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Rethinking Productivity: Why has Productivity Focussed on Labour Instead of Natural Resources?

Notes on the Relevance of a Classical Debate*

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Abstract: The contribution of natural resources and ecosystems to economic processes still remains underassessed by market evaluation and productivity analysis. Following the historical lines of the classical productivity debate ranging from the French Physiocrats to early neoclassical growth theories, the productivity concept underwent a gradual transformation from its previous understanding based on natural resources and other environmental factors to its contemporary narrow notion. This paper claims that the course of the classical debate has shaped the scope of predominant contemporary analysis. Except for some very recent findings, multifactor productivity largely focusses on a two-factor model. Material Flow Analysis (MFA) provides a useful step for widening the measurement and notion of productivity.

Keywords: Productivity, Natural Resources, Measurement, Material Flow Analysis.

JEL classification: B10, O13, O47, Q26

Productivity is usually defined as the "quantity of products and services produced from each hour of a worker´s time" (Mankiw 1998, p.11). An increase in productivity demonstrates better technical performance and allows lower prices to be charged for certain products. Lower prices offer competitive advantages and increased market shares. This mechanism generates growth rates and promotes higher wages. The transition from pre-industrial societies with rather primitive technologies towards modern industrial methods has improved labour productivity in different countries by a factor varying between ten and forty (Maddison 1995). Productivity is therefore widely acknowledged as the "key mechanism by which average income and welfare are improved" (Englander and Gurney 1994, p. 112).

Beyond recognising the general function of productivity, it is puzzling as to what kind of factors contribute to economic growth and the manner in which they do so. So far, there is no

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genuine "productivity theory", but rather a broad spectrum of measurement concepts, as well as growth, production and modernisation theories well known to academic audiences (see Dogramaci 1981; Jorgenson 1995a + b; Link 1987). Recalling them is not the intention of this paper. It should be pointed out, however, that labour productivity is at the centre of most econometric models and development statistics. Research calibrates multifactor productivity, taking into account capital, human capital, services, information, infrastructure and other factors. The question, however, is: Do these efforts properly reflect the role of natural resources and environmental services? Unfortunately, the answer is no, not yet.

At the empirical level, the development of productivity has never been neutral in the sense of Hicks or Harrod. Almost all countries have managed to achieve relatively high rates of labour productivity growth, but lower (or even negative) rates of capital productivity and – the focus of this paper – low rates of productivity growth for energy and natural resources. In Germany, for instance, labour productivity increased by 307% from 1960–1995, whereas the same ratio for energy is only 131%, for natural resources 149%, and for water 136% (Federal Office of Statistics 1998). Such differences lead us to query the extent to which these long-term trends are due to some underlying or "secret" laws of technical progress, or if they are bound to change if factor prices, markets and technical progress move in a different direction. This is, of course, a question of great relevance as long as unemployment remains a concern in many countries and the environment continues to deteriorate.

In the following I make the assumption that market evaluation still underassesses, or even grossly ignores the contribution of natural resources to productive processes. While research is currently being undertaken in regard to improved measurement concepts, the main focus of this paper will be on the classical productivity debate. It is my hypothesis that the classical debate and its successors demonstrate a gradual transformation from a former understanding of productivity based on natural resources and other environmental factors to the contemporary narrow notion. In reviewing the thoughts of the main classical thinkers, I shall demonstrate how the transformation has taken place, as well as the extent to which it shapes our contemporary notion. The paper thus attempts to shed light on the theoretical background of measurement concepts and econometric models, moving it away from the realm of history into the provinces of environmental economics and social sciences. In doing so, I hope to attach economists more closely to the genesis and diffusion of words and ideas. If the paper also contributes in some way to widening or redefining the notion of productivity, in shifting rationalisation from labour to energy and materials or, more precisely, from labour to resource productivity, I will be more than satisfied.

1. The French Physiocrats: Land and Agriculture as Productive Factors

The French Physiocrats extended the view of earlier natural law philosophers and held land to be the main source of wealth, and agriculture to be the most important economic activity (Quesnay [1757] 1921; Turgot [1766] 1977). Land and agriculture alone were acknowledged as being capable of producing net value ("produit net"), i.e. the surplus of harvest to seed. Productivity did not therefore refer to labour or any amount of goods produced, but to nature as a whole. In his "tableau économique", Francois Quesnay remarked on agriculturalists as the "productive class" of society and other groups as "sterile classes". Turgot called farmers the "unique source of all wealth" (Turgot [1766] 1977, p. 46).

According to the Physiocrats, it was necessary for prices for agricultural products to be higher than their costs, whereas prices for other goods were to be equivalent to their costs. Quesnay assumed low costs for peasants resulting from a tax exemption for the productive class (a radical proposal at that time!) and economies of scale via the introduction of large agricultural utilities. He advocated free trade for all commodities. All these proposals would perhaps have lowered costs, but there is no inherent mechanism recognisable that would have led to higher prices for agricultural products compared to other goods. Why should prices for these products increase in the real economy? The Physiocrats clearly refused any price increase via indirect taxes. The application of physiocratic price theory remains a puzzle. Because price theory was closely related to productivity theory, an analytical deficit in the physiocratic approach remains.

Mining activities and their related material flows were regarded as non-productive. Quesnay argued that the mining industry produced commodities and was therefore part of the "sterile classes“. In no form whatsoever did he state that mining activities would deplete non-renewable resources. He also failed to reflect properly on the transformation of natural capital into man-made capital and the possibility of creating wealth while simultaneously exploiting the natural environment. Such questions properly belong to contemporary resource economics. One might raise a speculative question: What would have happened to the development of economic theory if the Physiocrats had recognised mining in any sense as being slightly more productive than they actually believed?

Given these two analytical weaknesses, a contemporary view of the French Physiocrats offers mixed findings. On the one hand, they developed some far-reaching principles of economics based on renewable resources and agriculture. Interestingly enough, many physiocratic ideas have been supported by contemporary research. McNally (1988) determined that agriculture produced economic surpluses up to the end of the 18th century. Caton (1985) and Hesse (1982) arrived at similar conclusions. On the other hand, unfortunately, the Physiocrats

developed neither concise market mechanisms nor price mechanisms, nor could they foresee the potential of industrial activities to create value in co-operation with nature. The distinction between "productive"and "non-productive" labour was perhaps their most serious impact during the following decades.

2. Adam Smith: Manufacturing as a Productive Factor

Adam Smith took up the distinction between “productive” and "non-productive" labour, as identified by the French Physiocrats, and made a decisive amendment to it. He considered industry and trade to be productive too. Smith declared labour to be the main source of the wealth of nations for which he was searching. But not all labour. According to Smith, the labour of servants, civil servants, politicians, artists, soldiers, lawyers, priests etc. should be treated as "non-productive" (Smith [1776] 1976, p. 330f.). His general criterion for "productive" and "non-productive" labour was the contribution of certain types of labour to any growth of the capital stock. Each activity devoted to the replenishment or growth of capital was considered "productive“. In his chapters on the division of capital stock, he distinguished between stock for immediate consumption, fixed capital and circulating capital, mentioning, inter alia, improvements in land use and human abilities.

In his chapters on capital theory, Smith assumed a permanent decrease in any capital stock, given consumption and typical vintage problems. A steady replenishment is therefore necessary if losses are to be avoided. Where should the input come from? Surprisingly, it was not labour but nature that was expressed as being the main source of replenishment! Agriculture, fishery and mining activities were able to exploit the free goods of nature and were regarded as being able to transform these gifts into capital (Smith [1776] 1976, p. 363f). According to Smith, they offered two ways to escape the Malthusian trap of a gradual economic decline:

- collection, procurement and reaping of gifts made by the "spontaneous production" of nature;
- technical progress in production methods.

Smith therefore clearly recognised nature as a precondition for economic activities. In all functions, however, he regarded nature´s resources and services as inexhaustible free goods. Real economic performance was assumed as being almost independent of nature and thus the result of man-made labour alone. For this reason, Smith declared agriculture as being slightly even more productive than manufacturing. Agriculture, mining and fishing (if intelligently organised) are potentially able to replenish the economy´s capital stock. Their productivity is high as long as they are able to produce at comparatively low costs.

If one accepts his basic assumptions, Smith´s model is, to a large extent, consistent. If nature is regarded as a free good without any particular economic value, any increase in productivity must result from different types of labour. Adam Smith is therefore the spearhead of a transformation in the understanding of productivity. Whereas in former times natural law philosophers and the French Physiocrats localised productivity in nature and wealth in a surplus of natural goods, Smith moved the whole economic focus to manufacturing activities. Although nature had certain functions, the illusion of development disembodied from ecological conditions was able to emerge. From today´s point of view, this criticism is as important as the optimism, historical preciseness and analytical strength of Smith which can be considered as the main intellectual force for the beginning of industrialisation.

3. The 19th Century: Smith, Ricardo, and Marx versus List, Mill, and the German Historical School

David Ricardo went a step further than Smith in arguing that economic value is completely determined by the relative amount of labour required to produce commodities. His main theme was to demonstrate that "every increase of the quantity of labour must augment the value of that commodity in which it is exercised" (Ricardo [1817] 1976, p. 7). He thereby introduced a labour-based theory of value as a one-factor theory. In doing so, he separated large parts of nature from economics. It is only in his theory of land rent (chapter II of his "principles") that he considered nature as being of some importance to economic activities. Rent is said to be due to the scarcity and different quality of arable land, and not, as the Physiocrats would have put it, to the physical productivity of nature. The value of wheat and other products of agriculture was in fact exhausted by the returns to labour and capital. Rent could thus be eliminated as an element in the pricing of goods. Interestingly enough, Ricardo transferred his observations on land and land rent to mining activities (chapter III in his "principles") but not to any other part of nature-related activities. In the long-run, however, Ricardo felt dismally convinced of the petering out of economic growth owing to the scarcity of natural resources.

Karl Marx followed Ricardo´s line in the assumption that labour is the main force of economic progress.[1] His surplus theory went even further than those of Smith and Ricardo. In the "German Ideology" he and Friedrich Engels stated blasphemously that by producing surplus (e.g. food) man creates himself (Marx / Engels [1845/46] 1962, p. 21). They also made the well-known tenet that nothing has value if it is not due to human labour. Their understanding of productivity was basically materialistic, as both considered intellectual activities and culture as dependent variables of production patterns.

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1 Marx / Engels ([1845/46] 1962; [1859] 1964; [1867] 1962).

On the other hand, Marx acknowledged society and the economy as parts of a larger natural context. According to him, societies should try to understand and use natural laws for their production needs. In this view, nature was a necessary precondition but, to a large degree, a passive one. It was not the quality of nature that was considered important to economic progress but the quality of labour. Only raw material which was believed to be both a product of natural resources and of labour had some value, whereas other natural amenities were "spontaneously provided" and thus could not possess value. Marx therefore clearly subordinated the value of nature to labour.

Adam Smith and Karl Marx provoked large numbers of intellectuals during their time. By labelling academic, administrative and teaching labour as "unproductive", both apparently excluded the activities of the above from the stream of industrial progress.[2] Against this psychological background it is well understandable why the debate on "productive" and "unproductive" labour proceeded more passionately than most other controversies in economic analysis. The whole German Historical School with representatives such as Adam Müller, Wilhelm Roscher, Gustav Schmoller and (later) Othmar Spann, as well as other economists such as Friedrich List, John Stuart Mill, Jean Baptiste Say and (later) Frieda Wunderlich clearly stated that intellectual and social labour should be regarded as being productive.[3] Say, for instance, developed a theory of "immaterial products" made by doctors, soldiers, civil servants and artists. Most illuminating are some polemics of List against Smith:

> "A breeder of pigs is regarded as productive, whereas a teacher of humans unproductive. A manufacturer of music instruments is regarded as productive, whereas he who plays these instruments like a virtuoso unproductive. (...) Newton, Watt and Kepler are not as productive as a donkey, a horse or a cow." (List [1842] 1930, p. 181, translation by RB)

List and others, therefore, perceived socio-cultural factors and particularly the related labour in terms of research and education as necessary preconditions of any industrial production. In this context, List introduced the "theory of productive forces" into economics. It should also be noted that he, Mill and others established the necessity of public infrastructure investments. From today´s perspective, their contribution to modern economics might still be regarded as the ability to remain productive tomorrow, instead of only considering the amount of goods being produced today.

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2 Ricardo wisely did not refer to the distinction between productive and unproductive labour, except in a footnote in his chapter on land rent. His labour theory of value was based upon the quantitative amounts of labour, not on quality.

3 List ([1842] 1930); Mill ([1844] 1967); Müller ([] 1977); Spann ([1918] 1967^4, 1937 1963^2); Wunderlich (1926). See also: Nelson and Winter (1982, p. 44); Schumpeter (1954, p. 413).

Two afterthoughts might be drawn regarding the productivity debate. Firstly, the successors of Smith and Marx swung the pendulum in the other direction. It was no longer manufacturing labour that was supposed to increase the wealth of nations over time, but a mixture of manufacturing and other non-manufacturing activities. Academic, social and administrative labour were rehabilitated. Secondly, any assumptions on the usefulness of nature for economic development gradually faded away, as this ground was analytically covered neither by the "materialists" nor by the "idealists" (with some exceptions stated by Mill). Although much confusion remained about the optimal mix of different types of labour, the common understanding of productivity being dependent on the quality (or, according to Ricardo, on the quantity) of labour and disembodied from natural conditions was strengthened. Ricardo's long-term pessimism failed to lead at this stage to advanced theorising about the scarcity of natural resources, ecological conditions and technical change. All of the analytical change was thus merely the result of shifting emphasis from material to immaterial concerns and not the result of improved theory about the relationship between labour and nature.

4. The Emerging Neoclassical Paradigm

At the end of the 19th century, the neoclassical paradigm emerged in economic theory and helped to put the productivity debate on a new footing. In particular, the Austrian School with representatives like Carl Menger and Eugen von Böhm-Bawerk introduced the concept of subjective values as opposed to objective values with "true" prices as supposed by the French Physiocrats, Smith, and Ricardo.[4] The new concept was based upon the individual utility considerations of private market participants. The only way to measure the value of goods and products was therefore exclusively via their market price and no longer via any objective analysis or any quantitative amount of labour necessary for their production. Price, utility and value were now regarded as being almost identical. In a general way, the rapid rise in the prestige of natural sciences during the second half of the nineteenth century also contributed to the changing paradigm.[5]

This whole new thinking marked a shift in the productivity debate. According to Blaug (1998[5], pp. 277), a "revolution" took place. It led to clarification in the overall confusion over which parts of a society are productive and which are unproductive. The new view stated that all labour is productive to the extent that it is paid, and vice versa. It introduced the same methodology for products and services: both are productive as long as they meet some type of market demand. The overall amount of goods produced is relevant because of its marginal

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4 Böhm-Bawerk ([1888] 1961[4]); Marshall ([1898] 1961[9]); Fisher ([1906] 1965). See also: Blaug (1998[5], pp. 277, pp. 406); Daly and Cobb (1989, pp. 109).

5 Mirowski (1988). See also the foreword of Böhm-Bawerk ([1888] 1961[4]), in which he portrays a clear picture of humans being dependent upon nature. But then he continues that this is outside the realm of economics.

utility compared to former years. Neoclassical economics therefore analyses marginal utilities and not average values or quantitative amounts of labour (both with the inherent objectivity illusion). To the present day, marginal productivity possesses great conceptual significance for neoclassical economists.

Historically, an important step to overcoming the classical understanding of productivity was taken at the conference of the German "Verein für Socialpolitik" (Association for Social Policy, i.e. German speaking economists) in 1909. During this conference, the whole debate of the 18th and 19th centuries was terminated. In his initial speech, Eugen Philippovich presented state-of-the-art economics and distinguished between "private" and "public" productivity (Verein für Socialpolitik 1910, pp. 359). In his definition, private productivity was the relation between any output to any input; public productivity referred to the wealth of society as a whole. He thought that any measurement would be difficult, and suggested criteria be defined for non-productive activities, which might then be deduced from any gross national product. What a visionary idea! But, unfortunately, he slipped on critical methodological areas of value judgements. Max Weber, Werner Sombart and others heavily criticised his analysis. Their simple suggestion was to dump the whole issue (they impolitely recommended the toilet).

For almost forty years the idea of dumping the productivity issue was eventually more or less accepted in European research (with the exception of Baxa (1926), Wunderlich (1926) and some others). After the Second World War and during the recovery period in Europe, the Anglo-Saxon approach prevailed, which was primarily based upon the neoclassical paradigm. A "European Productivity Agency" was institutionalised in the OEEC/OECD context and strengthened the neoclassical notion (Boel 1997).

5. The Golden Age of High Growth Rates

After early neoclassical economics superseded the classical productivity debate, the next major step towards our contemporary understanding of productivity took place in the 1950s. Nobel laureate Robert Solow (1956) paved the way for growth theories that, inter alia, subordinated land to capital. Two production factors remained relevant: capital and labour. Growth theories also started to characterise technical progress as an engine that drives economic wealth. An increase in labour productivity was regarded as the measurable implementation of technical progress in industry. In fact, it was substantial progress on the measurement concepts begun in the 1930s and 1940s by, inter alia, the U.S. Bureau of Labour Statistics which influenced the evolution of growth theories (Griliches 1996). According to Solow, some 80 % of U.S. growth rates between 1909 and 1949 could be put down to technological change. Since then, technical progress has been regarded as almost identical with labour productivity and the deus-ex-machina which falls like "manna from heaven".

Although the genesis of innovations and their diffusion was largely unknown at that time, they were assumed to be abundant, timely and forever. If one accepts a comparison with the French Physiocrats, technical progress and labour productivity had now supplanted the former functions of nature and agriculture in order to produce economic surplus. Both were believed to escape the Malthusian, Ricardian, and post-war[6] trap of a scarcity of natural resources´. Growth theories, increases in labour productivity and upward economic trends fuelled the vision of a "golden age" which was believed by many scientists, politicians, entrepreneurs and the public.

At that time, most industrialised countries established co-operative structures between unions and employers. The resulting increases in labour productivity and economic growth gave rise to higher wages and high employment rates. Unions and employees were highly motivated by labour productivity and rising living standards. Why would anyone have looked for any hidden factor of production? For a very long time therefore, the extensive identification of technical progress with labour productivity has alleviated the relationship between unions and employers. Their informal contract for higher wages was acceptable to both sides as long as the increase in labour costs was legitimised, employment performance was well perceived, nature served as a silent servant to the economy and no environmental policy demanded any structural change. In most countries, these conditions applied for decades. Since the early nineties, the increasing global competition regarding the localisation of industries, high unemployment rates (in large parts of Europe and elsewhere) and global environmental problems seems to indicate that the end of the partnership between unions and employees is approaching. The imbalance between underusing labour and overusing nature - in my view - might favour a transformation from labour to resource productivity.

Table: Historical Stages of the Productivity Debate

Issue / Stage and School	Main Productivity Source	Important Actors	Understanding of Wealth
The Physiocrats (Quesnay, Turgot) *late 18th century*	land, agriculture, natural resources	Farmers	net value (harvest)
Smith, Ricardo, Marx *late 18th to mid 19th century*	(manufacturing) labour	entrepreneurs and manufacturing businesses	objective values, increase in capital stocks
List, Mill, Say and the German Historical School *19th century*	productive forces in administration, education and research	public services, education and research	objective values, public productivity
Early Neoclassics *late 19th century*	(marginal) labour productivity	markets and firms	sum of subjective values, market assets
Contemporary Notion	(marginal) labour and multi-factor productivity	markets, firms and technology	GDP

Source: own compilation.

6 As a result of post-war economic recession, the U.S. Materials Policy Commission (1952) surveyed a possible scarcity in natural resources for the US economy.

6. Multifactor Productivity and Material Flow Analysis

Having reviewed both the classical debate and its outcome, it might be worthwhile briefly looking at measurement concepts. One would expect to see a focus on the productivity of paid labour as well as on other market-based factors. This is exactly what is being measured. Standard concepts to measure multi-factor productivity assume an aggregated Cobb-Douglas production function with labour, capital and technical progress as the factors being measured. The notion of technical progress allows for a flexible residuum, which accounted for some 80% of factor-related growth in the early growth theory of Solow (1956). Thanks to more sophisticated models it has now been reduced to roughly 20% (Englander and Gurney 1994, p. 125). To complete the picture, other production functions like the CES (constant elasticity of substitution) or the translog production function are also used to measure productivity. In these models, however, multi-factor typically means integrating capital plus a weighted average of capital and labour productivity. Natural resources are, if at all, only accounted for by their monetary value as part of a man-made capital stock. The point being made is that conventional measurement concepts do not explicitly account for the state of natural resources or environmental services.

More recent research concentrates on integrating important factors like services, infrastructure and human capital including knowledge (Barro 1991; Mankiw, Romer and Weil 1992). Basic measurement errors are eliminated step by step (Diewert and Fox 1999). Bernard and Jones (1996) have constructed a new measure of multifactor productivity, in which the initial levels of economic activities are pinned down in a new manner. Concentrating on human capital, a new concept has been developed by Maudos, Pastor and Serrano (1999). Still, the point stands that they do not explicitly account for the state of natural resources or other environmental services.

Resource economics has indeed made valuable contributions. In mentioning just a few of the substantial writings, one might recall Barnett and Morse (1963) as well as Hartwick (1977). Solow (1986) has introduced a rule of intergenerational equity regarding the scarcity of natural resources. Pearce et al. (1989) and Daly and Cobb (1989) have simultaneously established the concept of "constant natural capital stock“. El Serafy (1997) has suggested a methodology for the accounting of natural resources. Boulding (1981), Klein (1978) and Weissmahr (1992) have developed factor models that explicitly reveal natural resources (and energy). Some countries have begun to develop integrated environmental and economic accounting systems (Federal Office of Statistics 1998). Jorgenson (1990, 1995) and Repetto (1996) have made decisive steps towards integrating environmental aspects into productivity

measurement concepts. The latter, however, still have to rely on existing statistical time series and, hence, cannot yet take account of recent findings in environmental science.

Among those recent findings, *Material Flow Analysis* (MFA) is perhaps the most promising. It aims at developing a core indicator for environmental pressure as a whole, overcoming individual scarcity considerations and integrating life-cycle aspects of resource use (Adriaanse et al. 1997; Bringezu et al. 1998; Hinterberger and Schmidt-Bleek 1999). MFA tracks the physical flow of natural resources through extraction, production, consumption, recycling, and final disposal. It relates the use of resources to nature´s capacity to provide materials *and* to absorb wastes. Methodologically, MFA adds up the weight of resources used plus the masses moved during exploitation processes and deliberate landscape alterations ("ecological rucksacks" which typically account for gigatons). Ayres (1969), Kneese et al. (1970) and Page (1977) should be mentioned in this context as important forerunners. The MFA debate, however lively it is, must still be linked to productivity analysis. Such an exercise remains to be done, but is not the intention of this paper.

This brief overview was not able to fully reflect the methodology of measurement concepts. But it has illustrated our hypothesis that the classical debate still hangs like a shadow over productivity analysis. Measurement concepts can hardly claim to build upon an everlasting and comprehensive theoretical framework but rather on a framework which is itself evolving over time, carrying some concealed premises in relation to value. To put it clearly: as the theoretical frame changes, measurement concepts will integrate environmental (and also social) aspects more seriously.

7. Conclusion

The conclusion to be drawn here is certainly not that the classical debate was more advanced than contemporary ones. After all, classical thinkers failed to come up with a clear definition and an administrable measurement concept. In this sense, judgements like "dusty museum piece" (Schumpeter 1954, p. 628) or the "probably most maligned concept in the history of economic analysis" (Blaug 1998[5], p. 53) are justified. On the other hand, recalling some classic insights would certainly deepen the workaday dialogue of economists. These insights include, inter alia, the value and productivity of nature as a whole (Physiocrats), the necessary replenishment of man-made capital by environmental services (Smith), the value of products as being related to quantified inputs (Ricardo), and the productive forces of research, education, administration and social labour (List, Mill, German Historical School). Moreover, one might question whether the well-known concept of negative external costs is, by and large, more advantageous than the classical notion of unproductive activities. Economists could also reflect on whether the concept of objective values still has merits for an analysis on the value of earth´s ecosystems. Taken together, these insights and stimulations form

elements of a research agenda to redefine the theoretical framework of productivity. In furtherance of this objective, recalling the history of the productivity concept helps to understand in a hermeneutical way why statistical data, measurement concepts, and many econometric models are still biased towards labour and largely ignore services from the natural environment (as well as from non-paid labour). The course of the classical debate has resulted in some pre-analytical cognitive acts which have so far shaped the scope of contemporary analysis.

As a starting point, research should reconsider measurement methodology. Material Flow Analysis seems to be a promising attempt at relating statistical needs in regard to environmental micro- and macroeconomics. It is already used by several statistical offices in the context of integrated environmental and economic accounting. A new, but simple measurement methodology might thus result from adjusted GDP per unit of natural resources (plus "ecological rucksacks") used in an economy per year. At the micro-level, a number of companies have begun to measure their material flows for managing resource productivity over the life-cycle of products and substances along their entire value chain. The resulting eco-efficiency gains can be tremendous (Weizsaecker et al. 1995; Lovins et al. 1999). Based on such MFA-accounts, research should aim at improving existing models of multi-factor productivity.

A further, although larger step towards a more balanced understanding of productivity might be found in linking human capital to natural resource productivity. Investments in human capital are – as I would propose - more appropriate if they are primarily intended to rationalise energy and materials instead of labour. Human learning processes are a key element in any development and at the same time lie at the heart of resource productivity. This might turn out to be the basis for a new coalition encompassing employment, human capital and the environment: An increase in resource productivity minimises the depletion of natural resources and simultaneously allows for a technological progress that is labour augmenting.

These last remarks, however, are primarily meant to stimulate further debate. It was not the purpose of this paper to investigate appropriate measurement concepts or political solutions. These research efforts are taking place anyway. If, however, a review of the classical debate makes us more aware of our intellectual heritage and casts new light on these ongoing questions, this paper will have fully served its purpose.

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