Robotization in disabled care: projection of the impact on the economy and methodological framework evaluation

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Abstract

Some leading studies concerning present millennium challenges emphasize recent technologies to disrupt the present market and offer new opportunities. Moreover, techno-economic analysis indicates that robotic industry appears to be a turning point in the pursuit. However, distribution of the impact sprawl discriminate those who theoretically should also enjoy the latest advances and developments – the disabled. Most of them often are excluded from any participation in public environment. Inclusion of these seems to be conflicting aspects into strategic provisions towards the model of societal progress - a great challenge. On the basis of their significance and quality the wider dissemination of research developments will stimulate more exchanges and collaborations among the research community and contribute to further advancement of this rapidly growing field. The article is to bring in a timely fashion and practical considerations for economic evaluation of robotization in the sphere of disability care.

Introduction

Resent scholars work in the field of creation the adaptive and intelligent robotic systems: since 1995, the emphasis from possibilities of industrial robots was made on the development and opportunities of the service-robotics. United Nations Commission of Europe (UNECE) forecasts strong even tremendous growth in application of this certain group and grounds the prognosis by a pragmatic reason: constantly aging world (Forge& Blackman, * Corresponding author. Tel.: +370-698-20720.

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From a largely dominant industrial focus, robotics in recent years is rapidly expanding into the challenges of unstructured environments (Bessiere et al., 2008). Some leading studies (concerning present millennium challenges of modern society emphasize in different aspects: the society undergoes transformations in economic, political and social environment. In the progress of such studies it became clear that recent technological advances are such that they will disrupt the present market and offer new opportunities. Moreover, techno-economic analysis indicates that robotics industry appears to be a turning point in the pursuit. However, distribution of the impact sprawl discriminate those who theoretically should also enjoy the latest advances and developments – the disabled, because most of them are excluded from any participation in public environment. Inclusion of these seems to be conflicting aspects into strategic provisions towards the model of societal progress - a great challenge requiring deeper investigation and formulation of valuable recommendations. Despite the fact abundant literature and case studies (Howell, 1985; Ferrer, Ayres, 2000; Metra, 2011 and etc.) reveal a diversity of opinions and scenarios on the subject that are often based on scant evidence and seem to reflect the position of certain interest groups as far as forecast the potential effects robots employment in industry. Only the short hint of the studies concerns the preconditions for the market share increase for so called social robots that satisfy the needs of the disabled. Furthermore, former research and a critical look at the robot industry (Schofield, 1999), some strategic documents (i.e. “Research Agenda for robotics in Europe 2014-2022”) allowed to determine that there is no structurally coherent assessment and no clear perspective guidelines or programs in the field that would allow to analyze the socio-economic phenomenon in a complex manner. In order to address this flaw this article is to bring in a timely fashion and practical considerations for economic evaluation and the strategic value of robotization in the sphere of disability care and support. The research purpose is substantiating the preconditions of robotization in the disabled care through introduction the impact sprawl and the methodological framework for its economic evaluation. The main research questions rely firstly on enhancing theoretical foundation in analysis of preconditions for technology acceptance, secondly - extending the existing understanding about possible areas of robot application and supporting the position that job (due to robot employment in the sector) is greater than job displacement, and finally – extent the cost-benefit analysis framework by introducing several approaches for evaluation of economic impact of robotization in disability care. Fundamental research methods applied: comparative structural analysis and synthesis, logical analysis of academic literature, practical construction method of theoretical perspective and modeling.

1. Recent research applications in disability: success, failure and preservation

Modern statistics refers, that one of six people in the European Union (around 80 million) (European Commission, 2011) or one of ten in globally has disability that ranges from mild to severe. Most state or local authorities incorporate disability issues into the development of social policy and create general obligations and measures. Taking this into account, most European countries are also called “… eliminate all obstacles to full participation in social life by disabled people and to educate public opinion to be receptive to the abilities of disabled people” (Official Journal C 186 of 02.07.1999). Historically, the response to disability was understood as social compensation like charity and mostly caring services what led to exclusion and under participation. But present position of most social actors and enthusiasts emphasize removing of barriers to so called equal opportunities in all spheres of life (World Program of Action concerning Disabled Persons). Analysis of strategic documents in the field allows to state, that most on them concentrate on: consolidation of cooperation between countries, development of social dialogue; contribution for non-governmental organizations working in the field of disability, strengthening the measures of unemployment prevention among the disabled, combat stereotypes, prejudices other practice towards the disabled. But present empirical studies allow concluding (Diamond & Sheshinski, 1995) that most of the initiatives fail to be implemented in practice. According to „American Disability and Data system”, disabilities still affect people in various ways and may differ from person to person (the elderly, pregnant women, temporary injured and etc.) in its perception as well thus they face enormous problems in their daily routine. In fact, “…disability is an evolving concept that results from the interaction between persons with impairments and attitudinal and environmental barriers that hinders their full and effective participation in society on an equal basis with others (“Convention on the Rights of Persons with Disabilities”). That means numerous cost-efficient methods have to be found in order to build accessible facilities to implement the fore mentioned goals, “EC
Guidance Note on Disability and Development” recognizes. The paper seeks one of modern methods – use of social and service (home) robots.

2. Potential of robotics invasion into daily environment: does it reach the disabled?

Primary introduction of robots for practical needs took place in automotive industry. The very term „robot“ (abbreviation R.U.R. – Rossum’s Universal Robots) was used in 1923 by Check writer K. Čapeks rand comes from the check word „robita“ that meaning „servitude, forced labor“. Since late 1960-ies robotic research contributed mostly to development of the systems that serve to the human in dangerous or unpleasant tasks (Forge & Blackman, 2010). Naturally over time the complexity of the tasks increased as well as the potential spheres of impact that robotics might perform. During last years „robotics has been aimed at finding solutions to the technical necessities, but because of changing societal environment the dominating emphasis was made on human necessities. Most authors agree that „creations of new needs and markets outside the traditional manufacturing robotic market inspired demand growth for service robots in different application areas (Garcia,2010).Japan Robotic Association, International Federation of Robotics report and forecast the growing market size of both – industrial and service robots within following categories: medical care, security, transport, industrial manufacturing, food processing, hazardous environments, agriculture, domestic service, professional service and toys (Shin’ichi, et al., 2006). However, future application scenarios of the former are not connected with the disability treatment. The crucial spectrum of the research concentrate on the barriers and social exclusion of the disabled in all aspects of a communities’ political, social, economic and cultural life or on the factors of disability cause (Ash, et al., 1997; Susinos, 2007; Ashworth, Bloxham & Pearce, 2010; Halld & Wilton, 2011; Agovino & Rapposelli, 2013 and etc.).The authors of the article consider that practical solutions must be offered and realized rather stating and discussing the aforementioned social phenomenon ant implications of its development. For the reason the service robots’ assistance and guidelines for the economic evaluation of the impact from macroeconomic position are core aspects of the following section of the paper.

3. Robotized care of the disabled: impact sprawl and economic substantiation

As it was mentioned in the previous sections of the paper, the disability as such might reveal itself as temporary or severe. In the first case various injures (car, domestic accidents, diseases, pregnancy and etc.) reduce person’s ability taking care of himself or herself and in certain cases require intensive care. According to America’s Census Bureau study, performed in 2012, one of five disabled people has severe disability. However, according to “UN conventions on the Rights of Persons with disabilities” the effect of disability also depends on what means are available to cope with it. Especially this concerns the situation in the developing countries, where more than four of five disabled people lack the devices and aids they need. The scope of the problem might be illustrated by the data provided by Centers for Medicare and Medical Services. Only the United States provide care for more than 2.4 million people annually (Alaiad & Zhou, 2014). The figures in EU vary, but according to several studies, severe disability rate seeks – 9.3 percent and two in five disabled persons aren’t getting basic needs (Barron, Mc Conkey & Mulvany, 2006). Naturally, “the family is still an important provider of care” (Bettio & Plantenga) 2004). Care here is understood as getting washes, dressing, cooking, leaving the house, providing medicine, communication and etc. All these activities require much of career’s time, efforts, affect their psychological and physiological health as well, reduce income, and put serious strains on the relationship, require additional costs incurred by the family (Ungerson, 1999; Rimerman, 2015and etc.). Furthermore, the paradigm of aging society and other demographic problems also raise additional questions related to the perspective to cope with the problem: the number of assistance requiring people constantly grows at the same time the number of the assistants (care takers) still diminishes. One of the key arguments of the authors of the paper – suggestion to employ semi or fully autonomous robots to perform different services: companion assistance, cleaning, personal rehabilitation, robotizes wheelchair, detection of obstacles and threat and etc. „Previous home robots research has focused on technology development, there has been little discussion on associate social, technical and managerial issues that are of equal importance of robot–success” (Alaiad&Zhou,2014).As it was mentioned in previous section of the paper, so called social, service home robots – is still emerging technology, Alaiad & Zhou (2014) emphasize. Wider interpretation of the functions is a growing
attention for these devices are discussed in the literature (Broekens, Heerink & Rosendal, 2009; Frank, et al, 2009 and etc.). Despite the fact that „<...>whereas about 50 publications were found in literature on ICT and robotics, most of these publications contain the results of studies that report positive effects of assistive social robots on health and psychological well-being” (Broekens, Heerink & Rosendal, 2009; Hegel, 2009; Henschke, Hobbs, & Wilkinson, 2012). In fact, most scientist working in this field, agree that the evidence indicating the scope and projection of the effects from economic point of view is still scarce. However, growing interest and field of the technology adoption requires understand the effects of its projection into socio-economic environment and functional instrument to aid users to identify the benefits and costs that might be obtained from certain implementation of new technology. The authors supporting the line conclude that reasoning the intervention of robots into the sphere of disability care must be also substantiated.

Generally, most researches are tended to project the impact of industrial robotization in economy through these subjects: labor market (unemployment growth because of automated jobs and created work places), firms (growth of productivity, improved quality and flexibility), consumers (growth of consumer utility, decreasing prices) introduction of new products, affecting spending patterns) and governments (efficiency of market outcomes, provision of public goods and enforcement). Though “their calculation vary widely depending on the methodology, jurisdiction, and data used” (Rimmerman, 2015), the greatest discussion in the wide public concerns the employment effects. Studies often report the calculation that testify negative effects of robot introduction into the labor market: job displacement remains several times greater than job creation. Furthermore the growth is detected (engineers) are highly skilled occupation and the decline in so called “blue-collar” and relatively low skilled occupations (welders, painters, machine operators, laborers) (Howell, 1985 and etc.). These arguments could be hardly neglected discussing the intervention of robots into the disability care sphere. The authors of the paper also tend to fasten the process but emphasize the problem of its efficiency: the lack of economic analysis framework specifically aimed at assessing the benefits of robotization not only stimulates the neglecting of the idea among the society members, is doomed to fail because stereotypes but also causes the slow rate of investment. To fill gap this paper offers the framework of economic analysis technique for evaluation economic impact – firstly projected in the labor market – of disabled care robotization. Several assumptions regarding the former:

- Governments sooner or later will be forced to introduce the home robots to the care markets, but prior to its intervention in resource allocation, precise calculations must be performed.
- Robotization of the disabled care is a costly project (see http://www.robotshop.com/eu/en/) firstly from macroeconomic point of view. The economic effect depends on the scale of use of the robots: massive production (supply) will lower the price of the item. But the cost of each also depends on the production complexity, so the variable also affects the cost and price of a single robot.
- The use of robots in the disabled care generates direct and indirect benefits: reduction of labor cost for the nursing people (in cases it relevant), improving quality and adequacy of the care itself, filling vacancies in robot constructing companies as well as service plants, that neglects assumption that robotization is one of the factors of unemployment growth in the low skilled occupations. Basing on Forge & Balckman (2010), it must be concluded that robot as such is a part of larger system. Several market segments, participating in the sector value creation might be mentioned: basic robot manufacture (research and development specialists, original robot designer and suppliers, prototype system integrators and testers, engineers of special components, software suppliers, marketing managers, deliverers and installation specialist) and integration into target application environment (target system design, target environment preparatory specialist, testers and correctors and etc.). All these positions in growing robot manufacturing sector must occupied even by these who would be displaced, but the proportions between the fired and newly employed (as the primary modeling results by the authors of former research show) benefit the former.
- The paper supports the arguments that the human nursing or assistance will never be absolutely substituted by robots because of cultural, religious and etc. perceptions, but the aging problem concerns the workers of the care sector as well. Furthermore, those who would be replaced by robots will be integrated in the commercial – or market – value creation chain which enhances productivity growth in national economy as well.

Supporting the position the conceptual framework of evaluation is presented (Fig. 1).
Cost and benefits relation of used robots in disabled care

$C_c$ refers to the cost of a service robot, which depends on the amount of the robot manufacturing quantity. The costs of the unit – the price of the experiential robot or so called prototype, and naturally is the highest. Equation (1) describes the dependences of robot manufacturing costs on the quantity produced. In the case of its growth the robot unit costs lower and at the production point $C_c'$ reaches possible minimum value which might be affected only by the employment of innovative technologies. $C_B$ represents the value added in the result of new job creation firstly in the robot service sector.

Formula (2) describes the economic benefits derived from the amount of robot maintenance sector. Increasing the amount this value monotonously approaches the position $A$ and does not grow further but only in the case if the network of robot maintenance network is complete and provides service for all robots exploited (under necessity). $C_R$ goes to the value added created the employees released by the robots form the disabled care sector by a linear dependence (3) directly linked to the quantity of robots.

$$C_c = R \cdot \exp(-N \cdot k_c) + C_{co}, \text{ when } N > 0, \text{ else } C_c = 0; \quad (1)$$

$$C_B = A \cdot (1 - \exp(-N \cdot k_B)); \quad (2)$$

$$C_R = k_R \cdot N; \quad (3)$$

here $C_c$ – cost of robot production, $R$ – unit costs, $N$ – numbers of the robots produced, $k_c$–complexity coefficient of construction and software, $C_{co}$ – costs of massive production.

$$C_B = A \cdot (1 - \exp(-N \cdot k_B)); \quad (2)$$

here $C_B$ – benefit of robot adaption, $A$ – value of saturation, $k_B$– complexity coefficient of production and service.

$$C_R = k_R \cdot N; \quad (3)$$

here $C_R$– costs of care per disabled person (in assistance of human).

Nonlinear inequality of the dependencies (4) represents the main but not the only effective condition of the technology adoption. When:

$$C_c < C_B + C_R, \quad (4)$$

robotic exploitation becomes economically efficient and feasible (Fig. 1, right side from E point).

The model integrates essential consideration – the equilibrium principle: the robotized disabled care system reaches economic equilibrium only in case when the subjects involved in the system take optimal solutions, gain maximum benefit and have no intentions to change their behavior.
Conclusions

The key arguments of the paper are that the lack of economic analysis techniques slow rate of investments if effective care of the disabled. The paper fills this gap by developing conceptual framework of evaluation of robot adoption in the disabled care using classic economic considerations of cost-benefit analysis but under certain assumptions: the use of robots in the disabled care generates direct and indirect benefits: reduction of labor cost for the nursing people (in cases it relevant), improving quality and adequacy of the care itself, filling vacancies in robot constructing companies as well as service plants, that neglects assumption that robotization is one of the factors of unemployment growth in the low skilled occupations.

The focus is made on society aging problems and prospectively growing labor demand: released care takers rs might be “in” the value creation as it is interpreted by the supporters of market economy.

The accuracy in the technology adoption what is recommended. Principal evaluation mechanism includes such variables as robot construction complexity, value of saturation and etc. in line of common cost (robot unit cost and cost of disabled care or nursing costs) and benefit (benefits of robot adoption) indicators remains a basis for further expansions and empirical test by further research.

References


World Programme of Action Concerning Disabled Persons. / http://www/un-documents.net/wpacdp.htm