Influence of Macroergonomic Factors on Production Systems Organizing in Automotive Industry

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ABSTRACT

The paper discusses the need to recognize factors determining the ergonomic conformity of production systems. The focus has been found to be vital for the design of such systems. To help adopt the approach, the authors have identified factors which affect the ergonomic conformity of production systems in the automotive industry and subsequently had them verified by experts. Furthermore, they employed the network thinking methodology to analyze the time and severity of impact of the individual factors. The studies carried out by the authors have made it possible to develop a model for the management of ergonomic factors. The authors additionally proposed conclusions on ergonomically-driven measures intended to eliminate barriers in designing production systems and on opportunities for enhancing the ergonomic conformity of working environment in manufacturing plants.

Keywords: Macroergonomics, Macroergonomic Factors, Production Systems, Automotive Industry, Network Thinking Methodology

INTRODUCTION

One of the roles of management is to ensure proper organization design. Such design combines the planning of activities and their proper deployment associated with carrying out and controlling of e.g. production. While organization sciences date back to the 19th and 20th centuries, their principles should continue to be upheld on par with the latest management methodologies and the proactive strife for continuous improvement.

Over forty five years ago, the classic human-machine model was redefined to produce a multi-faceted system better suited to embrace third generation ergonomics, i.e. macroergonomics [Pacholski L., Trzcielinski S., Wyrwicka M. K., 2011, pp. 147, 148 [based on:] Hendrick H.W., Kleiner B.M., 2002; Jasiak A., 1993, p. 15]. As an ergonomic science, macroergonomics deals with sets of physical and social factors encountered in the working environment. Its focus is on relationships among complex production systems. Such systems, which provide e.g. regional and local technical support, constitute classic examples of macroergonomics [Pacholski L., Trzcielinski S., Wyrwicka M. K., 2011, pp. 147, 148 [based on:] Pacholski L., Wyrwicka M.K., 2006]. Furthermore, macroergonomics is a study of the impact of technical subsystems on organizational and worker subsystems complete with the details of the related deployments. “Macroergonomics has come to focus on the design of organizational and work system structures and related jobs and human–machine, human–environment, and user–system interfaces of new technique to the interaction between organizational factors and the technology used in the organization” [Erensal Y. C., Albayrak E.,

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2007, p. 6, [based on:] Hendrick H.W., 1994, pp. 713–718; Hendrick H.W., 1995, pp. 1617–1624]. Macroergonomics emphasizes the interaction between organizational and psychological and social factors as well as the implementation and operation of technical items in the overall system [Erensal Y. C., Albayrak E., 2007, p. 6, [based on:] Hendrick H.W., 1994, pp. 713–718; Hendrick H.W., 1995, pp. 1617–1624]. Socio-technical design of work and macroergonomics are closely related. [Erensal Y. C., Albayrak E., 2007, p. 6, [based on:] Ingelgaêrd A., Norrgren F., 2001, pp. 93-105]. At the level of the organization of production systems, macroergonomics is a pivotal factor for effectiveness.

Businesses and other organizations as well as the people involved in them in various capacities (such as as employees) operate in a complex environment of mutual interactions. The links among them can be analyzed by means of the network thinking methodology which is a total approach. Studies relying on that methodology adopt a systemic view of issues with proper account taken of any such specific factors as affect the environment in which a given focus of research is embedded.

Penc noted that Polish enterprises do little management while focusing heavily on ruling. For that reason, the analysis centers on identifying approaches which enable one not only to operate a business but also to protect human health and lives, specifically those of the enterprise's labor force. It is therefore the aim of this paper to find ways "to boost the significance of ergonomic compliance in the design of production systems of automotive plants". The discussion highlights the role of any stakeholders for whom addressing such issues should become central as well as any decision-makers in a position to influence their plant's conformity status. Further in the study, the authors defined the mutual interactions and links among factors affecting ergonomic conformity of production system design. The outcome of this exercise was a network of mutual interactions. Subsequently, experts were used to assess:

- the relationships and the nature of interactions among factors affecting the matter at hand (adversely or positively),
- the type of such relationships and interactions (two- or one-way),
- their intensity (ranging from no impact, defined as "0", to very strong impact, assigned the value of "3")
- the duration of impact of individual factors on the matter at hand (ranging from short to long).

All of these factors were brought together to devise an impact matrix featuring active, passive, critical and indolent factors, as well as an intensity map differentiating between managed and unmanaged factors.

Today's business organizations operate in a network of relationships and links between themselves and the external environment. Similarly, affected by all-encompassing globalization, people are part of greater entities (such as universities or industrial plants) which also interact among one another. Such links can be researched by means of the network thinking methodology, which offers a comprehensive approach. Studies carried out by that methodology rely on the systemic approach to the issues at hand. They additionally recognize any factors which significantly affect the examined environment. When employing the network thinking methodology, it is essential to use precise and understandable language. Terms and notions should only be defined after a debate involving all concerned parties. This is essential to ensure that the resulting view is consistent across the board. The methodology helps identify barriers and limitations of various sorts as encountered in the decision-making process [Grzelczak A., Werner K., 2011, pp. 21-22; Zimniewicz K., 2003].

The network thinking methodology rests on 7 theoretical foundations which are [Grzelczak A., Werner K., 2011, pp. 21-22; Zimniewicz K., 2003]:

- the whole and its parts,
- network characteristics,
- openness,
- complexity,
- order,
- management, and
- growth.

Procedurally, the methodology is followed through six stages which, in addition to adhering to the sequential order of the stages themselves, require responses to feedbacks which allow one to make adjustments in any completed stages. The stages involve [Grzelczak A., Werner K., 2011, p.24]:

- defining goals and developing a model of issues,
- analyzing mutual interactions,
- identifying and interpreting opportunities to modify current status,
- explaining options to gain control,
- devising an action strategy,

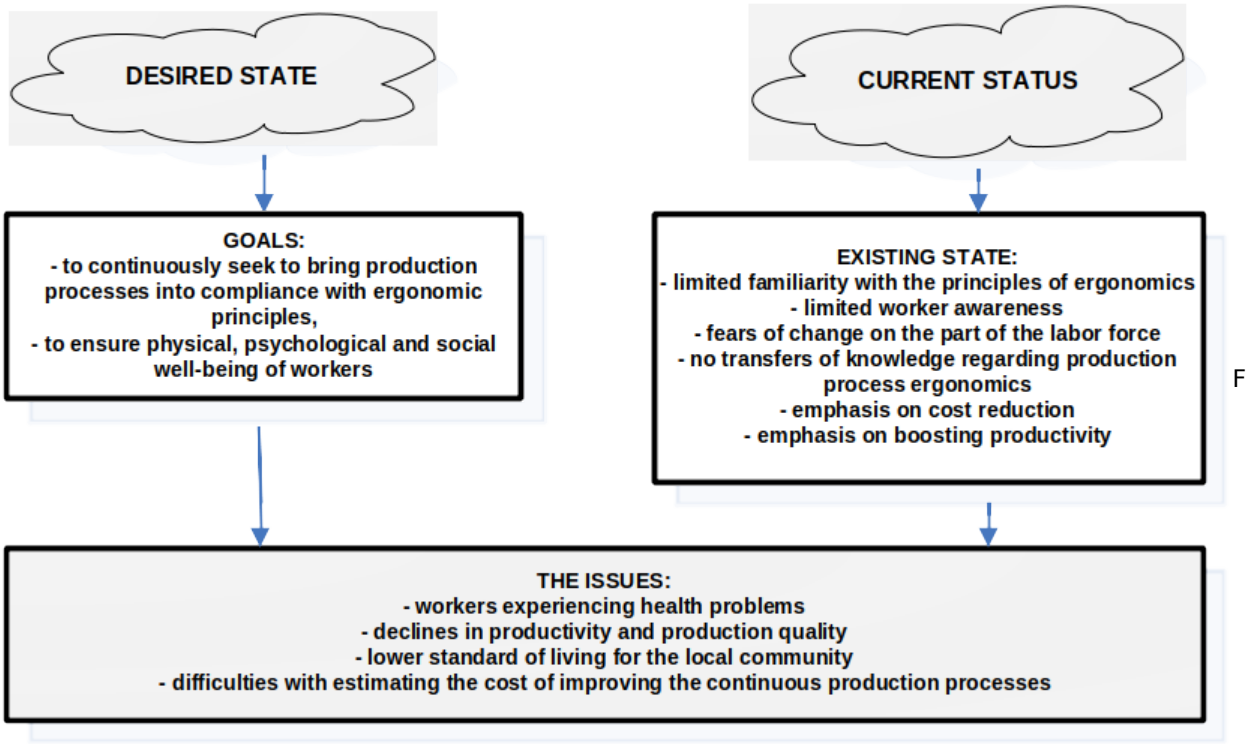
- adopting solutions to problems in business practice.

PRODUCTION SYSTEM ANALYSIS

Defining goals and developing a model of issues

The study consisted in analyzing the production system of a selected automotive enterprise based in the Polish Region of Wielkopolska. The organization is a member of a large corporate group which emphasizes extensive customization of products and exports its goods to a dozen plus countries around the world.
In examining the system in macroergonomic terms, the authors set out to find ways to:
"ensure better recognition of the importance of ergonomic conformity in the design of production systems in automotive plants". Their intermediate aim was to define any factors affecting the ergonomic conformity of production systems in the selected enterprise and to examine such systems in depth. The intended outcome of applying the method is a set of measures (scenarios) indicative of the decisions that need to be taken to achieve the ultimate goal. Although universal in its design, the solution will nevertheless be company-specific.

Step one was to investigate the problem environment which is a complex process requiring a multifaceted approach. A roundup of the key issues is provided in Figure 1.



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igure 1. The challenges faced (authors' work).

Defining scenarios

The next stage of the study was to define scenarios by identifying any individuals and/or institutions having influence on the ergonomic conformity of production systems in Company X. The findings produced at this stage are summarized in Figure 2.

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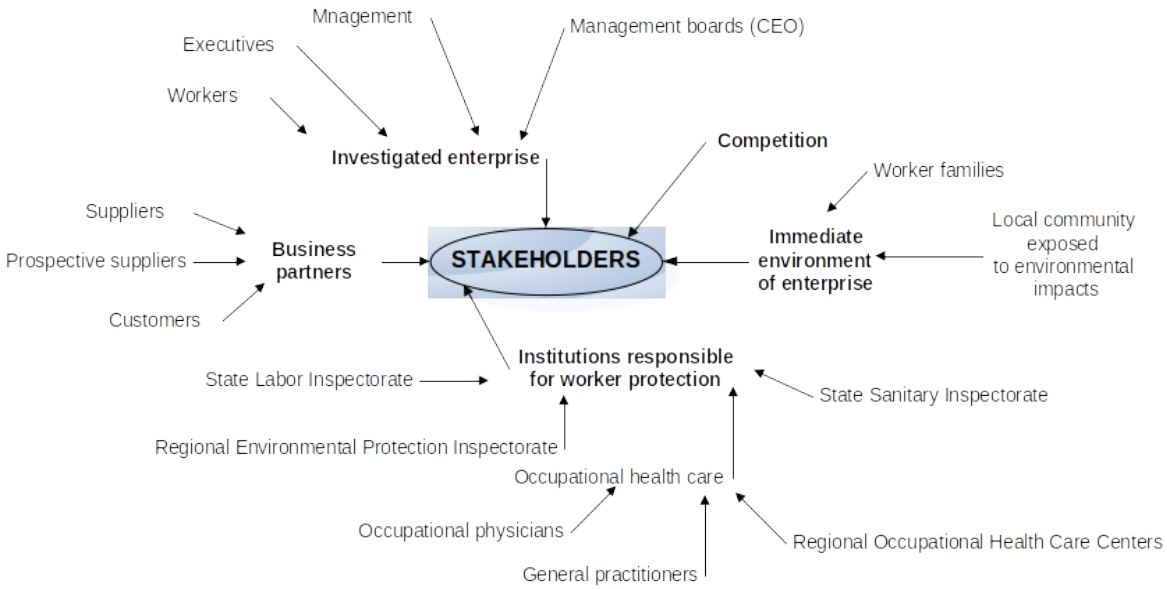

Figure 2. Individuals and institutions having influence on ergonomic conformity of production systems in Company X
(authors' work)

In keeping with the above, the authors distinguished the following five key stakeholder groups:

- the enterprise in question – the persons concerned with the ergonomic conformity of production systems within the company are not only the workers (who are the target group directly exposed to the company's production system) but also the management (responsible for the choice of production methods and production system design as well as ergonomic compliance). A properly designed production system would benefit these stakeholder subgroups: the workers would see health improvements, the Management Board and other levels of management would achieve reductions in absenteeism and worker turnover (which has been high), the organization would gain a renewed image as a friendly employer and a company which cares for safe employment and ergonomically designed work;
- the competition – interested in any ergonomic solutions that boost productivity and reduce production costs. With no ergonomic system in place on the production floor in the examined company, the competitors are in a position to attract workers who resign, distraught over serving an organization that shows little care for the health of its employees, experts in their respective fields;
- business partners – as ergonomic conformity depends largely on machinery, tools, semi-finished products, etc. which the company procures from its suppliers, it is essential to incorporate ergonomic considerations at the stage of supplier selection. Customers, in their turn, have an interest in receiving a compliant product at a specified time, produced in an effective manner with full respect for ergonomic principles;
- the company's immediate environment, which, for the purposes of this study, was defined as including worker family members (who ultimately want their close ones to suffer no health issues as a result of their work) and the local community whose members care to ensure the company does not pollute the local environment;
- institutions responsible for worker protection – these include any institutions in charge of overseeing compliance with occupational health and safety requirements; the system is designed to reduce insured and uninsured costs which are borne by society at large.

Analyzing mutual interactions

The study of mutual interactions began with the pivotal factor. This was found to be the ergonomic conformity of production systems. Relationships among the factors at play are shown in Figure 3.

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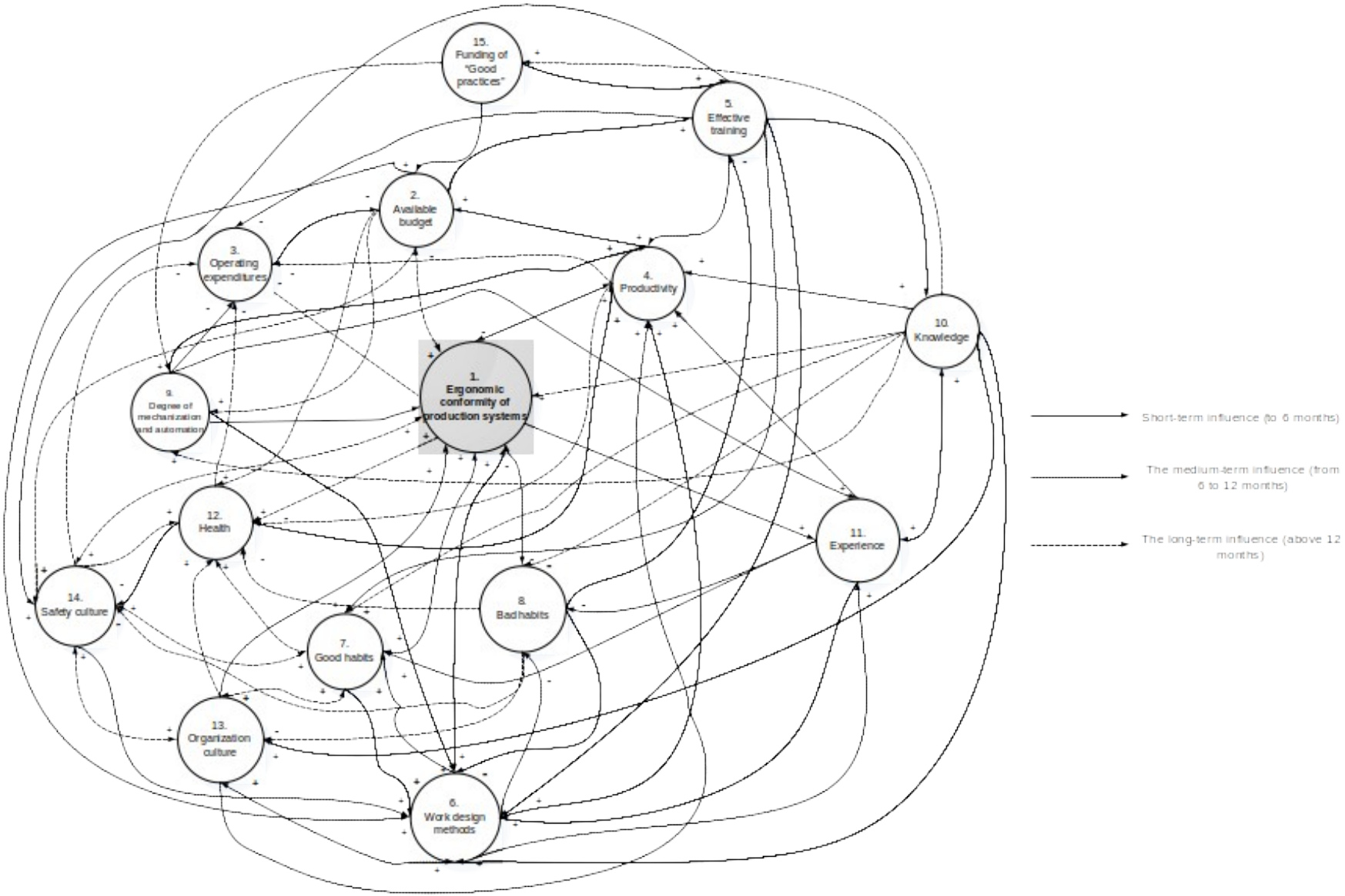

Figure 3. The network of interactions among factors at play (authors' work)

Figure 3 depicts the relationships and the nature of interactions among individual factors which affect the ergonomic conformity of production systems in the selected enterprise and mutually impact upon one another.

The influences have been denoted as "+" to denote any directly proportional impacts and "-" to denote any impacts found to be adversely proportional. The factors applied in developing the network of interactions were identified by examining the current status and by accounting for all stakeholders. In today's approach to ergonomics, ergonomic quality does not depend on any single factor or any set of multiple factors which a user may be able to influence. Rather, such quality is a function of multiple components in the macro-environment [Butlewski M., Tytyk E., 2012, pp. 298-306]. For that reason, the issue of quality was not dealt with separately. Instead, it was assumed to be an upshot of a well-functioning production system. Table 1 brings together the overall descriptions of factors which affect the ergonomic conformity of production systems complete with a numerical value of help at further stages of the study.

Table 1: Interpretation of factors identified in the interaction network (authors' work)

Name	Description
Ergonomic conformity of production systems	A collection of features of a production system which enable a business organization to ensure the psychological, social and physical well-being of any affected individual
Available budget	Funds appropriated to maintaining and improving production systems
Operating expenditures	Funds spent to operate production systems
Productivity	The quantity of products compliant with applicable standards per unit of time
Effective training	Training courses designed to raise worker awareness of ergonomic issues and enhance organization culture
Work design methods	Consistently and deliberately employed methods for selecting best measures and ways to utilize company resources to generate operating profit [Gryffin R.W., 1996, p. 329; Martyniak Z, 1976, p.16]
Good habits	A set of means and ways of conduct conducive to compliance with ergonomic requirements
Bad habits	A set of means and ways of conduct conducive to incompliance with ergonomic requirements
Degree of mechanization and automation	The level of mechanization and automation of any production processes carried out within a system
Knowledge	The overall information acquired, among other things, through effective training and from lessons learned, defined as the body of knowledge on ergonomics. Such knowledge makes it more likely for a company to produce innovations to improve the ergonomic conformity of production systems
Experience	Any acquired skills and competencies affecting worker behavior
Health	A state of complete physical, psychological and social well-being – the notion extends beyond being free of illnesses, disease and disabilities [Dahlke G., 2013, p. 5 [based on:] Preamble to the Constitution of the World Health Organization, 1946]
Organization culture	A system of values and rules of conduct constituting an integral part of an organization. Organization culture manifests itself in ways of thinking and conduct which are properly ingrained and approved by a team [Wyrwicka M., Stasiuk A., Drzewiecka M., Masadyński M., 2011, p. 176 [based on:] Malinowska, 2004, p. 56; Nogalski, 1998, p. 95; Wiernek, 2000, p. 24].
Safety culture	An approach to one's own health and life as well as that of persons in one's environment, defined as: "a set of psychological, social and organizational factors which activate or sustain activities which protect lives and health at work and beyond" [Ejdys J., 2010, p.17 [based on:] R. Studenski, 2000 , p. 1]
Funding of "Good practices"	Programs of funding projects aimed at improving working conditions and ergonomic conformity, e.g. European Union financing or funding by the Polish Social Insurance Authority (e.g. http://www.zus.pl/default.asp?p=4&id=422)

To identify the detailed interactions among the individual factors, a study was conducted in terms of:

- the types of interactions (two-way, one-way), as marked with arrows in Figure 3;
- the severity of impact measured on a scale of 0 to 3 (where 0 denotes no impact; 1: low impact; 2: high impact and 3: very high impact);
- impact duration ranging from short (up to 6 months) to medium (6 to 12 months) to long (above 12 months).

The following stage is to examine the impact matrix which divides all of the analyzed factors into the four groups of [Zimniewicz K., 2003]:

- active factors which very strongly affect other influences but which themselves are unlikely to succumb to any influences (great A total);
- passive factors having little effect on others but likely to be influenced by them (low A total);
- critical factors which strongly impact upon others and are strongly influenced by other factors (high P total);
- indolent factors which poorly impact on others and are only slightly influenced by them (low P total).

An analysis of the impact matrix is shown in Table 2. The numbers assigned to individual factors correspond to the numbering given in Table 1.

Table 2: The impact matrix (authors' work)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTAL A
1	**X**	**1**	**1**	**2**	0	**2**	**1**	**2**	0	0	**1**	**2**	0	**2**	0	**14**
2	**3**	**X**	0	0	**1**	**1**	0	0	**3**	0	0	**1**	0	**1**	0	**10**
3	0	**2**	**X**	0	0	0	0	0	0	0	0	0	0	0	0	**2**
4	**2**	**1**	**1**	**X**	0	0	0	0	0	0	0	**1**	0	0	0	**5**
5	0	0	**1**	**1**	**X**	**1**	**1**	**1**	0	**3**	0	0	0	0	0	**8**
6	**3**	0	0	**2**	0	**X**	**1**	**1**	0	0	**2**	0	**1**	0	0	**10**
7	**2**	0	0	0	0	**1**	**X**	0	0	0	0	**2**	**1**	**2**	0	**8**
8	**1**	0	0	0	0	**2**	0	**X**	0	0	0	**2**	**2**	**3**	0	**10**
9	0	0	**2**	**3**	0	**2**	0	0	**X**	0	**2**	**2**	0	0	**1**	**12**
10	**2**	0	0	**1**	0	**2**	1	1	**2**	**X**	**2**	0	**1**	0	**2**	**14**
11	0	0	0	**2**	0	**2**	**1**	**1**	0	**2**	**X**	0	0	0	0	**8**
12	0	0	**1**	**3**	0	0*	0	0	0	0	0	**X**	0	**1**	0	**5**
13	**1**	0	0	**2**	0	**2**	**1**	**1**	0	0	0	**1**	**X**	**3**	0	**11**
14	**2**	0	**1**	**1**	0	**1**	**1**	**1**	0	0	0	**2**	**1**	**X**	0	**10**
15	0	**2**	0	0	**1**	**1**	0	0	**2**	0	0	0	0	0	**X**	**6**
TOTAL P	**16**	**6**	**7**	**17**	**2**	**17**	**7**	**8**	**7**	**5**	**7**	**13**	**6**	**12**	**3**	**133**

* no disabled persons are employed in the production system in question

The selected factors should also be shown on an intensity map (Figure 4) which serves the purpose of identifying their nature. The position of a given factor is a value shown on the map by marking intersections between value A (severity of impact) and value P (factor responsiveness) [Ziemniewicz K., 2003]. At this stage, a decision needs to be made as to where to place the dividing lines (borders) to delineate on the severity map four fields which correspond to the individual factor categories. The simplest division would be to select the maximum A and P values and divide them by two [Ragin-Skorecka K., Grzelczak A., Werner K, Mroczek B. 2011, p. 106]. By following this presumption, the authors originally arrived at A = 7 and P = 8.5. This network line arrangement was then debated bringing the authors to the conclusion that the lines should remain unmoved. This choice was based on:

- a thorough analysis of all borderline factors,
- the need for unambiguous assignment of all individual factors to a given category.

The tool allows one to observe the characteristics of impact factors. Where active and critical factors prevail, the current situation may be modified to a great extent by means of these very factors. In the converse case, however, the options for interfering are considerably more limited. This is because the use of passive and indolent factors will,

expectedly, result in little impact on the overall system [Piekarczyk A., Zimniewicz K., 2010].
The factor severity map is shown in Figure 4.

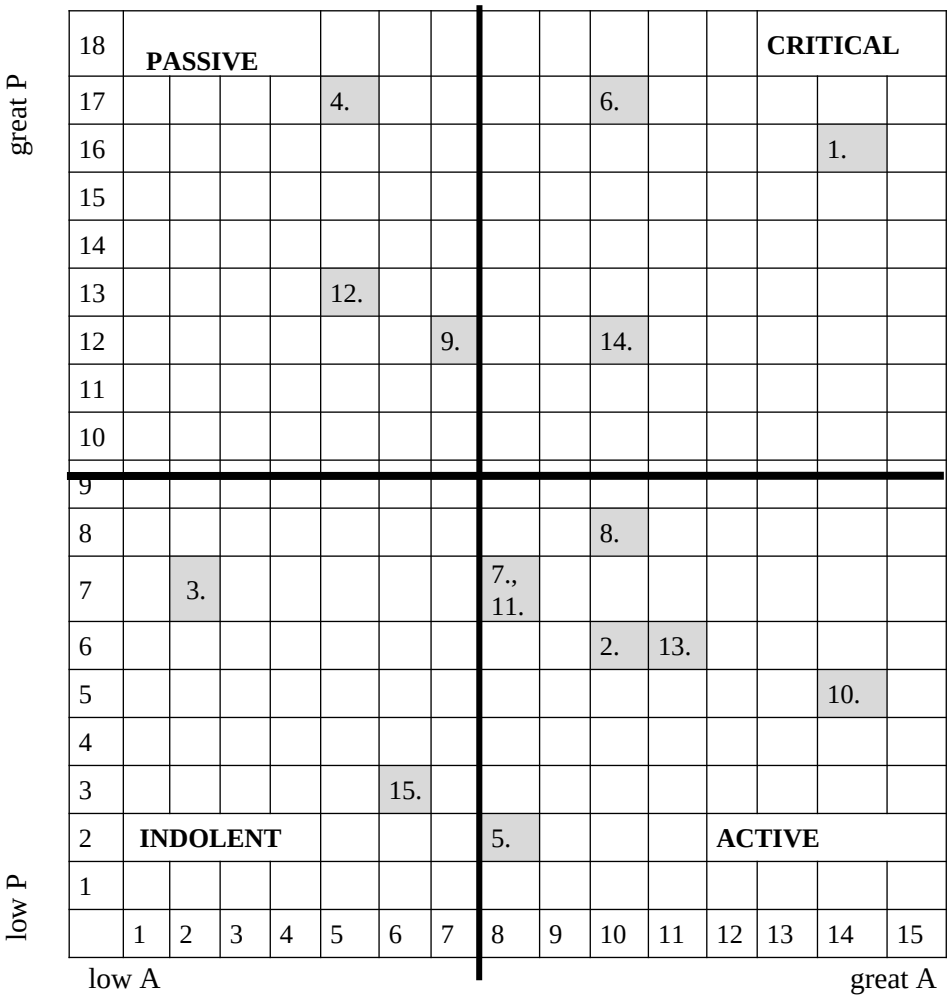

Figure 4. Factor severity map (authors' work)

Once the findings of the factor severity study have been placed on the factor severity map, the distribution of factors turned out to be disproportional. The assignment of individual factors into groups and preliminary conclusions are shown in Table 3.

Table 3: Interpretation of individual factors (authors' work)

GROUP	NAME OF FACTORS	CONCLUSIONS
ACTIVE	**2. Available budget**	The factors can be managed to bring the production system to a state of ergonomic conformity. The factors have strong influence on others but are only slightly influenced by their impact. **Available budget**, i.e. funds appropriated to the design of production systems in an ergonomically-compliant manner may have a substantial impact on ergonomic conformity. However, the choice of whether or not to spend the funds rests with the Management Board of the company in question. It is therefore necessary to point out the potential impacts of establishing a system which greatly conforms with
	5. Effective training	
	7. Good habits	
	8. Bad habits	
	10. Knowledge	
	11. Experience	

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GROUP	NAME OF FACTORS	CONCLUSIONS
	13. Organization culture	ergonomic standards. In designing new solutions, use should be made of the design tools which aid manufacturing (CAD CAM, such as Delmia, JACK or RAMSIS) and which rely on ergonomic conformity assessment methods. **Effective training** has unquestionable impact on a system's ergonomic conformity. It is difficult, however, to assess the effectiveness of such training before it is held. It is therefore advisable to verify training effectiveness and learn proper lessons to help formulate any future training plans. Preference should be given to the forms of improvement which ensure a positive results. The difficulty with guaranteeing such results is reflected in the impacts matrix (the borderline with indolent factors). One should nevertheless note the importance of training and ensure its consistency bearing in mind that a one-off course of training will not result in a permanent improvement of worker awareness. **Good habits** have a huge impact on the ergonomic behavior of workers but, unfortunately, cannot be easily influenced. The only way to ensure good habits is to instill in the workers themselves a deep-ingrained conviction about the importance of their system's ergonomic conformity. Once acquired, good habits have the potential of preventing a great number of undesirable situations. Unfortunately, the top management have little influence on such habits as it is the workers themselves who need to acquire them based on years of experience and knowledge. **Bad habits** in workers are a formidable barrier to developing safe and healthy working conditions. Such habits have a powerful influence over new hires. In the production system in question, some of the difficulties with eradicating bad habits lie in the great variability of the jobs performed by employees as well as diverse locations of the work zones. It is therefore impossible to define (design) worker workflows and adopt special tools for the tasks they perform. **Worker knowledge**, as gained through training, should result in ergonomic awareness – however, such knowledge is not always utilized in a proper way. The communications passed on to the workers should be coordinated with new technological and work design solutions. **Experience** – similarly to training and good habits, experience has much positive impact on the system's ergonomic conformity. Top managers should therefore make every effort to properly shape such experience. However, due to the specific nature of this factor, interference comes with certain restrictions. This is because experience is a personal characteristic of each individual worker. Certain measures can be taken during induction and continued to build experience through training. **Organization culture** – shaped largely by the workers, organization culture is compromised by the bad habits of persons who have served the company longer. Such culture can be impacted in a number of ways, including by effective training and by implementing new work design methods while upgrading work and production factors.
PASSIVE	**4. Productivity** **9. Degree of mechanization and automation**	While the above factors can be influenced strongly by others, these factors themselves remain passive (exert little influence on other items). Such factors are of little interest as they offer little potential for affecting other values in the network. Nevertheless, they should not be ignored. The factors may motivate

GROUP	NAME OF FACTORS	CONCLUSIONS
	12. Health	stakeholders to support the drive to establish an ergonomic production system. **Productivity** has little impact on the issue at hand but is itself susceptible to many influences (see Table 2). **Degree of mechanization and automation** – surprisingly, this factor has no significant effect on the ergonomic conformity of the production system. This factor is tied closely to productivity. **Health,** itself a function of many factors, has little impact on the investigated issue. An ergonomically friendly production system should avert health problems among workers.
CRITICAL	**1. Ergonomic conformity of production systems**	These factors are key to the study. It is these factors that predominantly determine the ability to achieve the desired ergonomic conformity of the production system. The factors strongly impact upon others as well as being strongly affected by them. **Ergonomic conformity of production systems** is the purpose of this study and its central aim. The factor powerfully influences other components in this study and is vulnerable to be strongly affected by them. **Work design methods** are ways to achieve the final outcome (purpose) of the company's activities which is operating profit. Proper methods are certain to help produce an ergonomic and highly efficient system. This factor is also open to a number of influences. **Safety culture** – provides information on the way the workers and shareholders approach worker safety. Safety culture is influenced by multiple factors including any existing good and bad habits. It also has the capacity to strongly affect other factors that strongly influence the issues at hand.
	6. Work design methods	
	14. Safety culture	
INDOLENT	**3. Operating expenditures**	These factors rank as indolent, meaning they have minimal impact on others and are hardly influenced by external impacts. **Operating expenditures** are largely a fixed value or one whose variability is limited (they are difficult to reduce). Hence, the factor offers few possibilities for modifying the system and ensuring ergonomic conformity. **Funding** – although funding may help adopt good practices and increase the budget, it is hard to acquire (in the amounts applied for). The majority of "good practices" in the production system in question can be found in training arrangements rather than in building the ergonomic conformity of work and production factors.
	15. Funding of "Good practices"	

IDENTIFYING AND INTERPRETING OPPORTUNITIES TO MODIFY STATUS

Explaining options to gain control

Once an issue has been analyzed (and the network has been developed and examined in terms of the types, durations and severities of impacts and the pace and aims of improvements), it is necessary to identify opportunities for managing change. A simplified management model is provided in Figure 5. To ensure proper change management, a management model has been developed made up of seven components: a manageable item (the ergonomic conformity of production systems), decisions (made by the automotive enterprise), manageable and unmanageable factors, indicators or early response measures, the feedback loop and a preemptive action system [Borowiec A., 2013, p. 66].

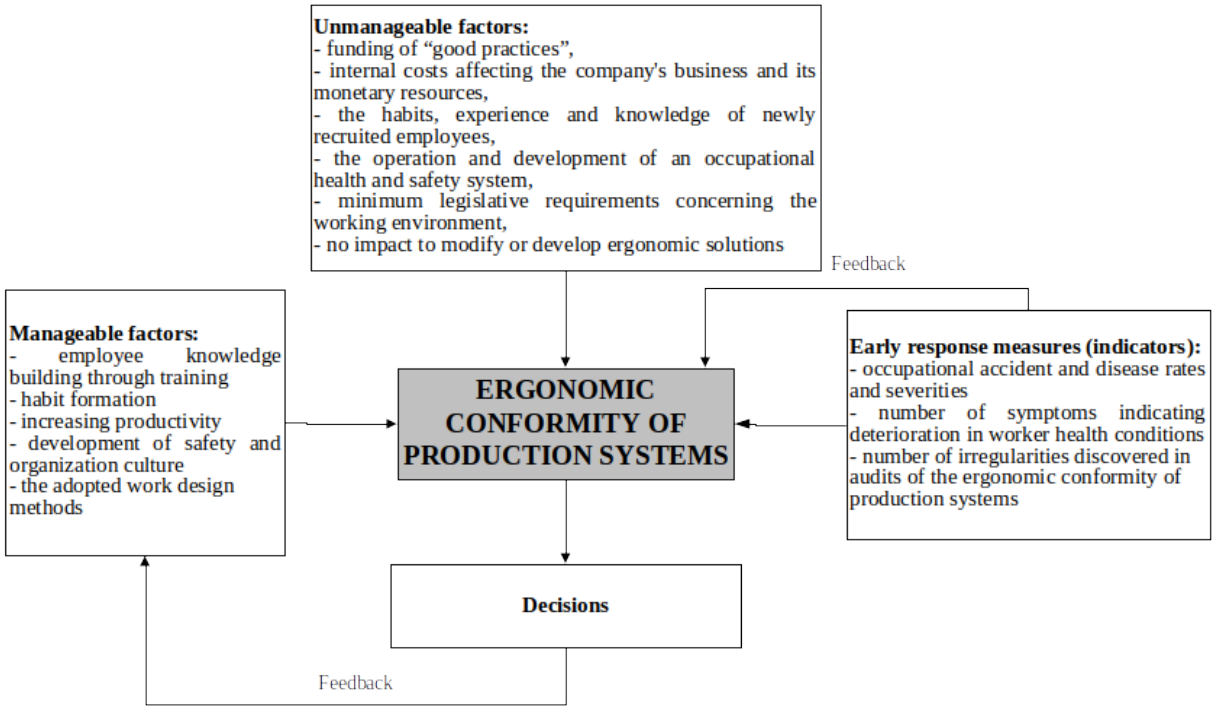

Figure 5. A model for managing the ergonomic conformity of production systems (authors' work)

The foregoing model shows the factors available to decision-makers to influence the ergonomic conformity of production systems as well as the measures they can use to assess the degree of such conformity. Also specified are unmanageable factors which will not allow decision-makers to modify the system.

CONCLUSIONS

The main goal of the paper has been described as aimed at: "identifying ways to foster the significance of ergonomic conformity in designing production systems in the automotive industry". To achieve this goal, the authors have carried out a case study by the network thinking method. Although they adhered to the standard stages commonly applied in the method, the factors selected by the engaged expert team were specific for the enterprise in question. What is also notable is that, despite the fact that specific criteria differ from one company or industry to another, the solution presented in the paper may well serve as a basis for other (similar) studies.

Expectedly, the factors of great significance for the investigated issue included finance ("the available funds") and "organization culture". What was not foreseen, however, was just how powerfully "experience", "knowledge" and "effective training" would affect ergonomic conformity. Of equal significance is the formation of good and bad habits which the literature rarely recognizes as central for the development of production system macroergonomics.

To build an awareness of ergonomics among individual stakeholders, it is crucial to promote positive and eliminate negative factors. It is not advisable, in this context, to dwell extensively on operating expenditures and the financing of "good practices". While such practices may well attract extra funding, even the best tools, machinery and equipment will do little to improve the ergonomic compliance of systems without proper knowledge and employee training.

As a science of the future focusing on complex systems, macroergonomics brings together a wide range of issues associated with organizations' activities. It is therefore best not to view increases in the level of ergonomic conformity as a single isolated set of characteristics but rather as components tied to a number of other factors which interact in various ways, at different times and with varying intensity.

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REFERENCES

Borowiec A., (2013), „Perspektywy rozwoju przedsiębiorstwa branży transportowej poprzez wykorzystanie instrumentu zamówień publicznych", in: Grzelczak A., Borowiec A., Górny A., Zastosowanie metodyki myślenia sieciowego. Tom II, Wydawnictwo Politechniki Poznańskiej, Poznań pp. 45-75

Butlewski M., Tytyk E. (2012), "The assessment criteria of the ergonomic quality of anthropotechnical mega-systems", in: Advances in Social and Organizational Factors, Edited by Peter Vink, CRC Press, Taylor and Francis Group, Boca Raton, London, New York, pp. 298-306.

Dahlke G., (2013), Zarządzanie bezpieczeństwem pracy i higieną pracy, Wydawnictwo Politechniki Poznańskiej, Poznań, p. 5

Erensal Y. C., Albayrak E., (2007), "The Impact of Micro- and Macroergonomics Considerations on Appropriate Technology Transfer Decisions in Developing Countries: The Case of Turkey", in: Human Factors and Ergonomics in Manufacturing, Vol. 17 (1), pp. 1-19.

Griffin R.W., (1996), Podstawy zarządzania organizacjami, Wydawnictwo Naukowe PWN, Warszawa, p.329

Grzelczak A., Werner K. (2011), „Podstawy teoretyczne metodyki myślenia sieciowego", in: Budowa scenariuszy transformacji wiedzy wspierających innowacyjną Wielkopolskę, Tom II, Wyrwicka M. (Ed.), Wydawnictwo Politechniki Poznańskiej, Poznań, p. 22.

Hendrick H.W. (1994). "Macroergonomics as a preventative strategy in occupational health: An organizational level approach", in: G.E. Bradley, H.W. Hendrick (Eds.), Human factors in organizational design and management IV, Amsterdam: North Holland. pp. 713–718.

Hendrick, H.W. (1995),"Future directions in macro-ergonomics", in: Ergonomics, 38, pp. 1617–1624.

Hendrick H.W., Kleiner B.M., (2002), "Macroergonomics: Theory,methods and applications", Mahwah, NJ:Lawrence Erlbaum.

Ingelgaêrd A., Norrgren F., (2001), "Effects of change strategy and top-management involvement on quality of working life and economic results", in: International Journal of Industrial Ergonomics, 27, pp. 93–105.

Jasiak A., (1993), Kryterium czynnika ludzkiego w projektowaniu systemów wytwarzania, Wydawnictwo Politechniki Poznańskiej, Seria Rozprawy, nr 283, Poznań.

Malinowska A., (2004), "Rola kultury i jej znaczenie w środowisku pracowniczym", in: Kultura organizacyjna w teorii i praktyce, Materiały na Ogólnopolską Sesję Studenckich Kół NAukowych, Leszno, p. 55-65

Martyniak M., (1976), Elementy metodologii organizowania, Państwowe Wydawnictwo Naukowe, Warszawa, p.16

Nogalski B., (1998), „Kultura organizacyjna, Duch organizacji", TNOiK, Bydgoszcz.

Pacholski L., Trzcielinski S., Wyrwicka M. K., (2011), "Clustered Macroergonomic Structures", in: Human Factors and Ergonomics in Manufacturing & Service Industries 21 (2), pp. 147- 155.

Pacholski L., Wyrwicka M.K., (2006), "Macroergonomics factors in managing the development of local community – infrastructure system", in: R. Pikkar, E.Koningveld, & P. Settels (Eds.),Meeting diversity in ergonomics, Maastricht: Elsevier Ltd.

Piekarczyk A., Zimniewicz K. (2010), „Myślenie sieciowe w teorii i praktyce", Polskie Wydawnictwo Ekonomiczne, Warszawa.

Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19 June - 22 July 1946

Ragin-Skorecka K., Grzelczak A., Werner K., Mroczek B., (2011), „Budowanie sieci zależności czynników oddziałujących na innowacyjną Wielkopolskę", in: Budowa scenariuszy transformacji wiedzy wspierających innowacyjną Wielkopolskę, Tom II, Wyrwicka M. (Ed.), Wydawnictwo Politechniki Poznańskiej, Poznań, pp. 77-113

Wiernek B., (2000), „Kultura organizacyjna przedsiębiorstwa", Oficyna Wydawnicza TEXT, Kraków

Wyrwicka M., Stasiuk A., Drzewiecka M., Masadyński M., (2011) „Organizational culture diagnosis as an element of supporting organizational change management",in: Knowledge management and organizational culture of global organization, Grzybowska K., Wyrwicka M.K.(eds.), Publishing House of Poznan University of Technology, Poznań, pp. 175-192.

Zimniewicz K. (2003), „Współczesne koncepcje i metody zarządzania", Polskie Wydawnictwo Ekonomiczne, Warszawa.

sjp.pwn.pl/lista.php?co=wiedza dostęp: 02.02.2014

www.zus.pl/default.asp?p=4&id=422 dostęp: 01.02.2014