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IMPACT OF MATERIAL CONSUMPTION AND CIRCULAR ECONOMY ON NATIONAL INCOME IN EUROPE – CHAPTER 2

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ABSTRACT

Objective: This study investigates resource productivity by exploring the factors that influence it and the strength of their impact using sustainability statistics from Eurostat.

Theoretical Framework: The research analyzes the interdependence between national income and material consumption, with a focus on the paradoxical effects of circular material use on these variables.

Method: Data from bibliographic sources are analyzed using statistical methods, including regression and path models, to assess the relationships between material consumption, national income, and the use of circular materials.

Results and Discussion: The study concludes that national income and material consumption are interdependent, with material consumption directly affecting national income. Notably, the use of circular materials, contrary to expectations, increases material use and decreases national income. The cases of Hungary and the Netherlands are specifically examined to illustrate these findings.

Research Implications: The findings suggest that strategies to increase resource productivity and sustainability performance need to consider the complex and sometimes counterintuitive impacts of circular material use on national income and material consumption.

Originality/Value: This study provides new insights into the relationship between resource productivity, national income, and material consumption, highlighting the unexpected effects of circular material use. It contributes to the broader understanding of sustainability performance, particularly in the context of Hungary and the Netherlands.

Keywords: Resource Productivity, Sustainability, Economic Growth, Environmental Impact, Netherlands, Hungary.

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IMPACTO DEL CONSUMO MATERIAL Y DE LA ECONOMÍA CIRCULAR EN LA RENTA NACIONAL EN EUROPA – CAPÍTULO 2

RESUMO

Objetivo: Este estudo investiga a produtividade dos recursos explorando os factores que a influenciam e a força do seu impacto utilizando estatísticas de sustentabilidade do Eurostat.

Referencial Teórico: A pesquisa analisa a interdependência entre a renda nacional e o consumo de materiais, com foco nos efeitos paradoxais do uso circular de materiais sobre essas variáveis.

Método: Os dados de fontes bibliográficas são analisados utilizando métodos estatísticos, incluindo modelos de regressão e caminhos, para avaliar as relações entre o consumo de materiais, a renda nacional e o uso de materiais circulares.

Resultados e Discussão: O estudo conclui que o rendimento nacional e o consumo material são interdependentes, com o consumo material a afectar directamente o rendimento nacional. Nomeadamente, a utilização de materiais circulares, contrariamente às expectativas, aumenta a utilização de materiais e diminui o rendimento nacional. Os casos da Hungria e dos Países Baixos são examinados especificamente para ilustrar estas conclusões.

Implicações da Pesquisa: As conclusões sugerem que as estratégias para aumentar a produtividade dos recursos e o desempenho da sustentabilidade precisam de considerar os impactos complexos e por vezes contra-intuitivos da utilização de materiais circulares no rendimento nacional e no consumo de materiais.

Originalidade/Valor: Este estudo fornece novos insights sobre a relação entre a produtividade dos recursos, a renda nacional e o consumo de materiais, destacando os efeitos inesperados do uso circular de materiais. Contribui para uma compreensão mais ampla do desempenho da sustentabilidade, particularmente no contexto da Hungria e dos Países Baixos.

Palavras-chave: Produtividade dos Recursos, Sustentabilidade, Crescimento Económico, Impacto Ambiental, Países Baixos, Hungria.

OBJETIVOS ECONÓMICOS SOSTENIBLES - CAPÍTULO 2 DETERMINANTES DE LA PRODUCTIVIDAD DE LOS RECURSOS EN LOS PAÍSES BAJOS Y HUNGRÍA

RESUMEN

Objetivo: Este estudio investiga la productividad de los recursos explorando los factores que influyen en ella y la fuerza de su impacto utilizando estadísticas de sostenibilidad de Eurostat.

Marco Teórico: La investigación analiza la interdependencia entre la renta nacional y el consumo material, centrándose en los efectos paradójicos del uso circular de materiales sobre estas variables.

Método: Los datos de fuentes bibliográficas se analizan utilizando métodos estadísticos, incluidos modelos de regresión y de trayectoria, para evaluar las relaciones entre el consumo de materiales, el ingreso nacional y el uso de materiales circulares.

Resultados y Discusión: El estudio concluye que el ingreso nacional y el consumo material son interdependientes, y el consumo material afecta directamente al ingreso nacional. En particular, el uso de materiales circulares, contrariamente a lo esperado, aumenta el uso de materiales y disminuye el ingreso nacional. Los casos de Hungría y los Países Bajos se examinan específicamente para ilustrar estos hallazgos.

Implicaciones de la investigación: Los hallazgos sugieren que las estrategias para aumentar la productividad de los recursos y el desempeño de la sostenibilidad deben considerar los impactos complejos y a veces contradictorios del uso de materiales circulares en los ingresos nacionales y el consumo de materiales.

Originalidad/Valor: Este estudio proporciona nuevos conocimientos sobre la relación entre la productividad de los recursos, el ingreso nacional y el consumo de materiales, destacando los efectos inesperados del uso circular de materiales. Contribuye a una comprensión más amplia del desempeño en materia de sostenibilidad, particularmente en el contexto de Hungría y los Países Bajos.

Palabras clave: productividad de los Recursos, Sostenibilidad, Crecimiento Económico, Impacto Ambiental, Países Bajos, Hungría.

4 RESULTS

The description of the results begins with an examination of the model fit

Table 3

Model Tuning Test Results

					General model test		
Model	**R**	**R²**	**Adjusted R²**	**F**	**(PHP 3, PHP 4)**	**(PHP 3, PHP 4)**	**p**
1.	0.829	0.787	0.763	29.1	20	265	<0.001

Source: author's own

Based on the value of R 2, the included variables represent 78.7% of our model. This suggests that many other variables influence resource productivity performance. Predictors predict the dependent variable significantly, based on the test result F(20, 265)=29.1, p<0,001. According to the estimated study values, equation (3) of the model is:

$$\begin{aligned} RES\_PROD = {} & -1193.08+19.44*EMP\_RATE+0.45*GFCF-2.61*RAndD + \\ & 5.34*WAST\_REC-1.79*REN\_EN+29.31*TRAIN+18.47*TERT\_SEC-0.06*RAW\_IMP- \\ & 0.32*CIRC\_MAT-0.34*(RANdD \cdot REN\_EN)- 0{,}8\ 2\ *(EMP\_KNOW \cdot TRAIN) + \\ & 0.31*(REN\_EN \cdot TRAIN)-0.33*(EMP\_RATE \cdot TERT\_\ SEC)+ \varepsilon \end{aligned} \quad (3)$$

The equation does not include non-significant effect variables or interactions whose absolute value of the effect coefficient (estimate) is less than 0,1, regardless of whether the determined effect is significant or not.

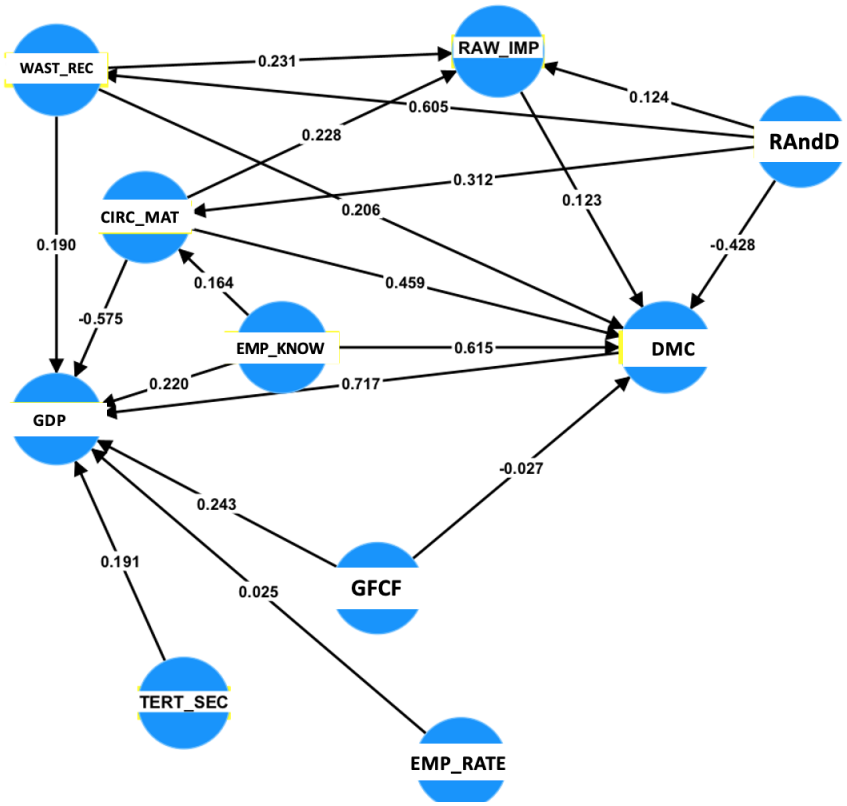
The employment rate, the economic structure (the proportion of the textile sector) and the environmental awareness variables are the basis of the model, with significance at p-level of 0.001. Among the latter, mainly by increasing the proportion of public rail transport, resource

productivity is significantly increased. In addition, there are interactions. At p-level of 0.05, an association with waste recycling was also found.

SEM adjustment data are adequate (SRMR.=0,089 and NFI=0,836). Figure 8 shows the model, and Table 4 shows the direct, indirect and direct impacts of the variables:

Figure 8

Resource Productivity SEM



Source: author's own

Table 4

Direct, indirect and total effects of MES

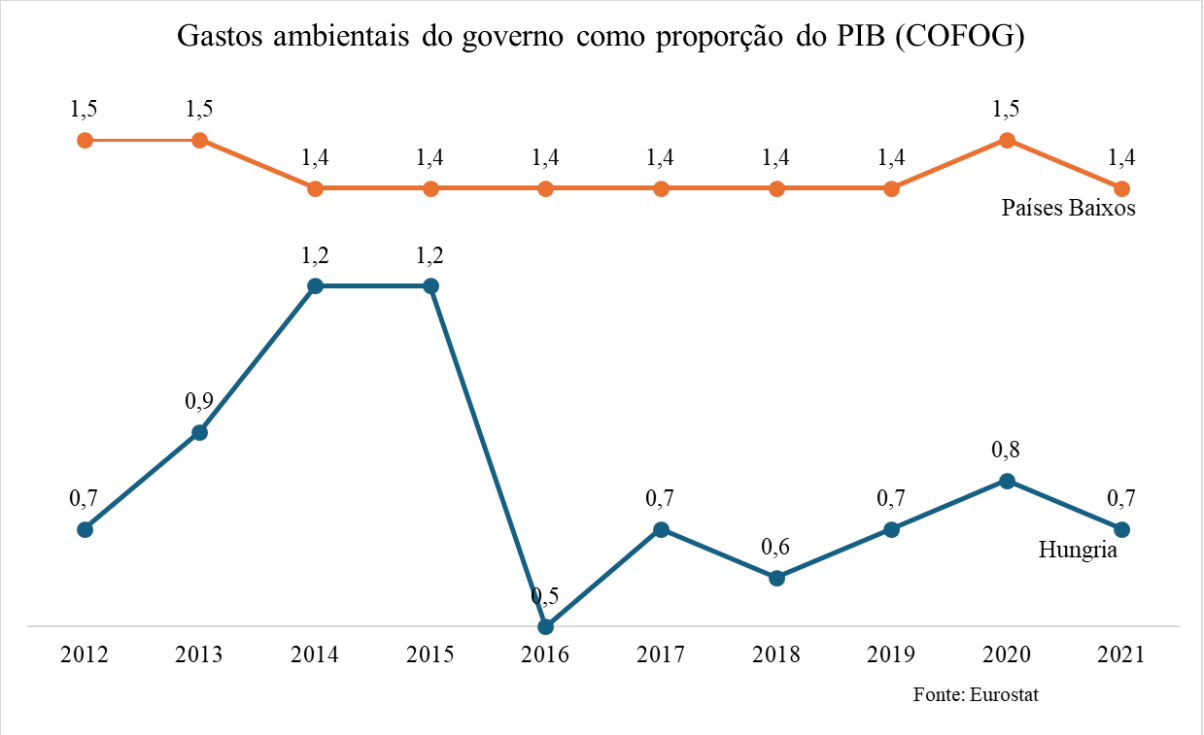
direct + indirect (total)	(PHP 3 = 3.0.6, PHP 4)	DMC	(PHP 3 = 3.0.6, PHP 4)	EMP_RATE	GDP	GFCF	(PHP 4 = 4.0.5)	R and D	(PHP 4 = 4.0.5)	(PHP 4 = 4.0.5)
(PHP 3 = 3.0.6, PHP 4)		0,459 + 0,028 (0.487)			-0,575 + 0,349 (-0,226)		0,228 + 0 (0.228)			
DMC					0,717 + 0 (0.717)					
(PHP 3 = 3.0.6, PHP 4)	0,164 + 0 (0.164)	0,615 + 0,08 (0.694)			0,22 + 0,403 (0.623)					
EMP_RATE					0,025 + 0 (0.025)					
GDP										
GFCF		-0,027 + 0 (-0.027)			0,243 - 0,019 (0.224)					
(PHP 4 = 4.0.5)		0,123 + 0 (0.123)			0 + 0,088 (0.088)					
R and D	0,312 + 0 (0.312)	-0,428 + 0,309 (-0.119)			0 - 0,15 (-0.15)		0,124 + 0,211 (0.335)			0,605 + 0 (0.605)
(PHP 4 = 4.0.5)					0,191 + 0 (0.191)					
(PHP 4 = 4.0.5)		0,206 + 0,028 (0.235)			0,19 + 0,168 (0.358)		0,231 + 0 (0.231)			

Source: author's own

The main difference between the two countries analyzed lies in the policy approach, according to Eurostat data and the results we obtained on our own account. Environmental expenditure in relation to GDP was higher in the Netherlands than in Hungary during the period examined. In addition, environmental expenditures in Hungary are fluctuating, while expenditures in the Netherlands remain stable (Figure 9).

Figure 9

Environmental expenditure in proportion to

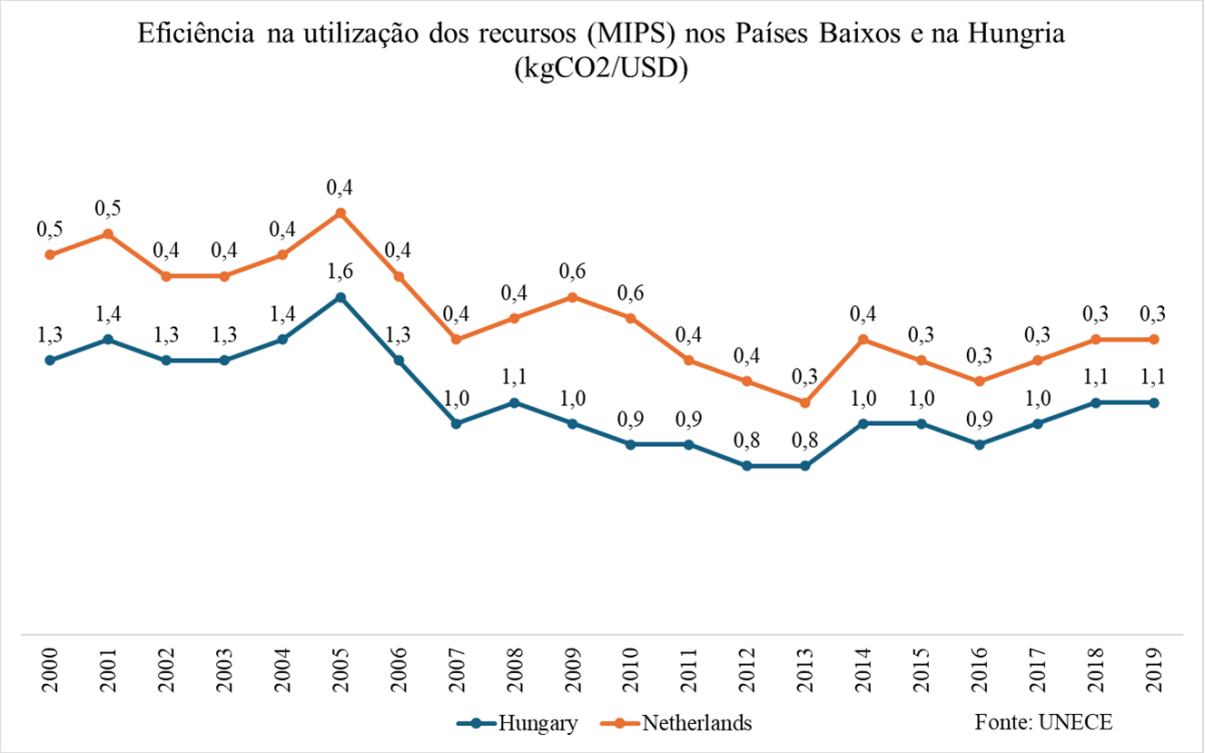


Source: Eurostat - own edition

The development of resource efficiency in the two nations is identical (Figure 10).

Figure 10

Resource efficiency trends in the examined countries



Source: UNECE, 2023 - own edition

Erro! Fonte de referência não encontrada.illustrates the development of reciprocal resource efficiency, resource productivity and resource components.

Table 5

Resource productivity growth and its elements (2011-2022)

	Hungary	The Netherlands
GDP/capita (thousand euros)	49%	25%
CMD/capita (kg)	37%	-11%
Resource Productivity (€/1,000kg)	8%	40%

Source: Eurostat - own calculation

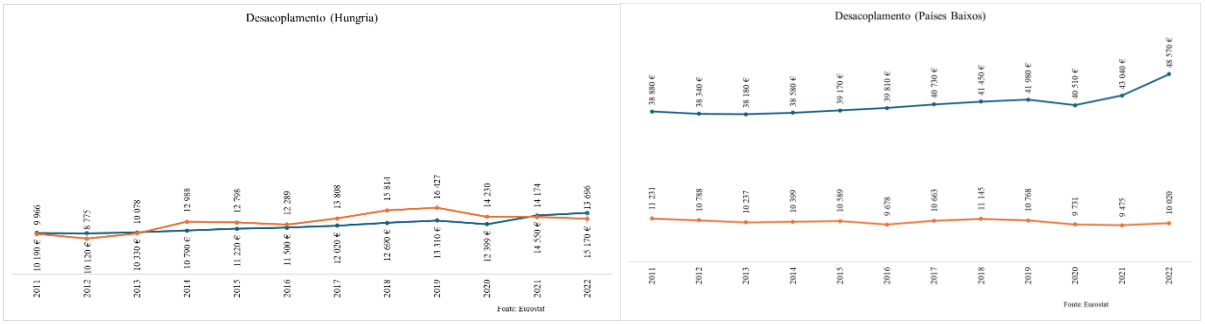
The changes demonstrate the differences between the two nations. In Hungary, GDP per capita increased by 49% from 2011 to 2022, while in the Netherlands it only increased by 25%. However, domestic material consumption in Hungary increased by 37%, while domestic material consumption in the Netherlands decreased by 11% due to its weak economic growth. The Dutch resource productivity increased by 40%, while Hungary increased by 8%.

As shown in Figure 11, the period in question was covered by the increased environmental impact of Hungarian GDP growth, which is also shown in Table 5. GDP

increased at a higher rate than DMC (relative decoupling). However, GDP in the Netherlands is increasing, but CMD can be considered constant (absolute decoupling).

Figure 11

Decoupling in the countries examined



Source: Eurostat - own edition

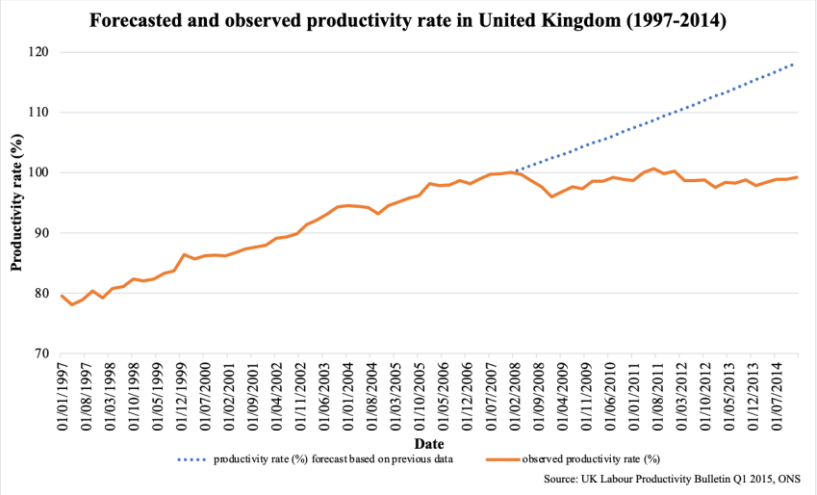
The results and literature can be interpreted as follows. Resource productivity affects not only economic growth but also financial sustainability. As the available materials decrease, their prices increase. Especially for materials such as phosphorus, lithium, cobalt, copper, silver and phosphorus, which are extremely necessary for green transition technologies. Open violence is not prevented by the companies involved. Tesla CEO Elon Musk's Twitter message about the 2019 Bolivian military coup: "We're going to strike whoever we want!" Don't worry about it (Kolláth, 2021). Bolivia owns more than a quarter of the world's lithium reserves, and the Morales government's planned actions have put Tesla's lithium supply at risk.

As a result, scarcity of resources can turn into one of the main factors driving inflation. (Schnabel, 2022; Baranyai & Banai, 2022)

The problems are exacerbated by the fact that it is impossible today to achieve productivity growth as strong as it was a hundred years ago. The slowdown in productivity growth coincided with the start of the 2008 economic crisis. However, it remains questionable why the increase in productivity was not accompanied by the increase in the economy during the recovery from the 2008 crisis. This paradoxical phenomenon is illustrated in Figure 12 of the productivity puzzle, as described by the economic literature (Newman, 2015).

Figure 12

The productivity puzzle



Source: Newman, 2015

Because population, investment and productivity are the three main sources of economic growth, stagnant productivity is a problem. The increase in population around the world does not mean that there are more skilled workers. Savings, or income not spent on consumption, are the source of investments, but not only the economy affects the realization of investments. Productivity is the third component, which in the field of research can be related to economic growth and the relationship (4) (Solow, 1956; Swan, 1956):

economic growth (%) = research productivity (%) * number of researchers (4)

Bloom et al. (2020), however, scientific productivity decreased significantly (

Figure 13

Aggregate data on growth and research effort

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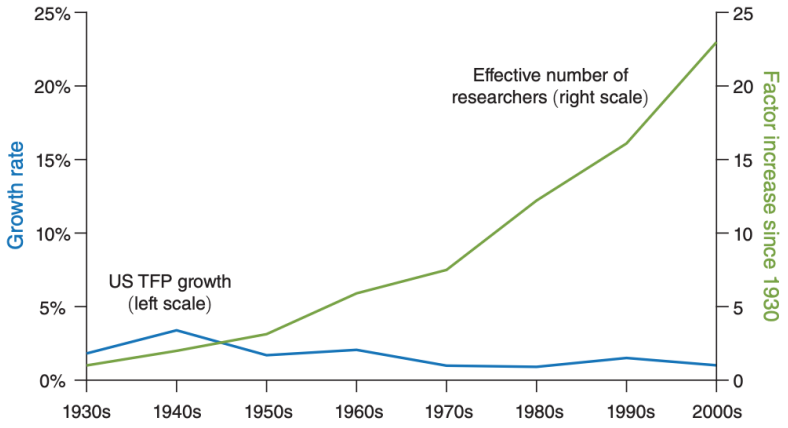
Figure 13

Aggregate data on growth and research effort



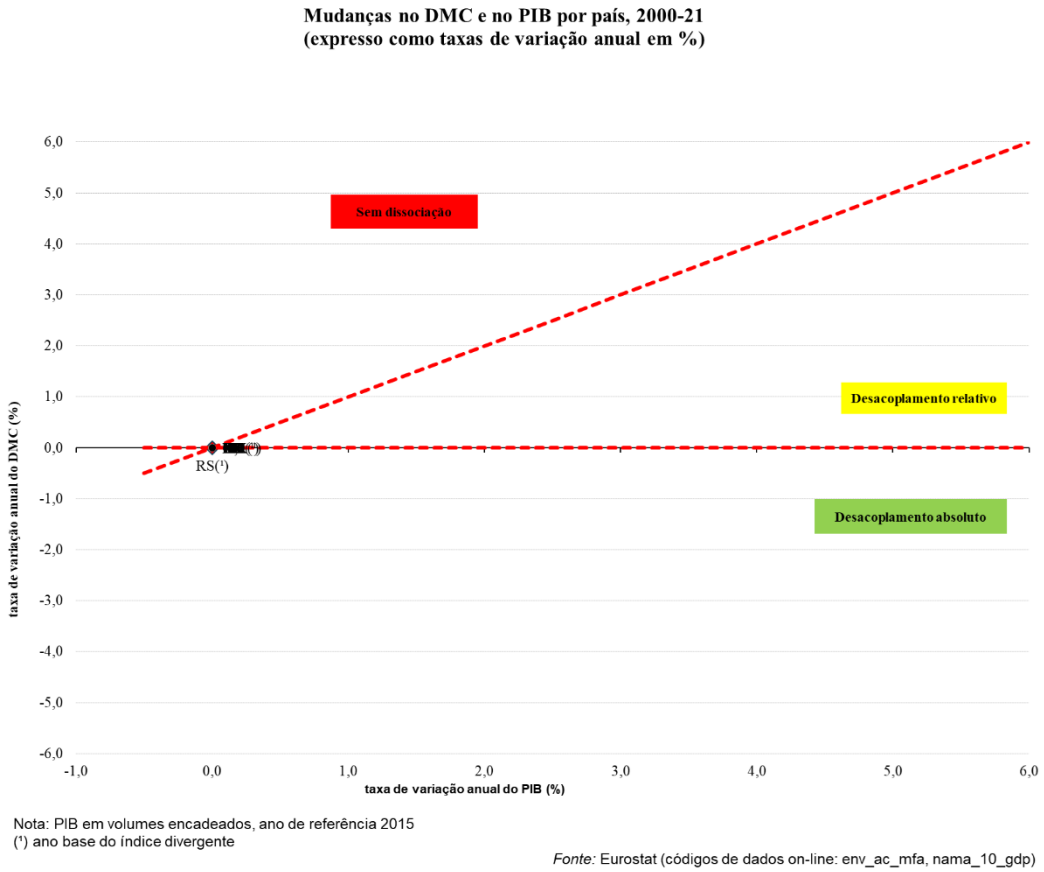
Source: Bloom et al., 2020

The U.S. Total Productivity Factor (TFP) (on the left-hand scale) has not changed in the last hundred years. However, on the right-hand scale, the number of researchers needed for a unit increase in productivity increased twenty-fold. Therefore, the countries that give priority to saving and to the productivity of the population may be the economic superpowers of the future.

The EU also examined the phenomenon of decoupling (Figure 14).

Figure 14

Decoupling in the European Union



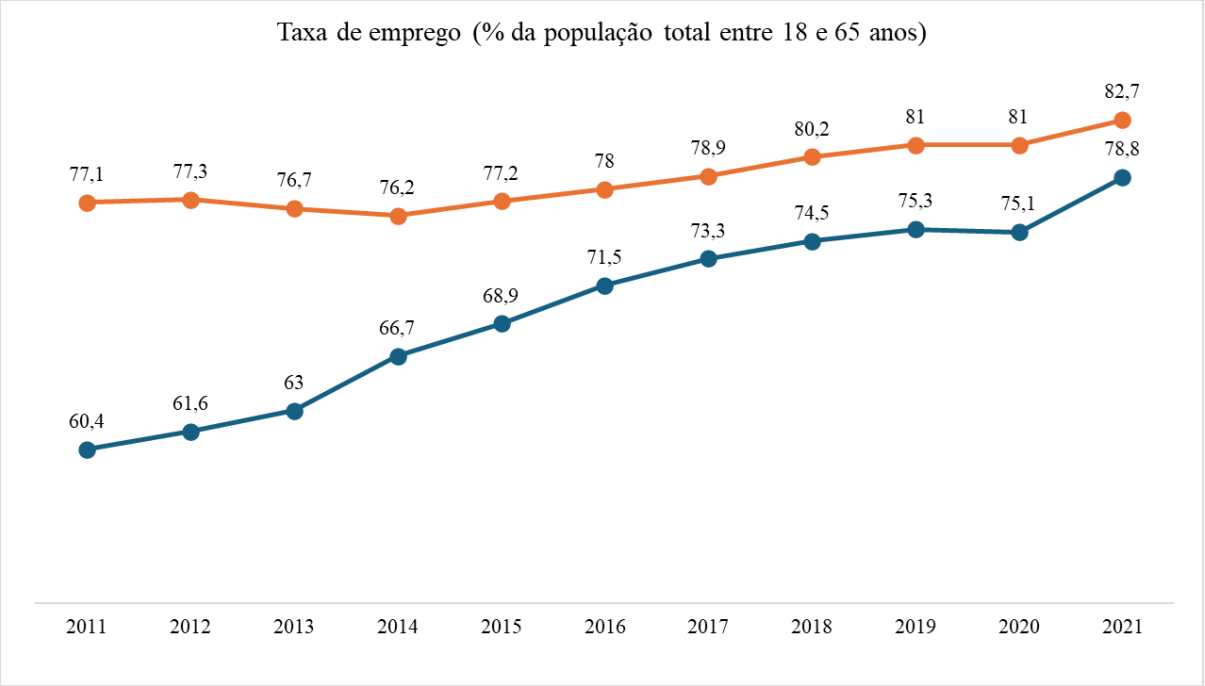
Source: Eurostat

The diagonal line shows that the rate of change of GDP and CMD is the same. Countries above the diagonal line failed to dissociate. Countries that are below the diagonal line, such as Hungary, have achieved at least relative dissociation. Many European countries, including the Netherlands and the EU as a whole, have achieved absolute decoupling below the horizontal line. However, this result needs more research, as it is possible that foreign countries have outsourced material and energy intensive sectors. The DMC indicator does not consider these characteristics.

There are three ways to increase resource productivity in EU nations, according to the regression model. In countries with low employment rates, increased employment can work. During the period in question, the employment rate in the Netherlands was consistently above 75%. The employment rate in Hungary increased by almost 20% in the same period (Figure 15). That certainly helped increase resource productivity, but we can't expect significant results today.

Figure 15

Employment rate in the Netherlands and Hungary between 2011 and 2021



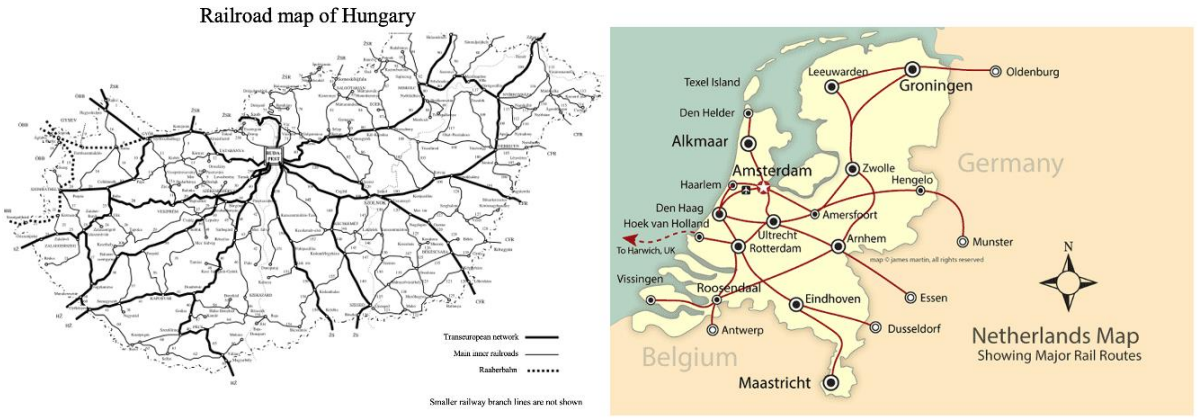
Source: Eurostat - own edition

Increasing the share of the tertiary sector in GDP is an additional alternative. Material consumption decreases and GDP increases with an increase in the proportion of services. It also increases the proportion of environmental protection expenditure in relation to GDP. The Netherlands and Hungary were ahead of this issue in the period analyzed (Figure 9). Improving environmental awareness is the third viable option.

The SEM model says that rail transport is the most effective way to transform public transport. The Dutch railway lines constitute a genuine network covering almost the whole country. However, Hungary's rail network is very centralized (Figure 16). Therefore, the expansion of the Hungarian railway system has the potential to contribute significantly to sustainable economic growth. The Rail Carpathia plan is one of its concepts (Zasiadko, 2022). The other is the revitalization of the railway connection between Budapest and Belgrade.

Figure 16

Railways in Hungary and the Netherlands (source: Mapping Europe)



Source: Mapping Europe

Paradoxically, it seems that the increase in research and development expenditure, as well as the increase in the ratio of imported raw materials and renewable energy sources, will have a negative impact. One possible explanation for the negative effects of raw material imports is that a nation that is required to import raw materials cannot rely on its own raw materials for economic growth. This lowers resource productivity. The depletion of rare earth metals and fossil materials increases as a result of the increased proportion of renewable energy sources. We will come back later for research and development reasons.

According to the results of the MES, resource productivity factors (GDP and CMD) are not fully independent of each other. CMD significantly affects GDP (+0.71). The increase in the circular material use ratio (CMU) directly reduces GDP (-0,575), while imports of raw materials and DMC increase GDP (+0,349), respectively. Circular use of materials means using the same materials repeatedly. This explains the impact of increased imports of raw materials. Again, this may require imported raw materials. In addition, the increased use of DMC in circular materials is due to the fact that the reused is added back to the use of the material. Although there is no direct reuse, recycling of waste also affects DMC by a similar mechanism.

It seems paradoxical that GDP decreases when the proportion of CMU in total material consumption increases. This phenomenon can be explained by the fact that used circular materials already represent a significant proportion of total material consumption (McKinsey, 2015). To further increase the ratio, substantial investments and technical developments would be needed. These investments are already expensive and do not match the growth of the available GDP.

Waste generated is a popular indicator of environmental impact. Preventing waste generation is the best way to reduce the environmental burden that waste causes. Recycling, reuse, recovery, energy recovery, incineration and, finally, waste disposal are other ways.

Moving from landfilling to recycling and use reduces the impact on the environment, creates more jobs and preserves the intrinsic value of materials.

The Dutch Ministry of Infrastructure and Water Management has put in place a plan to reduce waste streams in these areas. The ministry's sustainable purchasing policy encourages private and public businesses (Government.nl, 2023). 79 percent of waste in the Netherlands is recycled, and the rest is used for energy production (Rijkswaterstaat, 2023). So 80 percent of the waste has been turned into resources.

Second, the effects of knowledge on employment and investment are tied between the direct effects on GDP. Its influence equals thirty percent of the impact of DMC, but demonstrates the significant importance of knowledge capital in economic development (Fogel, 1994; Schultz, 1961; Schumpeter, 1980; Schwab, 2016). Both factors mentioned are directly impacted by the investments. They reduce DCM and increase GDP as a result of development.

The impact of model-based research and development is a significant problem. Increases waste recycling by 0.605 and material reuse by 0.312. It has a direct impact on all kinds of material use. These are results of innovative solutions as they significantly decreased (-0,428) DMC. Imports of raw materials increase (total effect: +0.335), as these are the only ways to get the materials needed for new and sophisticated products. The evolution of the GDP can be explained in 77% (r2=0.770) and the evolution of the CMD in 69% (r2=0.692) based on the indices used in the research.

5 CONCLUSIONS

Development has always accompanied the economy. However, the Earth remains our only place of residence. Our life is supported by its material and energy sources. But these resources are not infinite. Therefore, continuous growth and development cannot be maintained for an infinite period of time. In the near future, the resources available will be exhausted. Currently, postponing this time to the maximum is the main objective, as it increases the probability of finding a solution. This can be significantly increased by increasing resource productivity. In addition, responsible and economic management contributes to financial sustainability through the prudent use of financial resources.

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