ARCHIWUM INŻYNIERII PRODUKCJI
PRODUCTION ENGINEERING ARCHIVES

2015, Vol. 8, No. 3, pp 2-5
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 01.0.9.2015 Accepted: 21.0.9.2015 Online: 30.0.9.2015

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

Wave theory analysis of the Hungarian vehicle fleet especially focusing on emission categories

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Abstract Toyotarity means the improvement of quality, decrease of production costs and production time, increase of safety and morale. With the help of tools of toyotarity strategic factors can be determined, production or service problems can be revealed. In this paper tools of toyotarity are obtained to analyse the driving factors of Hungarian vehicle fleet and car renewal. Product analysis was conducted on the basis of wavetheory.

Key words – toyotarity, wavetheory, product analysis

1. General requirements

Transport represents a crucial sector of the economy. Carbon dioxide (CO_2) emissions from road transport increased by nearly 23 % between 1990 and 2010, and without the economic crisis, growth could have been even bigger. Transport is the only major sector in the EU where greenhouse gas emissions are still rising. Transport is responsible for around a quarter of EU greenhouse gas emissions making it the second biggest greenhouse gas emitting sector after energy (Fig. 1). Road transport alone contributes about one-fifth of the EU's total emissions of CO_2 in 2012.

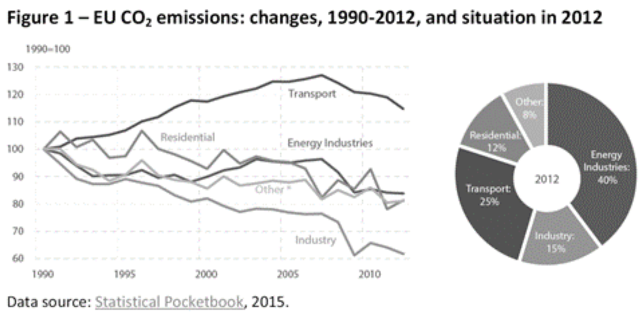

Fig. 1. EU CO_2 emission in 2012

While emissions from other sectors are generally falling, those from transport have increased 36 % since 1990. Basically aggregated, national, macro level data are available on road transport fuel consumption, vehicle fleet or mileage. CO_2 emission and fuel consumption are influence by these parameters (*TUTAK ET. AL., 2015, BERECZKY, 2012, BARABAS, 2015*). The existing research literature on transport sector's CO_2 emissions is mainly distinguish between model categories of methodological perspectives.

The first category is the bottom-up sector analysis where the microscopic data are available (*JOHANSSON, 1995), (BELLASIO ET AL., 2007), (JUNEVIČIUS ET AL., 2011), (PRAVEEN AND ARASAN, 2013), (HILMOLA, 2013*). This method is also useable to estimate emissions based on passenger travel behaviors in cities areas (*HE ET AL., 2013*).

The second method is the top-down analysis. Transport sector's CO_2 emissions are generally decomposed into changes in fuel mix, modal shift, economic growth, population, changes in emission coefficients and transport energy intensity. This is a process of data disaggregation (*TIMILSINA AND SHRESTHA, 2009*) (*TIAN ET AL., 2014*) where the studied factors responsible for the growth of transport sector's CO_2 emissions, and the results showed that economic growth and transport energy intensity are the principal factors. (*ANDREONI AND GALMARINI, 2012*) also indicated that economic growth is the main factor behind CO_2 emission increase in EU27.

The third method is system optimization. It has been widely used in forecasting energy and transport demand and CO_2 emission (*AZAR ET AL., 2003); (LUCKOW ET AL., 2010); (HASSAN ET AL., 2011); (AHANCHIAN AND BIONA, 2014); (MOTASEMI ET AL., 2014*).

The fourth method is econometric models. Using time series models, (*HALDENBILEN, 2006) (MRAIHI ET AL., 2013*) investigated the role of the fossil fuel price in the demand of the transport sector. (*LU ET AL., 2009), (TÖRÖK AND TÖRÖK, 2014*) predicted the development trends (*CZAJKOWSKA, STASIAK-BETLEJEWSKA, BORADE, 2015*) of the number of motor vehicles, vehicular energy consumption and CO_2 emission.

In this paper author has made a combined method. Dynamic wave analysis were conducted on standardized penetration of environmental categories and on vehicles as products.

2. Methodology

In order to be able to forecast the future possible tendencies of vehicle fleet authors have statistically analyzed the Hungarian vehicle fleet in order to reveal the production waves of environmental categories. For that:

- standardization of environmental group market proportion,
- wave analysis were conducted.

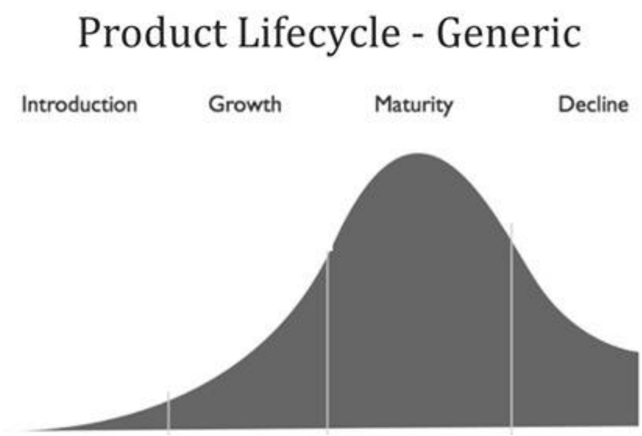

Fig. 2. Generic Product Lifecyce Wave
(source: Tracey M. Flynn, Where Are You in Your Certification Lifecycle, http://www.trainingindustry.com/blog/blog-entries/where-are-you-in-your-certification-lifecycle.aspx)

As it can be seen on *FIG. 2*. the product life-time can be separated to four different stages that can be modelled as a wave. At first stage product is introduced on the market. Second stage is growth where the market penetration is increasing. Third stage is maturity where the market penetration reaches its maximum - here is the amplitude maximum. Fourth stage is decline where competing product gains market.

Preliminary statistical result were already communicated of statistical analysis of huge sample based on Hungarian used car databank (*SZENDRO, HORVATH, TOROK, 2015).*

These data are basic driving forces of production waves and need to be investigated and integrated into a joint model.

3. Results

For wave analysis the different amplitude need to be avoided therefore waves were standardized. Preliminary analysis showed different time category intervals has a great influence on wave. It can be stated that in the case of road transport and vehicle fleet evolution the waves have a larger scale during the introductionary period; therefore the time of investigation needs to be expanded. It must be noted that this general equation can hardly be implemented in forecast due to its current limitation on drivetrain variability and market penetration. For instance, in electric cars it can hardly be applied. Although in our conceptual framework it can easily be adapted as in Hungary, alternative drivetrains have insignificant market penetration therefore, the general approach for internal combustion engines is working properly.

As can be seen in Fig 3. currently the older EURO standards dominate and will continue to do so in the near future, the wave has a high amplitude.

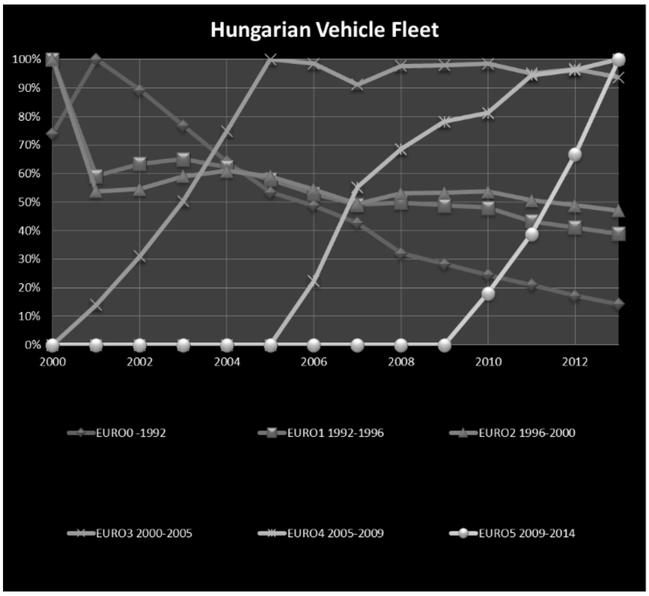

Fig. 3. Dynamic wave analysis of vehicle fleet in Hungary

Source: own compilation

In order to understand the market penetration of newer technologies, the life-cycle of older technologies need to be examined. In order to ensure the cross counting effect of changing in total number of vehicle fleet in all year the maximum was 100 % for each category. Therefore authors have separated the environmental categories by year in order to reveal the life cycle wave of each category:

As it can be seen the shape of wave and market penetration can also be investigated and holds information on product lifecycle. As it can be concluded the physical wave theory can be applied to product lifecycle assessment in case if Hungarian passenger car vehicle fleet. With the further analysis of drivetrains and environmental standards the scope of investigation needs to be enlarged. With the properly applied driving factors – such as taxes –the product life cycle wave can be shifted and modified to a proper direction.

4. Conclusion

Results shows:

- that EURO 0 category is now of the peak and has been driven out from the market, each year has lower and lower market share.
- EURO 1 and EURO 2 categories has quasi constant market share nowadays, probably EURO 1 some minor decrease in the recent years.
- EURO 3 has reached its top in 2005 and since holding its market position.
- EURO 4 is a newcomer with a continuous increasing market share.
- EURO 5 (most advanced category at the time of investigation) has very little market share but great potential in the future.

5. Acknowledgement

Authors are grateful for the support of Erasmus+ LLP Programme.

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