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# The service-stock trap: analysis of the environmental impacts and productivity of the service sector in Hungary

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## Abstract

Urbanization and the emerging share of the service sector in economic output may support the sustainability transition due to lower material input and emissions, while further accelerating the economic growth at the same time. Nevertheless, there are significant barriers to the transition. In this study, the service sector of Hungary and its four commercial sub-sectors have been analyzed with regard to their material requirement (input flows and stock) and greenhouse gas emissions (GHG) emissions utilizing EXIOBASE v3. General policy implications are also provided with special regard to costs, possible taxes and productivity of resources. The share of direct and indirect GHG emissions and material input generated by the sector was stable and moderate. A permanently improving trend is present in GHG, and material input intensity. Material stock accumulation in the service sector (capital stock), however, shows an ascending trend, and it has increased from 42% in 1995 to be 55% in 2015. Material input productivity of investments into services has increased until the economic crisis, then it starts to decline or stagnate; while overall stock productivity has decreased in two sub-sectors, and slow improvement was observable in sub-sectors of transportation and information and communication technology (ICT). Stock productivity of ICT and machinery capital stock was decreased dramatically in all sub-sectors. Four economic sub-sectors of the commercial services analyzed in this study have increased their capital stock from 130 to 288 Mt between 2000 and 2015. The exponential trend in material stock accumulation is an environmental issue with rising scientific concern and awareness, since it constitutes the basis of crucial waste management, resource scarcity and resource use challenges in the future. The current study indicates general reinforcement of the environmental pressure of material stock accumulation by the service sector. This phenomena was defined as the ‘service-stock trap’, which refers to the sign of a trade-off between the descending flow-type environmental impacts and ascending impacts of capital stock accumulation during the economic transition towards a service-based economy. As a promising way out of the trap, the resource tax was discussed in detail, which seems to be suitable for forming investment decisions of the business actors.

## Introduction

Two substantial socio-economic megatrends associated with long-term economic development are urbanization and the emerging role of services in economic output. Both processes are assessed generally to be able to contribute to the sustainability transition. Urban development may provide more

efficient energy, transportation and other infrastructure oriented services (Tukker *et al* 2010, Baynes and Musango 2018). This effect, however, seems to be offset by higher urban income levels (Weisz and Steinberger 2010, Ala-Mantila *et al* 2014); falling victim to the rebound effect (Wiedenhofer *et al* 2013). Ivanova *et al* (2017) even disapproved of the impact of

efficiency gains on data about the carbon footprint at the EU level.

Economic output of services is characterized by lower resource intensity (Kovanda and Weinzettel 2017). As Steger and Bleischwitz (2011) have presented in their model, one percent of increment in the share of the services in gross domestic product (GDP) results in 1.35% decrement in resource intensity in the EU-25 country panel between 1992 and 2000. Parallel consumption, however, may override these benefits. Since urban areas are characterized by lower living space per inhabitant, space provided by several services is utilized as extension of homes (e.g. restaurants, bars, laundries, malls). As a result, urban citizens spend less time at home, which probably causes a not proportional decrement in their resource use at home, such as heating, for example. At the same time, they utilize resources in the form of services for relatively short time periods (Heinonen *et al* 2013, Ala-Mantila *et al* 2014).

During the transition of the socio-economic system over the last few decades, decoupling of economic output and the material turnover performed as an ongoing process (Krausmann *et al* 2009). Material intensity declined during the whole of the 20th century. Meanwhile, significant changes occurred in the emerging material use of the society; material stock accumulation became the major driver of natural resource use. The ratio of stock building materials has increased globally from 20% to 58% of the domestic extraction (DE) (Krausmann *et al* 2017). Consequently, the material stock not only constitutes valuable service infrastructure for society (dwelling, mobility, production and consumption), but is also a key driver for resource use, the object of technological lock-in and a challenging waste management problem in the future (Weisz *et al* 2015, Haberl *et al* 2017). Furthermore, construction materials are scarce as well; sand, for example, became a basic resource with a limited supply and numerous harmful environmental impacts (Torres *et al* 2017). To this end, the key role of material stocks, as infrastructures, has recently been emphasized with special regard to future emissions and resource use (Wood *et al* 2018, Haberl *et al* 2019). Furthermore, several results suggest that a significant part of the material stock consists of capital stock of the economic processes (Ortlepp *et al* 2015, Cao *et al* 2017).

Nevertheless, decoupling is ambiguous in its nature. Krausmann and colleagues (2017) revealed that the productivity of input material flows indeed ascends; however, the productivity of material stocks rather stagnates or even descends. Increasing dwelling and mobility demand certainly determines the strong bond between the affluence and the stocks built up by society, as the motorization rate and living space per capita emerge rapidly. Recent evidence implies that urbanization and the economic transition might affect the stagnating stock productivity. With special regard

to material stocks, services operate on a higher relative level of material requirement. Analysis on an individual process level indicates a lower input/stock ratio in the case of services (Dombi 2018). Fishmann and his colleagues (2015) have revealed that the service sector is a significant driver of material stock accumulation in Japan, while growth in the gross prefecture product (GDP on the level of subnational units) of other sectors has a minimal effect on the material stock formation.

Thus, on the one hand, urbanization and the emerging share of the service sector in economic output may support the sustainability transition due to lower material input and emissions, while further accelerating economic growth at the same time. On the other hand, there are significant barriers to the transition represented by the rebound effect, the parallel consumption and the extension of material stock required by the services. The question has arisen, whether the service sector and its sub-sectors amplify environmental pressure through accumulation of material stock. There is an obstacle in the way of absolute decoupling in the form of capital stock accumulation, which tends to offset the positive ecological benefits of the service sector—this is the ‘service-stock trap’.

In this study, the service sector of Hungary and its four commercial sub-sectors have been tested with regard to their material requirement (input flows and stock) and greenhouse gas emissions (GHG) emissions against the hypothesis of the ‘service-stock trap’ introduced above, as a case study; in line with several general findings regarding our options for a way out of the trap. As Chester *et al* (2014) emphasize, the ‘hard infrastructure’ (buildings, dams, machinery, etc.) constitutes the environmental stressor itself, however, it is shaped by the ‘soft infrastructure’. It covers institutions such as policy, culture, spatial planning and economic signals. The International Resource Panel (2018) highlights the priority for ‘system efficiency’ as well, hence efficiency gains of individual means (e.g. vehicles, buildings, electronic devices) are prone to be offset by rebounds and rising income. A variety of administrative and economic measures are available towards improvement in system efficiency, for example, urban planning, promotion of behavioral changes or taxation. This study relates to the latter, since it seeks for links between material stock accumulation, resource costs and the economic productivity of stocks.

The economic structure of Hungary has been changing intensely over the last few decades, and this transition was followed by a convergence of the consumption patterns to Western European countries. In this regard, Hungary may share several economic and environmental trends with current emerging countries. The study may also contribute to the methodological toolbar of the research on material stock with the estimation process of capital stock. The study thus

provides novel methodology to assess a significant, but unexplored type of material stock on the one hand, and raises the issue and provides evidence of the trade-off between stock- and flow-related environmental impacts of the service sector on the other hand.

## Methods and data

Material input and GHG emissions of services were investigated by the widely applied environmentally extended multi-regional input–output table dataset EXIOBASE v3 (Tukker *et al* 2013, Wood *et al* 2015, Stadler *et al* 2018). Services covered by EXIOBASE were aggregated into sub-sectors of EU classifications using 18 sectors. In this way, these results are able to analyze in line with material stock estimations.

The stock estimation tool disaggregates the gross fixed capital formation (GFCF) as the annual new stock accumulation into 18 sectors, then splits the GFCF of each sector into the net addition to stock (NAS) of buildings and other infrastructures ( $NAS_b$ ), as well as information and communication technology (ICT) and machinery ( $NAS_m$ ). After that, coefficients of employment ( $L$ ), the two types of capital stock ( $K_b$  and  $K_m$ ) and other factors ( $Z$ ) ( $\alpha$ ,  $\beta_m$ ,  $\beta_b$ ,  $\gamma$ ), as well change in the total factor productivity ( $\Delta A$ ), were estimated by historical data on output ( $q$ ), in a non-linear regression model as parameters of a Cobb–Douglas production function. See (1) for the key equation of the method. Here,  $K_{b0}$  and  $K_{m0}$  are initial values of the stock at the beginning of the period (2000). To find detailed descriptions of the calculations, as well as scripts in R, please see the supplementary materials available online at [stacks.iop.org/ERL/14/065011/mmedia](https://stacks.iop.org/ERL/14/065011/mmedia).

$$\Delta A = \Delta q - \alpha \Delta L - \beta_m \frac{NAS_m}{\sum NAS_m - K_{m0}} - \beta_b \frac{NAS_b}{\sum NAS_b - K_{b0}} - \gamma \Delta Z \quad (1)$$

The results therefore provide consumption-based insight into the Hungarian service sector in general, and its four commercial sub-sectors, i.e. the wholesale and retail trade; repair of motor vehicles and motorcycles (G), transportation and storage (H), accommodation and food services (I) and information and communication (J) between 1995 and 2015. Financial services were excluded because of data scarcity, while the ‘real estate services’ sector was omitted, hence it contains material inputs related to residential stock accumulation as well. Public services are also out of the scope of the analysis, since investment decisions of education, health care, scientific units and arts are rather policy-motivated.

## Results

The Hungarian service sector—including both commercial and public services—has slightly increased its role in income generation, i.e. the share in GDP from 61% in 1995 to 67% in 2009. After the economic crisis, this ratio has been moderately decreased and it performs as 64% in 2015 (figure 1). This share is significantly lower than the average of high-income countries and the European Union (74%), and it does not even reach the global average (68%). In the last few years, the economic growth of Hungary was merely driven by the export of agricultural and machinery commodities and investments into these sectors.

As for the environmental impact of the service sector, the ratio of direct and indirect GHG emissions and material input generated by the sector was stable and moderate, thus the low material and emission intensity of services relative to other sectors is justified. A permanent improving trend is observable in GHG productivity; from 1.74 in 1995 to 6 EUR per kg CO<sub>2</sub> eq in 2015. The GHG productivity of services have thus risen with 247%, which exceeds general improvements of the economy (159%) (supplementary material, table 1). Material input productivity shows similar trends; 1.62 EUR per ton of material input was induced at the beginning of the period, and 4.43 EUR at the end. The improvement is 174%, while it is 142% in the economy as a whole (supplementary material, table 2). Despite significant advances in material intensity, GHG emission seems to be reduced more successfully.

Contrariwise, material stock accumulation in the service sector (capital stock) is shaped by an ascending trend, and it emerged from 42% in 1995 and increased to 55% in 2015. Furthermore, the service sector leans increasingly on capital stock; its demand for stock accumulating materials has risen in the post-crisis period (2009–2015). Material productivity of investments has been improved significantly between 2000 and 2015 in all sub-sectors. It exceeds, however, the current levels in the time period 2007–2012 (supplementary material, table 3); probably due to limited investments in economic recession, which was a long period in Hungary compared to other European countries.

In the following section, four commercial services are analyzed in detail. These branches deliver nearly one-fourth of the Hungarian GDP. Accommodation and hotel services have the highest GHG emissions and material input among the four sub-sectors (figure 2, supplementary material tables 1 and 2). At the same time, this sub-sector is characterized by the lowest productivity as well (i.e. income per material input or GHG emission), hence it has a moderate contribution to GDP (below 2 percent). Transportation and ICT have decreased their environmental impact after 2005; also their productivity has a positive trend in the last decade. Sub-sector G represents

almost 10 percent of the GDP alone on the basis of the lowest total material input and GHG emission among the analyzed branches. Its productivity is thus topping, however, it has stagnated in later years. To sum up, two out of four sub-sectors were able to significantly improve the productivity of resource use in the second half of the analyzed time period, namely transportation and storage, as well as the information and communication sub-sectors.

Material requirement (A), GHG emissions (B), material productivity (GDP/material requirement) (C) and emission productivity (GDP/GHG emissions) (D) are provided for the analyzed sectors. Sectoral abbreviations are as follows:

G—Wholesale and retail trade; repair of motor vehicles and motorcycles

H—Transportation and storage

I—Accommodation and food services

J—Information and communication

Data on GHG emissions in sub-sectors H and I were eliminated in the year 2004 (2B), as there was an error in the emission dataset of the environmental extensions of the utilized multi-regional input-output table (MRIO). The volatility of the data, however, remains remarkable. Sectoral disaggregation on the one hand, and footprint-type analyses presented in this study, as the sum of direct and indirect material requirement and GHG emissions on the other hand, tend to magnify the short-term variation in impact measurements.

The capital stock estimation results are presented in table 1. Input intensity parameters, i.e. coefficients of the regression model, imply the influence of a given production factor or other determinant on the output of the sub-sector. Two branches (G and H) have been described by the labor and capital input. These sub-sectors are rather ‘industrial’ in their nature, contrary to sub-sectors I and J. Accommodation and food services (I) are strongly dependent on wealth of the society, while penetration of ICT is strongly bonded with the technological progress, which were built into the model. Since data traffic in terrabites (Tb) was

**Table 1.** Estimation of the capital stock in four sectors.

	G	H	I	J
$\Delta A$	−0.04	−0.09	0.10	−0.21
$\alpha$	2.51	0.60	0.01	−0.05
$\beta_b$	0.76	1.23	0.49	−0.02
$\beta_m$	−0.14	0.69	−0.71	−0.01
$\gamma$			0.43	0.79
return to scale	3.12	2.51	0.22	0.75
$K_{b0}$ , kt	26 348	47 295	6770	39 420
$K_{m0}$ , kt	404	7241	153	1995
$K_b$ , kt	57 109	93 547	13 767	51 654
$K_m$ , kt	18 516	32 617	1444	19 281
$MP_{Kb}$	−2.39	0.30	15.48	1.03
$MP_{Km}$	0.36	0.69	91.78	1.05
Residual standard error	0.1298 (df = 10)	0.4456 (df = 10)	0.0467 (df = 9)	0.018 (df = 9)
Number of iterations	52	34	66	18
Correlation coefficient	0.61 (1.1e-2)	0.53 (3.5e-2)	0.57 (2.2e-2)	0.99 (2.2e-16)

$\Delta A$ —change in total factor productivity (TFP), also referred to as the ‘Solow residuum’;  $\alpha$ —intensity parameter of labor in the production function;  $\beta_b$ —intensity parameter of building and other heavy infrastructures;  $\beta_m$ —intensity parameter of machinery and ICT;  $\gamma$ —intensity parameter of other factors, namely ‘not basic household expenditures’ in sector I, and data traffic (Tb) in sector J.  $K_{b0}$  and  $K_{m0}$ —initial stock of buildings and infrastructure, and machinery and ICT, respectively. They refer to the amount of stock already in existence at the beginning of the time period;  $K_b$  and  $K_m$ —actual amount of stock; MP—marginal product.

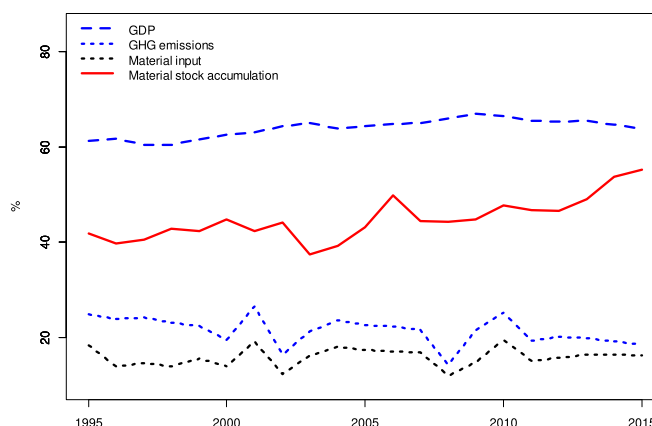
G—Wholesale and retail trade; repair of motor vehicles and motorcycles,

H—Transportation and storage,

I—Accommodation and food services

J—Information and communication.

involved among production factors of sub-sector J, it captures the majority of growth in the output. In this



**Figure 1.** The share of the service sector in the total Hungarian material input, GHG emissions and GDP.

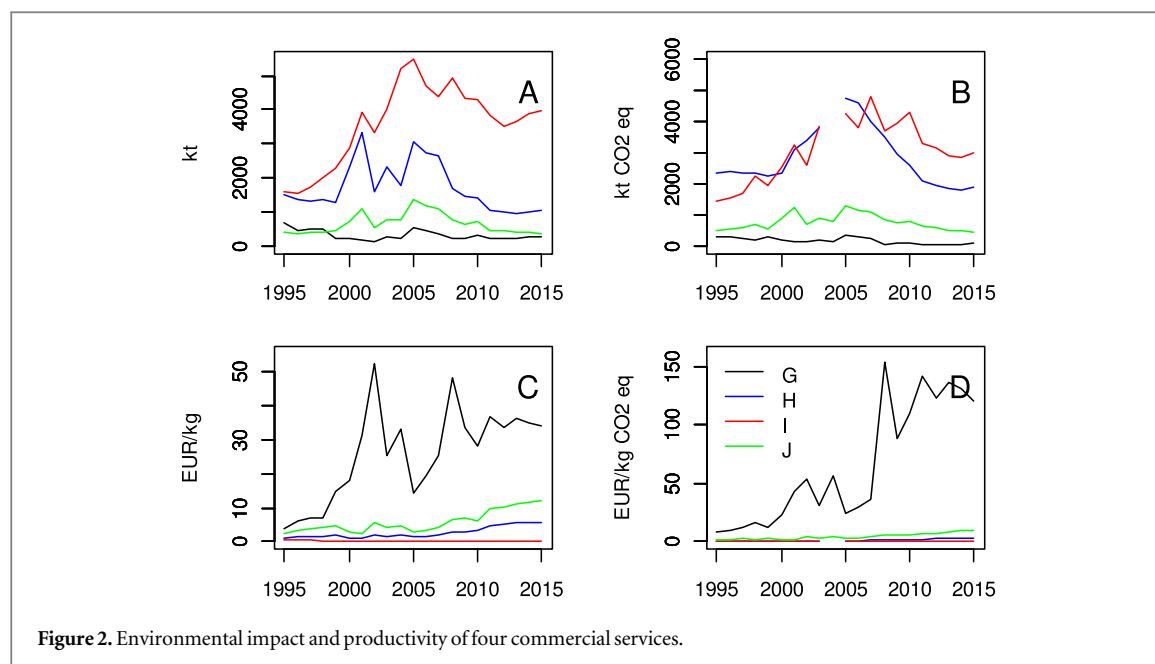


Figure 2. Environmental impact and productivity of four commercial services.

way, changes in the total factor productivity ( $\Delta A$ ) have turned into negative values.

The intensity parameters of  $K_m$  in G and I are negative as well, which implies that increasing mass is counterproductive. Sub-sectors G and H are strongly bonded to building-type infrastructure, as its intensity parameter suggests (0.76 and 1.23). It means that the rise in the volume of the traded commodities calls for expansion of the commercial space as well as the building of infrastructure in transportation and storage. This correlation may mitigate in the future, since online shopping has only become significant in the last few years.

The increment in capital stock of machinery and ICT between 2000 and 2015 exceeds the addition into building and infrastructure stock significantly. The latter type of capital stock ( $K_b$ ) has been doubled in transportation (H) and accommodation and food services (I), whereas its growth was higher (117%) in sub-sector G, and moderate in J (31%), compared to initial stock in 1999 ( $K_{b0}$ ). The rise of  $K_m$  is remarkable; capital stock of machinery in G grew forty-six-fold, and tenfold in I and J, while it grew 350% in sub-sector H. In this latter case, the initial stock of machinery was already essential decades ago, contrary to other branches. Machinery obviously plays an important role in production of the sub-sector, as it is indicated by the intensity parameter of 'rolling stock' (vehicles), it is the highest among the four examined sub-sectors.

Overall stock productivity has been decreased in two sub-sectors (G:  $-6$  and I:  $-14\%$ ); while in sub-sectors of transportation (H) and ICT (J) slow improvement was present. Branches G, H and J have improved their performance of  $K_b$  productivity. It is one order of magnitude lower than the stock productivity of  $K_m$ , which has fallen dramatically in all cases. The modest decrement is observable in sub-

sector H ( $-45\%$ ); other sectors' productivity of  $K_m$  is four to six times lower than at the beginning of the century. (See tables 4 and 5 of supplementary material for details.)

## Discussion

### Uncertainty

There are several sources of bias with regard to this investigation of capital stock at the level of sectors, as macroeconomic units. Given that the EXIOBASE is a well-established and often used MR-IOT with environmental extensions, two major issues remain to harm the estimation with uncertainty; a stochastic and a systematic one. The former is derived by the estimation itself, while the latter originates from the waste statistics used to produce NAS estimations from GFCF.

Non-linear regression models of capital stock estimation in the four sub-sectors are evaluated by a correlation coefficient and the p-value, which denotes the probability of the rejection of a null hypothesis, indicating that the estimated model is identical to a predicted one. Weak correlation was measured in transportation sub-sector (H), while the estimation model of sub-sector J shows a good fit. Sectoral disaggregation may increase the goodness of fit in the non-linear regression model utilized by this method. The 18 sector division coerces different processes into a general sub-sector; for example, postal services and inland water transportation services are part of the same sub-sector H, despite the obvious variance in their demand for labor force, equipment, communication channels, etc.

Waste statistics are limited in Hungary and in the EU; sectoral disaggregated data are available every two years after 2004 in 18 sub-sectors. The average annual



amount of construction material, as well as equipment waste, ranges from 1% to 15% of the GFCF (see supplementary material). Changes in the average value of the yearly demolition rate, however, result in moderate changes in the estimation results of  $K_b$  and  $K_m$ . Three alternative models were constructed by modified demolition rates. The highest change in capital stock estimation was observed in sub-sector I, namely  $K_m$  was estimated 43% lower, when the demolition rate of equipment was modified alone. In other cases, effects range between 0 and -23% (supplementary material, table 2.).

The results are thus statistically less, yet systematically more reliable. With regard to further testing of the estimations, it is worth investigating them in their socio-economic context. Cao *et al* (2017) estimated the cement content of material stock globally. They have found, that with regard to the 15 largest economies, 15%–45% of cement is accumulated in residential buildings, while the remainder is built into non-residential buildings and infrastructures. Based on bottom-up analysis of Wiedenhofer *et al* (2015), Hungarian residential stock is estimated as 566 Mt, while roads and railway infrastructures are estimated as 2000 Mt in 2014 (Dombi *et al* 2017). Ortlepp *et al* (2015) estimated non-residential building stock in Germany to be about 6800 Mt, constituting 42%–45% of the total building stocks. Current estimation shows 288 Mt capital stock, of which 216 Mt denotes buildings and other infrastructure in the analyzed sector group, representing 25% of Hungarian GDP.

Despite the fact that macro-scaled physical inventories are infrequent, several options to cross-check the results exist. Vehicle statistics, for example, are well-maintained. Total rolling stock in Hungary is estimated to be about 8 Mt, after summing up all heavy vehicles in road freight and passenger transportation, using an average specific weight of 15 ton; as well as all railroad cars (50 t each). This is one-fourth of the  $K_m$  result (32 Mt). Results on sub-sector H are not demolition rate sensitive (supplementary material, table 1), however, the goodness of fit is the lowest in this case. Nevertheless, this sub-sector does not serve road and rail transport exclusively, as equipment for air, water and pipeline transportation, postal services and storage (logistics) are accounted for here as well. The fleet of aircraft operated by WizzAir, registered in Hungary, adds nearly 5 more Mt to the total  $K_m$  of the sub-sector (98 pcs. of Airbus A321); still, we have no information about the machines operating at Liszt Ferenc Airport, Budapest, and other smaller ports, as for example in Debrecen.

Material stock estimation of residential dwelling stock frequently utilizes living surfaces as a proxy of material intensity. Building stocks of the trade (G) and accommodation (I) sub-sectors are able to approximate in this way. Pubs, restaurants, bars and hotels together occupy 4.77 million square meters in Hungary, which is 1.4% of the residential living area (4.5

households on average 80 square meters each). As it was formerly introduced, the dwelling stock is assumed to be 566 Mt; sub-sector G requires approximately 8 Mt of  $K_b$ , consequently. It covers 60% of the estimated  $K_b$ . Retail trade sites use 18 million square meters, which is 5% of dwelling stock (28 Mt). In this way, half of the  $K_b$  in sector G is explained. This surface was constant over the last decade. Thus, the expansion in the sub-sectors' building stock was probably driven by other activities, on the one hand, as trade and repair of vehicles. On the other hand, retail trade became highly concentrated in Hungary. Investments into the sub-sector in the form of malls and other out-of-town shopping facilities have enforced intensive accumulation of capital stock.

### Signs of the service-stock trap

Capital stock, thus, has emerged in all analyzed sub-sectors intensely. Machinery was the key driver of the process; its share in the total capital stock became appreciable. Meanwhile, productivity of  $K_b$  has even slightly increased. Therefore, investment into  $K_b$ , as a major type of capital stock, does not offset all the effects of growth in income generation of the services; GDP growth (130%–350% during the period 2000–2015) has passed the growth of total capital stock (100%–150%) in every analyzed sub-sector. Note, however, that material input productivity has improved significantly in line with the material accumulation process introduced above (figure 2). A strong rebound effect is thus assumed between material flows and stock accumulation of these sectors; as increasing material flow productivity is bonded to the increasing amount of material stock.

Material stock productivity culminated in all the sub-sectors between 2003 and 2008. After the economic crisis, fall in stock productivity is a general phenomenon. The explanation of this trend is multiple. First of all, the post-crisis context can be similar to those after the oil crisis in the 70s. After the oil price crisis, the resource efficiency became a key aspect in management as a result of general increment in raw material costs. After 1973, a push for energy-saving technology occurred, which resulted in permanent decrement in energy intensity, even after energy prices had fallen again. Additionally, this transition was proved by an increased number of patent applications for energy-saving technologies, R&D expenditures and efficiency surplus of plants, which were built during the period of high energy prices (Alpanda and Peralta-Alva 2010). The annual increase in material stocks exceeded the growth rate of material input globally after the oil price crisis (Krausmann *et al* 2017). Investments connected with the energy-saving technological change might stimulate this process. However, the material stock formation has also launched in developing countries these times, especially in China, which adds an independent reinforcing driver to the

structural change motivated by the efficiency improvement.

Secondly, costs of production factors (labor, energy, material input and capital) determine investment decisions. Economically, utilization of a factor depends on its price and marginal product. Marginal product (MP) denotes the amount of output variation induced by the change in utilization of a production factor. MP refers to the ability of a factor to contribute the improvement of the production process. Until the quotient of the MP and the price of the factor equals for all production factors, the production recipe remains optimal. Since the MP falls in line with the rise of the utilized amount of the factor (law of diminishing returns), the emerging factor price cuts down the demand for the given resource.

In recent years, crude oil prices have risen from 28 USD/barrel to nearly 100 USD in 2008 and 2010–2014 (more than 700 USD per ton). After the crisis in 2008, electricity and natural gas prices have rapidly risen in Europe; by 28% and 40% in Hungary, respectively. The costs of construction materials (minerals) were significantly lower in the last century (5–15 USD<sub>1998</sub> per ton in the case of sand and gravel, while around 200 USD<sub>1998</sub> for cut stone), characterized by long descending periods (Sverdrup *et al* 2017). The Hungarian price index of raw materials grew by 8%–14% annually between 2005 and 2012, with exception of the year 2009, with no increment, but with a 14% rise in the previous year. At the same time, the price index of investments ascended only by 1%–4% annually.

Price levels and their growth rate are thus moderate for stock accumulating material categories, contrary to flow-type material inputs. These conditions thus provide an incentive for the enterprises to substitute other factors with machinery, building and other infrastructures, especially when the costs of labor, energy and other resources increase at a higher pace. The results in table 1 also imply that the machinery-oriented substitution was and still is relatively cheap.  $K_m$  has increased significantly faster than  $K_b$ , however, the mean  $MP_m$  and  $MP_b$  are at the same order of magnitude, which should probably be applicable for the price levels of the two capital types as well. The level of capital stock, especially that of  $K_m$ , is probably still under the optimal; considering the current factor prices.

Consequently, *ceteris paribus*, improvements in material flow productivity and intensive stock accumulation are coupled, constituting an organic barrier to the decoupling process. As a future perspective, market price and scarcity of a resource are weakly bonded; therefore, current market systems are unable to prevent non-renewable resources from the depletion (Popp *et al* 2018). Keeping to a business-as-usual scenario, we can run out of sand and some essential metals in decades, even without any price shocks, after accumulation of enormous amounts of material stocks consuming the majority of the energy sources

and harming with a permanent demand for maintenance and waste management issues.

In addition, as a country-specific effect, subsidies from the European Union have been rising rapidly after 2006 in Hungary. Monetary flows, mainly supporting investments, have risen from 140 million EUR in 2000 to 1400 million in 2007, up to 4400 million in 2014. Furthermore, the economic effectiveness of several subsidies is doubtful, which affects productivity negatively.

Do these drivers influence the service sector exclusively, or the economy as a whole? Material input productivity was lower in 2015 than in 1995 only in sub-sector I (−7%); in the other three sectors the improvement was 350%–790%, which is significantly higher than improvement of the total economy (140%). With regard to stock, there is no estimation available yet on total capital stock of the Hungarian economy. However, as figure 1 suggests, the share of the service sector in the GFCF grows faster than the sector's contribution to the GDP. Consequently, the structure of the economy will probably turn into even more 'service sector stock heavy', in line with the proportional contribution of services to income generation—this is exactly what decreasing productivity means. It suggests that the shift towards capital stock accumulation in line with increasing efficiency of flow-type material use is characteristic of the service sector.

### Resource tax

Fundamental system innovation is required to launch novel business models towards sustainability, e.g. sharing economy or circular economy, since current economic circumstances conserve the accelerating trend of resource consumption through numerous rebounds and barriers of decoupling, as one of these was presented in this article. Restructuring of production costs is a possible means of intervention. A remodeled taxation system could reduce the cost of labor, innovativeness and other production factors independent from the natural resources, and increase relative costs of land use, minerals and fossil fuels due to resource taxes at the same time. Incentives for utilization resources for both material flow and stock accumulation would decline accordingly. Ekins *et al* (2009) proposed a volume tax for resource use, while Diestelkamp *et al* 2009 modeled a 15% decrement in the use of construction materials, and a 1.5% lower total material requirement by introducing a 2 €/ton resource tax on minerals. According to Bahn-Walkowiak *et al* (2012), resource tax is an infrequent measure of environmental policy; furthermore, its range was notable in the UK exclusively, where the 'Aggregates Levy' contributed to the boost in the recycling market significantly. Tang *et al* (2015) presented a general computable equilibrium model on coal tax in the ranges 5, 10, and 15%. Their results imply, that carbon intensity of the Chinese economy



could decline by up to 42% in line with a significantly lower fall in energy use, which suggests high ability for substitution among different technologies. It is probably applicable for the services as well, since innovative marketing channels and management solutions are available already, which allows for operation with lower resource intensity, e.g. home delivery, online shopping and shared office use.

## Conclusions

Evaluation of the environmental pressure of the service sector is not an easy task at all. Based on the results of this current study, a higher share of the service sector in economic output is desirable from the point of view of flow-type environmental impact, i.e. material input and GHG emissions. Sub-sectors of economic services analyzed in this study are characterized by rather decreasing material and GHG intensity, and the service sector generally contributes to one-fifth of these environmental impacts, providing two-thirds of GDP at the same time.

With special regard to material stock requirements, however, the sector constitutes a barrier of absolute decoupling, and it is responsible for increasing scarcity and environmental impact related to construction materials. The four economic sub-sectors of the commercial services analyzed in this study have increased their capital stock from 130 to 288 Mt between 2000 and 2015. The material intensity of the investments into services has almost doubled after the crisis in 2008, while capital stock productivity decreased in two sectors significantly, namely in accommodation and food services, and trade services. Transportation has slightly, while the ICT sector has significantly improved its stock productivity. As was discussed in this article, the costs of material input (raw materials, energy carriers) have risen rapidly after the 2008 crisis. This process probably drives the intense accumulation in economic sectors through the optimization among the utilized production factors. This effect is dominant in the service sector.

The exponential trend in material stock accumulation is an environmental issue with rising scientific concern and awareness, since it constitutes the basis of crucial waste management, resource scarcity and resource use challenges in the future. The amount and the dynamics of material stocks became intensely researched features of socio-economic systems, however, material stocks of economic processes are less analyzed as yet. As intently growing capital stock presumably constitutes a significant amount in and essential function in material accumulation, these stocks are foreseen as vital in the management of natural resources in the future. Measurement and the recognition of the capital stock's role in the socio-economic system with special regard to other stocks, material flows,

emissions and socio-economic processes is one of the crucial challenges of sustainability science.

This study reveals that the service sector generally reinforces the environmental pressure of material stock accumulation, which mankind will face in the future. As a promising way out of the service-stock trap, the resource tax was discussed in detail, which seems to be suitable for forming investment decisions of the business actors.

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