycles to regenerate depleted resources, *but above all in their inability to absorb waste* (Jackson, 2009). In the face of this, the proposal of this work is to look to the Toyota system, and to some of its typical premises and features, as a methodological approach for avoiding the overshooting of our environment's carrying limits, both in terms of incoming resources and as regards outgoing waste. With this aim in mind, the flexibility of the *lean* system should be highlighted, understood as its great potential for application outside the automotive sector (something that has already happened in several cases) and outside manufacturing in general: the Toyota system can go so far as to become a sort of universal organisational paradigm; it is scalable and can move beyond the conveyor belts of car factories (Japanese or otherwise). Womack and Jones (1996) show that lean thinking rests on a number of pillars, five principles that can be scaled anywhere: specify value, identify the value stream, make activities flow without interruption, let the customer's demand pull production and, finally, pursue perfection. Applying this philosophy, even in sectors other than automotive, would not only be possible but would also mean achieving a sort of structural lightening, with economic and operational benefits even in the short term. Not only, then, can the lean model be applied in a variety of situations and benefit those who adopt it, but several studies show that it is intrinsically linked to environmental protection (despite having been created to deal with the *other* type of scarcity). King and Lenox (2001) have shown statistically that companies obtaining ISO 9001 certification (a quality management standard associated with the adoption of lean production) not only produced fewer pollutants and emissions, but were also much more likely to develop dedicated environmental management systems and obtain ISO 14001 certification, which is closely connected with the establishment of, and compliance with, specific environmental policies, objectives and responsibilities. Moreover, a lean system would help (precisely because its nature privileges the reduction of waste at source) to reduce scrap and pollutants through a *preventive* approach rather than through end-of-pipe

treatment, also lowering the marginal costs of environmental management (Florida, 1996; King and Lenox, 2001). According to this approach, removing pollutants upstream could lead to economic savings, in particular thanks to the smaller quantity of inputs required, simplified processes and lower compliance and liability costs (Hart, 1995). There are several other correlations between the Toyota method and environmental protection; in particular, it may be noted that, according to Florida (1996), «the pursuit of zero defect and zero inventory manufacturing strategies produces spill-over benefits to the environment and creates the context for innovative approaches to emission reduction and pollution prevention, leading in turn toward zero emission manufacturing strategies»; we can therefore say that a *lean* approach is genuinely sustainable and produces a positive spiral in which economic and ecological advantages reinforce each other, in continuous improvement on several fronts. Aware of the by now undeniable advantages that the Toyota method brings, the task is not only to exploit them but to incorporate them into a larger design. It is increasingly evident that our current economic system is no longer compatible with the physical and thermodynamic constraints of the planet; global warming has reached unprecedented levels and is causing an ever-growing number of extreme weather events; we therefore live on a planet that is increasingly hot and polluted, and whose resources we are plundering at an unsustainable rate: so-called "Earth Overshoot Day", which marks the point in the year at which the natural resources the planet can generate are used up, falls ever earlier (whereas in the 1970s it fell in the last months of the year, in 2026 it arrived on 30 July) (NASA, 2024; World Economic Forum, 2026). We cannot continue to produce and consume at our current rate; a far-reaching change on several fronts is therefore needed, one that the lean production system *is unable* to provide on its own. Certainly, it can be said that the first step in such a change is the shift from a linear to a circular economy. A model based on the essence of *take, make, use, lose*, which helps itself liberally to metals, minerals, biomass and fossil fuels, turns them into products and sells them to consumers who will turn them into waste, however much benefit and profit it may have brought, must come to an end because it rests on non-existent premises (the myth of infinite abundance) and has disastrous consequences that run counter to the rhythms and functioning of the planet (Raworth, 2017). The circular economy model is much better suited to today's problems, because it rejects the assumption of infinite resources and is the opposite of the linear model, in that it imitates

natural cycles and takes nature as its model: the very concept of waste is eradicated, or scaled down, because the waste from one process becomes the input for a different use; in this way materials (whether "technical", such as synthetics, plastics or metals, or "biological") are not used and thrown away but continue to be used again and again, remaining in circulation for as long as possible, and in this sense the economy tout court is understood as «regenerative by design» (Raworth, 2017). However, as the anthropologist James Franquesa warns (Il Tascabile, 2026b), the adoption of circular practices must not translate into passive acceptance of the fallacy known as "green growth" and of the assumption that growth in itself is always desirable and positive: this rests on the (false) hypothesis, unsupported by any scientific literature, that economic growth can be separated from the pressure it exerts on the environment. In this sense, traditional GDP accounting (PIL, in Italy) proves completely inadequate, according to a study conducted at the University of Leeds entitled "A good life for all within planetary boundaries" (Il Tascabile, 2026a): to assess real social progress, reference should be made to *qualitative* indicators. The study shows how a rise in average per capita income has a positive effect on quality of life (which also includes elements such as life expectancy, education and perceived happiness), but only up to a certain threshold (around twenty thousand dollars). It therefore becomes necessary to adopt alternative parameters for evaluating societies, such as the Sustainable Development Index, which includes aspects such as health, education, emissions and per capita material footprint: since the 1970s, countries such as Bhutan have placed alongside GDP an indicator of "Gross National Happiness", known as GNH, which is measured against parameters such as equitable and sustainable socio-economic development, good governance, environmental protection and the preservation of culture; the variables of the country's well-being include level of education, air quality and the percentage of the country covered by forest, but also biodiversity, psychological well-being and others. Returning to the concept of the circular economy, whatever model we use to imagine how it works, it represents a conceptual as well as a practical step forward; indeed, it achieves not "only" the prolonged reuse of materials, energy savings and a smaller quantity of waste, but essentially, precisely through the creation of circular "loops", the slowing down of the flow of materials into and out of the economy. This is the conceptual novelty that the circular economy introduces: if we imagine the life cycle of any material entering the classical economic

process, it would be extracted, used to become a product, sold to a customer and thrown away relatively quickly. The circular movement, however it is represented through one of the various existing models, does nothing other than reduce the speed at which materials enter the process and leave it. How? By trapping them in loops, that is, by recycling them and finding one use for them after another, with the aim of keeping them within the process of use for as long as possible. What has just been said should lead us to reflect on two elements; the first is that, from a circularity perspective, the build quality of the product, expressed above all in terms of durability and repairability (virtues that would keep it within the loop of use for a long time and prevent it from becoming waste), becomes a fundamental characteristic in the pursuit of genuine sustainability: the manufacturing sector will therefore have to overcome (where it makes sense to do so) planned obsolescence and pay greater attention to the durability and repairability of products (Jackson, 2009). The Toyota production system is, as we have seen, particularly well suited to producing quality goods and to doing so in the most parsimonious way possible. The second element that should pique the reader's curiosity comes from observing the circular economy model itself: we have said that it seeks to slow down the flow of materials into and out of the economic process by bending its shape from linear to circular, but this is not enough: according to Georgescu-Roegen (1971), the economic process (whatever form it takes) is nothing other than an irreversible and inevitable physical transformation that degrades low-entropy resources into a state of high entropy (that is, into waste). The only solution is therefore to slow this process down upstream, and the circular economy, supported by lean production, succeeds in doing so only in part: the change we hope for is of a higher order, at the level of the general functioning of the economy and of consumption. This change requires, first and foremost, the recognition and dismantling of the social logic on which the current economic paradigm rests: according to Jackson (2009), modern capitalism has chained us in an «iron cage of consumerism», in which economic growth is a categorical imperative, translating into a continuous cycle of destruction and innovation that exploits a psychological need for consumption as a strategy of identity and social affirmation. In such a framework, Jackson argues, achieving greater productive efficiency would indeed reduce the resources entering the system, but this would translate into lower costs, and hence greater demand for the good and, ultimately, further growth in production. Efficiency, therefore, would

not lead us to consume less, but would push production further still, eagerly welcomed by consumers who buy not only on the basis of primary needs but driven by symbolic needs for communication, affiliation with social groups, giving meaning to their existence or soothing an "empty self" through consumption. Neither more efficient production methods (whether technical or organisational, such as lean), nor the adoption of a circular economy can reverse course, and thus slow at source that flow of materials and energy, unless they are embedded in a radical (and also cultural) transition in consumption patterns: the solution (Cooper, 2005) is a genuine slowing of the global economic metabolism, and this can be achieved only through the concept and practice known as « slow consumption », a perspective in which reducing the absolute volumes of production and consumption becomes the main objective. Cooper's slow consumption necessarily entails high product quality and longevity and, consequently, the establishment of a different relationship between consumers and products: durable products require owners willing to care for them through maintenance, repair and upgrading. It is, finally, from the union of these concepts (the lean method, the circular economy and slow consumption) that we can achieve genuine sustainability, and it is within this union that the Toyota production method can be embedded: it would cease to be a tool of efficiency in the service of an economy geared towards infinite growth and unbridled consumption, and would instead become a parsimonious tool for delivering the product quality needed for the economic transition described by Cooper (2005), on which a circular model can operate (without being rendered futile). As anticipated as early as the early 1970s (Meadows et al., 1972), the underlying problem remains the prospect of continuous and uncontrolled growth and consumption; this is what must be stopped if we truly want sustainability; producing parsimoniously with a lean system, or applying the circular economy, can help, but not if they remain systems subservient to that basic assumption, namely that continuous economic growth is possible. It is towards the solution identified by Jackson (2009), namely a «prosperity without growth», that we must turn our gaze: in this sense, prosperity has value as the "flourishing" of human beings within the limits of ecological possibility, a concept that goes far beyond the materiality of material satisfaction. Within this new horizon of values, the goal of business changes, following that of people, shifting towards maintaining the value of the product and providing services that serve this human "flourishing", rather than focusing on compulsive selling.

The first concern from a lean production perspective is to understand the definition of value perceived and desired by the consumer, and to focus on it, eliminating activities that do not contribute to achieving that value (Womack and Jones, 1996): value will no longer lie in ephemeral novelty, but in a product that is durable, repairable and does not quickly become obsolete. Freed, therefore, from the goals of continuous growth, the Toyota production system can become the productive engine of an economy of conservation, well-being and care, contributing the parsimony and qualitative excellence of which it is capable.

### 3.2 Designing for circularity: overturning planned obsolescence

#### 3.2.1: Designing for durability: maintainability and repairability as an evolution of Total Quality.

Achieving genuine sustainability, and therefore overcoming the paradox of continuous growth, made up of production and consumption that keep increasing and are often reinforced by technological efficiency gains, necessarily requires, as we have seen, slow consumption, that is, an approach that slows down both the rate at which materials are transformed into products and the speed at which products are "used up". In short, sustainable development is inspired by two principles, efficiency and sufficiency (Cooper, 2005): the first calls for the efficient and productive use of resources (and in this the Toyota method is a champion), but since this is not enough, the second aims at the slowdown discussed above in the "need" to make products, sell them and use them. Both these principles lead logically towards extending the life of products: the recycling of materials is merely the last link in the chain of the circular economy, whereas the first step is the durability of the good, that is, its capacity to resist wear and remain fit for a long time for the use for which it was designed, and this characteristic begins precisely with the conception of the product. In this scenario, Total Quality Management, as applied by the Japanese and a pillar of the Toyota system, undergoes a profound change: in classic lean production, total quality is achieved through an ecosystem of practices (described above) and arises initially to meet pressing internal needs, namely to eliminate defects at

the root, to eliminate rework and to guarantee perfection on delivery, through the reduction of muda and costs within the company. That system was economically successful because it was able to interpret correctly what customers (including those overseas) regarded as value, and to offer, in accordance with their wishes, products that worked and were free of defects, and to do so in the least costly way possible. In short, the total quality that Ohno had in mind was quality understood as perfection (at least as an aim) in every industrial act, an intolerance of defects and of the waste of any input at source: although this pursuit of absolute quality was conceived as a dynamic internal to the factory and did not have the absolute durability or longevity of the product as its ultimate goal, it somehow ended up being «built in» to the final product precisely thanks to the production method. In this method, in which errors and imperfections were systematically eliminated at their inception, the natural result was to turn out cars capable of withstanding wear for decades, to such an extent that the Toyota name became renowned and associated with the concept of reliability. There is no shortage of examples: industry reports such as the Vehicle Dependability Studies of J.D. Power (J.D. Power, n.d.), a well-known independent market research and data analytics firm, have consistently placed Toyota and Lexus (its premium brand) at the top of the rankings for decades; there are also cases of vehicles more than thirty years old that continue to run without trouble even with almost half a million kilometres on the clock (Toyota Motor Corporation, 2018). The iconic status of Toyota's toughness was even put to the test on television in the famous BBC programme Top Gear, in which a Hilux pick-up remained driveable after being deliberately submerged in the sea, set on fire and brought down together with a 23-storey building under demolition (BBC, 2003). These are practical demonstrations that a production method free of "flaws", in which quality is instilled at every step and thus "enters" the product, led Toyota to create goods less likely to suffer catastrophic failure during their lifetime: although this was not the main objective, it did not happen by chance, but as the consequence of a virtuous method. In the "slow" economy described by Cooper (2005), the Toyota system proves particularly well suited to serving as the technical backbone, both because of its parsimony and efficiency and because of the product quality it has shown itself capable of. Longevity would become an end, a goal, and products (whether cars or any other manufactured goods, bearing in mind that the lean system can be scaled to other sectors) would therefore be designed to last a

long time, to be disassembled and repaired, and finally to be fed into the circular economy through reuse and recycling. In the study "Product design and business model strategies for a circular economy" (2016), Nancy Bocken and her colleagues, recognising the importance of the product design phase as the locus of its circular sustainability, build an interesting theoretical framework concerning how products should be made in order to be durable and circular. The design approach is divided into two broad categories of action: «slowing resource loops», which has to do with slowing down resource cycles, that is, focusing on product durability, and «closing resource loops», that is, ensuring genuine circularity. To slow down the use and extraction of resources, the most important thing is to keep the object in use for as long as possible, and there are essentially two routes at the design stage to achieve this: «designing long-life products» on the one hand, and «design for product-life extension» on the other. Designing for a long life means not only that the product must have a design geared towards reliability and durability, but also towards the psychological durability of the good, and hence a design «for attachment and trust»: designing against psychological obsolescence means creating products with which users can develop an emotional bond that deters them from replacing them. Durable products are not only strictly a matter of how well the object withstands time and wear, but also of how far its life can be extended through processes of repair or upgrading: design for product-life extension therefore means conceiving an object that can be maintained and repaired, but that is also capable of evolving and accommodating future modifications or upgrades, that is, of keeping up with the times and improving its qualities and performance as the user's needs change without having to be thrown away; for this reason, it is important that components be standardised and interchangeable. According to Bocken and colleagues (2016), moreover, once the life of the product in question has come to an end, ideally, from a circular economy perspective, it should never become waste, whether it is a technical or a biological component. Furthermore, for both the durability of the object and, subsequently, its recycling to work as well as possible, one design feature is essential: it must be designed for disassembly and reassembly. A product that is easy to take apart and put back together will allow easy and inexpensive inspection and maintenance, and it will be easier to repair or even upgrade, possibly by adapting parts from other products; moreover, this feature will also prove useful at the recycling stage, lowering its costs. It is at the design stage that all the characteristics are decided

which will enable the product to last a long time and be kept in working order, and although these characteristics are not necessarily the prerogative of manufacturers who adopt the Toyota method, that method can nevertheless prove extremely useful in applying its own architectures, aimed at achieving a durable good produced without waste, in the simplest, most economical and most ecological way possible. Traditional Fordist manufacturing industry has historically designed hardware with an exclusive focus on optimising primary assembly (with the aim of reducing production cycle time and the immediate cost of manufacture), a short-sighted approach that did not consider the entire life of the product but was concerned only with selling it. Packard (1960) points out that, in the era of mass production, «in their preoccupation with gadgetry and production short cuts—and perhaps obsolescence creation—manufacturers often gave little thought to the problem of repairing their products (or deliberately made them hard to repair) ». This purely consumerist logic led, as Packard (1960) himself testifies, to the production of objects unsuited to repair: toasters riveted together so thoroughly that it took almost an hour to inspect their insides, or appliances that had to be dismantled entirely in order to replace a single part costing a few cents. In many cases this made replacement the economically advantageous option. This short-sighted design (whether more or less deliberate), detached from the interests of the end user and from the complete life cycle of the product, concerned only with packaging goods to be *pushed* onto the market, is precisely what should be avoided. A lean production style could, by its very nature, help to solve certain problems: Womack and Jones (1996) emphasise that the starting point of lean logic is the definition of what value means for the customer, and it is this, through a pull logic, that drives all production. If the end customer does not want a disposable product and costly, complicated maintenance, then value for that customer will lie in the virtues of the “long-life product”: consequently, design and production will be placed at the service of that value (which is redefined over the life of the product) and will not be distorted by the manufacturer’s internal requirements. This closeness of the lean system to the end user and to the repair technician could be one of the features that make it particularly suited to this change in economic paradigm. Nor should we forget that the new imperative of extending the life and value of the product from a circular perspective does not dispense with the need to create products that are, as far as possible,

born free of defects, or to stop defects from spreading, nor with the need to avoid all waste and overproduction: the classic principles of the TPS therefore remain valid and usable.

### 3.2.2: Challenging the consumption model: the product as capital and the overcoming of obsolescence

It is by now clear that planned obsolescence, in all its forms, represents damage to the environment and a failure of design: it succeeds in saturating the market with products and in stimulating consumption, but it fails at the environmental and design levels; in other words, it represents the subjugation of design to the myth of continuous growth and consumerism. This model squanders enormous quantities of energy and matter in order to shorten the life of products and force their replacement (Packard, 1960), and it goes so far as to poison even the relationship between subject and object, erasing the emotional connection between the user and the product itself and preventing us from forming closer and more lasting bonds with the objects we use in everyday life. Persisting with this model means operating according to a short-sighted model focused on the wrong parameters, from both an economic and an environmental point of view; Hawken and colleagues (1999) point out that industrial capitalism has accumulated great amounts of capital with enormous success, but that natural capital is meanwhile disappearing. An economic system is normally based on four types of capital: human (labour, culture), financial (monetary instruments), manufactured (factories, infrastructure and machinery) and natural (raw materials, living systems). Our economic model is unsustainable because, while it uses all four types of capital, it continues to operate in opposition to its natural component; that is, it continues to assign no value to the natural and living resources that it exploits, on the one hand, and destroys, on the other. All this results in a Western society essentially founded on waste and afflicted by three different crises: «the deterioration of the natural environment; the ongoing dissolution of civil societies into lawlessness, despair, and apathy; and the lack of public will needed to address human suffering and social welfare». According to the authors, all these problems would leave us very far from the real well-being or “growth” that our indicators, such as GDP, would have us believe in: these do not measure the costs and waste that the system itself produces; indeed, GDP

counts them positively. GDP is wrong from an accounting point of view, because by focusing on monetary transactions it conceals waste and the structural crisis of society and of natural habitats; it does not account for their true costs by deducting them from the balance, but instead adds them to the total, portraying them as economic progress. The result is that a large part of the GDP of rich countries such as the USA is in fact made up of economic activities that create no value (waste) or that destroy natural and social capital to which no value is even assigned. Of the 9 trillion dollars that the authors indicate as being spent each year in the United States, «at least $2 trillion annually is wasted». To give an idea of the waste that appears in economic indicators, a situation familiar to everyone is cited, «sitting in a traffic jam» , as an example of a condition in which money and resources are consumed (increasing GDP) in activities that generate no value of any kind: according to data from the period (the late 1990s), 250 billion dollars a year were spent on costs arising from road accidents and traffic congestion, more than 500 billion on treating diseases caused by pollution and unhealthy lifestyles (including obesity and substance abuse), 40 billion on illegal drugs, 65 billion on unnecessary medical tests and 200 billion on energy inefficiencies, and the list could go on. According to the authors, «as much as half of the GDP» could be attributed to transactions we make to remedy the environmental, social and material degradation that we ourselves create with our current economic system. Continuing in this way would not be possible, from a lean perspective either: it is more imperative than ever to accelerate the move towards the economic framework described in the previous section, that of a slow-consumption, circular economy *supported* by lean production. The economist Herman Daly (Il Tascabile, 2026b) argues, through the concept of the "marginal disutility" of growth, that once a certain saturation threshold has been passed, the marginal utility of new products and goods begins to decline, while their social, health and environmental costs (or rather, the externalities associated with their production) increase, giving rise to what he calls "uneconomic growth". The first risk that comes to mind for an economy that deliberately seeks to slow down consumption and production (in a word, growth) is a recessionary spiral: according to Jackson (2009), our economies depend on growth to maintain stability, which gives rise to a «growth dilemma»: on the one hand, growth is unsustainable; on the other, de-growth would inevitably lead to falling demand, unemployment and recession. The solution lies either in making growth sustainable or in

making de-growth stable: the second option is the one pursued here. The author proposes a «Cinderella economy», an economy of conservation, much closer to human beings (in terms of its affinity with their personal and social needs for flourishing within the limits imposed by the environment), circular in structure, with slower consumption and production, and in which the labour market is completely transformed: businesses would devote themselves more to services, such as the maintenance, repair, recycling and upgrading of durable goods, rather than to selling them. Attention should therefore shift to sectors with high labour intensity and low ecological impact: «community energy projects, local farmers' markets, slow food cooperatives, sports clubs, libraries, community health and fitness centres, local repair and maintenance services, craft workshops, writing centres, water sports, community music and drama, local training and skills», all activities connected with the human "flourishing" discussed above and with a low environmental impact, which in capitalist terms would be considered unproductive. Such an economy, with low growth (in which output is in some way limited) and with labour productivity that continues to rise thanks to technological and digital innovation, necessarily requires fewer working hours and fewer workers: to avoid problems, the author proposes policies to reduce and share working time: distributing the available work more equitably by shortening the working week would improve work–life balance and guarantee fair employment. The new economy would also see changes in its financial component: investment would become oriented towards ecological objectives, often long-term ones, which would completely change the meaning and functioning of the return on capital and investment. At the macroeconomic level, then, it would be services that kept the economy going, oriented towards human and social flourishing and towards the transitions needed to improve sustainability (energy efficiency and infrastructure, sustainable mobility, investment in public and social spaces and initiatives, ecosystem protection); at the microeconomic level, however, companies that produce goods must still protect their balance sheets from lower sales volumes. A useful strategy in this area is what Bocken and her colleagues (2016) call «access and performance», which marks the definitive shift from the sale of physical ownership to the provision of a service and of the product's functionality: in this model the product would become a service; that is, the manufacturer would offer value to the customer not by selling ownership of a good but by providing the enjoyment of a service, taking on the burden of maintenance. The

price paid by the consumer would therefore be per unit of time or of service delivered, and the entire system would push companies economically towards a circular model and towards keeping goods in use for a long time: in this “performance-based” model, the breakdown or obsolescence of a good would become an economic loss for the manufacturer itself, which would have an economic incentive to keep it in good working order and to upgrade it; this would naturally have knock-on effects upstream on production and design, which would be geared towards durable products that are easy to repair. It is precisely in this paradigm shift towards services that the Toyota method and lean thinking prove indispensable and renewed, both as the technical and productive tool underpinning the new economies and as an element that helps to stabilise them and keep them on their feet: Womack and Jones (1996), observing that lean thinking had always been applied to the design and engineering of the car as a product but never before to the «total product » (that is, mobility tout court), describe a scenario, to remain within the automotive field, in which they hypothesise the shift from the traditional sale of cars to the provision of a service of «short-range personal mobility». In this scenario, a mobility provider (a car manufacturer, a rental company, a public utility) takes charge of insurance, registration, routine maintenance and repairs, guaranteeing the user value that lies in the possibility of using a “hassle-free” service without interruption. All this would be not only economically feasible but also advantageous, and the Toyota method could be applied in an extended version, exploiting its benefits in terms of the absence of waste: vehicle production would take place through agreements between the service provider and the manufacturer, and this would help to achieve unprecedented regularity of demand, both in volumes and in specifications, levelling production upstream and eliminating errors, inventory, space, unsold stock and dealerships; in short, lowering costs. The advantages would also extend to circularity: the service provider contributes to the construction of the car and to its specifications, and has an interest (as owner) in having products that are durable, easy to maintain and upgrade and inexpensive to recycle, and could intervene to refine design features using data from customer feedback: the Toyota model could thus provide “a way to revitalize a highly mature "product" by converting it from a hassle-laden good to a hassle-free service.” There are several similar academic proposals: Raworth (2017) also highlights how the sharing economy and the collaborative commons, based respectively on the exchange or rental of local goods instead of their

purchase, would allow people to obtain use value while bypassing the need to place new products on the market. The great challenge for these and other slow consumption initiatives lies in their economic viability within the competitive, growth-based market in which we operate today. We have seen how producing fewer physical goods risks translating into lower revenues and, potentially, into higher unemployment and, ultimately, economic recession. It is precisely into this gap that the Toyota method, understood both as a method of industrial and manufacturing production and as a way of thinking about business and the economy, fits as an engine capable of making a slowing economy financially sustainable. There is no better method or way of operating in conditions of resource scarcity and economic difficulty. As described by Womack and Jones (1996), applying lean principles frees up enormous quantities of internal company resources: space, labour hours, inventory and tied-up capital; whereas in a traditional mass-production logic these resources would be used to increase overproduction still further, in the new economy of conservation it would simply be a matter of reusing the resources saved not to grow indefinitely, but to finance high quality, the development of after-sales services and customisation. In a single sentence: the Toyota method would help to make a slowdown of the current economy economically viable. One important point: overcoming obsolescence and arriving at a slower economy with a low rate of consumption does not represent a halt to progress, but its highest stage of maturity. It would not be a sort of "defeat", but a fulfilment. This concept was already anticipated, almost prophetically, by one of the fathers of classical economics, John Stuart Mill, in his "Principles of Political Economy". In this work of 1848, Mill himself, who had understood long before the 1970s that indefinite material growth in a country with finite resources was illusory, rejected the idea that the end of capitalist accumulation would coincide with the decline of civilisation; as cited by Meadows and colleagues (1979), he wrote: «a stationary condition of capital and population implies no stationary state of human improvement». The improvement of humanity, progress, is not forever bound to economic growth; the two are separate. In such a situation of slowing growth, it is precisely the end of the race to accumulate and of competition for status (what Mill described as «the art of getting on») that would finally open the door to human flourishing, also called the «art of living»; indeed, of that situation of economic stationarity Mill writes: «There would be as much scope as ever for all kinds of mental

culture, and moral and social progress; as much room for improving the art of living, and much more likelihood of it being improved, when minds ceased to be engrossed by the art of getting on». The economic stage at which GDP (at least for the countries and blocs that have completed their industrialisation) levels off is by no means to be rejected; rather, it is desirable, and the Toyota Production System, combined with lean thinking, can undoubtedly (in the ways we have seen) be necessary tools for reaching that stage and for turning Mill's vision into industrial reality.

## Conclusions

The research path developed in this dissertation set out to investigate the historical roots and the crisis of the Golden Age as a period characterised by strong economic growth, while at the same time challenging that growth in its various negative effects and beginning to illustrate some systemic alternatives, with an eye to the future. Through a historical and economic rereading of the advent of the age of limits and of the transition from a Fordist industrial paradigm to a post-Fordist one (or to alternative models), the aim has been to show that the transition towards a degrowth economy does not represent a negative utopia, but rather a biophysical necessity that cannot be escaped for long. The main findings are summarised below, together with, above all, the unresolved issues and the questions that remain open for future research.

The first finding to emerge from the historical and economic analysis is the demystification of the Golden Age: that quarter-century of unprecedented expansion and material growth did not represent a stable condition of industrial capitalism, but an exceptional interlude that may not necessarily be repeated. The entire post-war economic miracle rested on truly unique energy-related, political-economic, financial and historical premises; the singularity of this combination of conditions, and the (economic) success of the years between the launch of the Marshall Plan and the first oil crisis, were optimistically mistaken for a structural constant of development. The end of this "optical illusion", marked (if one wishes, simplistically, to identify a precise date) by the oil shock

of 1973, ushered in the age of limits. Although awareness of the unsustainability of perpetual growth had *already* begun to gain ground (thanks to works with a wide public resonance, such as that of Rachel Carson, and to significant academic contributions such as the MIT study on the limits to growth, which had brought to light both the saturation of the biosphere with industry's polluting by-products and the possible exhaustion of incoming resources), it was the energy crisis of 1973 that represented the historical watershed. The dissertation has shown that the responses to that crisis, of whatever nature (new efficiency laws, the creation of international institutions, the diversification of extraction), sought in some way to *circumvent* the limits discussed, through eco-efficiency and technological innovation: the world behaved as if there were no limits to growth at all, either in terms of resources or in terms of the capacity to absorb waste; once the economic problem had been fixed, the objective remained the same: to keep growing. However, historical analysis and the present situation show that such an approach is not sufficient: within a macroeconomic framework perpetually geared towards continuous growth, technological progress cannot save us, nor can it save the planet: this is what the Jevons paradox (or rebound effect) holds, namely that every increase in efficiency lowers the unit cost of using a resource and ends up stimulating its consumption still further. The solution, therefore, is not to be found *only* in technological or engineering solutions, or in entire systems of economic and industrial organisation (such as the circular economy or the Toyota method), but in leaving the myth of infinite growth behind.

Given the failure, in the absence of a paradigm shift in the *ends* of the economy, of purely technological, organisational, regulatory or any other kind of solutions, this research offers as its contribution not so much the Toyota Production System or the Toyota philosophy as a solution in itself, but rather a re-signification of it, as an organisational structure capable of supporting a new economy based on sufficiency, on a well-being that is not equated with consumption, and which accepts degrowth. Toyotism thus takes on a new guise in this dissertation: it is freed from the role of a mere tool for cost compression and reinserted into a shift in economic paradigm in which it joins a number of other solutions. The reason lies in the very nature and genesis of this system and of the way of thinking that has distinguished it: it is a tool born to achieve absolute parsimony and the avoidance of every form of waste, and therefore ideally suited to the economic phase we must face. However, the work shows how the ecological potential of

the TPS or of other systemic solutions such as the circular economy (as well as of any other "small" intervention, such as the production of quality, durable goods, the end of planned obsolescence and others) remains crippled, or even becomes harmful, if it is still embedded in a market that demands growth in sales, consumption and production. A key step in the research lies in the new convergence between "lean" thinking and circular business models based on performance and services. If the economic model is converted from the sale of ownership of a good to its use (with ownership remaining in the hands of the manufacturer/provider), then the durability and repairability of goods cease to be undermined by the need to keep selling and producing them. The end of obsolescence and waste, and of pointless consumerism, lies along this path, and on this model a "lean" way of producing and managing activities can still be applied (and with greater ecological sense). All this is not enough: the second level of reasoning that the dissertation proposes is not limited to the switch to models based on performance and services; it is the race for continuous economic growth that must be left behind. The shift to services can (and should) be part of a larger change, in which the economy is *deliberately* slowed down (at the cost of changing macroeconomic formulas) and reoriented towards different modes of consumption, more focused on activities linked to human well-being in terms of culture, social cohesion, leisure, sport, education and health. The very objective of the economic machine must cease to be growth in industrial terms (which is ecologically impossible) and must instead become the optimal management of existing resources, the protection of the planet and the *genuine* development of human beings, which (in Western societies) is increasingly distinct from the mere possibility of consuming more.

Reiterating the importance of the distinctions between countries at different stages of economic development and growth, which must be respected and taken into account, especially when addressing the concept of degrowth, honesty requires that the limitations of this work be highlighted, in case they are not already evident, together with the unresolved issues and questions that constitute the frontier for future research. The most conspicuously unresolved element concerns the very feasibility of any economic system in degrowth: the financial structure of capitalism and the very way in which societies and nations function are founded on economic growth. While it is relatively easy to imagine a single company operating parsimoniously or ecologically (thanks to the combination of circular solutions and the TPS) within a society that remains oriented towards expansion,

it is extremely difficult to imagine an entire macroeconomy that does not grow at all in classical economic terms such as GDP. The key institutions of our (Western) societies, such as social security and pension systems, the welfare state, defence, healthcare and education, the entire banking and credit sector, and public debt itself, are structurally founded on the premise and expectation that the economy will grow, that people will be employed and will consume, and that they will therefore be able to pay taxes. Can a modern society function without growth? What changes, and at what levels, would have to be made for such a transformation to be possible? The details of how to keep a degrowth economy standing and functioning are not a problem that this dissertation is able to solve (it confines itself to reporting some ideas and proposals already present in the literature); it is an objectively difficult issue, to which far greater effort and attention should be devoted than the academic work of a few interested scholars alone. Further questions, which did not initially motivate the research, arose during the writing itself: another sore point of the transition becomes apparent when one considers the balance of relations between different countries; not only is it difficult to imagine the precise economic mechanism by which a country might somehow manage to function and fund its services while renouncing growth; even if it succeeded, how would the balance of power with other countries change? The economic power of a nation or bloc of countries is the precursor of its military strength, its strategic influence and countless other aspects. Even assuming that a bloc such as the European Union decided to embrace a stage of degrowth or post-growth, it would inevitably experience a relative "decline" compared with "rival" powers (such as the United States or China) that might be determined to continue along the path of expansion. The risk of being marginalised, overtaken or supplanted in any respect constitutes a strong deterrent to the consideration or adoption of degrowth policies, and this keeps all the players in the game, almost in a sort of prisoner's dilemma. To what extent, then, is economic competition between countries causally intertwined with military and strategic competition? In addition to assessing the practical effects of such degrowth on international cooperation, the frontier for future research lies in defining the architecture of the multilateral agreements needed to defuse aggressive strategic competition and make a coordinated transition possible. In short, giving up perpetual economic growth seems as difficult as overturning society as we

know it today, because that is precisely what it entails; and it is an effort that would potentially bring together every discipline of knowledge, or a large part of them.

These obstacles are by no means small, and they constitute excellent starting points or fields in which to continue existing research, but the analysis carried out cannot retreat. The scientific certainty of the irreversible damage that industrial and economic activity has inflicted on the Earth, and the awareness that the planet's biophysical limits have been exceeded, together with various social problems, must make us all the more determined to overcome every obstacle: we know that our planet has long been unable to sustain the pace and the waste of human economic activity, and we know that natural resources are not infinite; therefore not everyone can grow, and certainly not indefinitely. A solution must be found; there is no alternative. Failing to escape the trap of infinite growth, or failing to embark on a path towards that goal for fear of financial or geopolitical risks, means knowingly taking part in global ecological collapse.

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