The aggregate loss of GDP resulting from premature mortality: a methodological approach based on GDP decomposition at occupational level

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Abstract

This paper proposes a novel methodology to estimate the economic burden of premature mortality in the working population. The method is based on GDP (value added) decomposition at the occupational level. The approach estimates the loss of value added due to premature deaths in Slovenia by considering the productivity of individuals in different occupations. By integrating data on working individuals, causes of death, and company balance sheets, the results provide a decomposition of GDP losses across occupational groups. The results show significant differences in the value added lost between occupational groups, with professionals and technicians contributing most to the total loss. This approach provides an alternative estimate of economic losses compared to traditional methods, by accounting for the occupational contributions to GDP. However, the study also acknowledges limitations, such as uncertainties regarding future retirement ages and a relatively small sample size for certain occupations. This methodology provides valuable insights for policymakers about the importance of addressing the economic burden of premature mortality in the labour force.

Keywords

Premature mortality, productivity loss, economic burden, value added decomposition, occupational level

1 Introduction

Between 2009 and 2022 every year just over one thousand working-age population died on average in Slovenia, representing around 0.11 % of the 900 thousand employed population on average. In this period, the average age at death was 49.4 years and the individuals retired at the average age of 59 years [1]. Not reaching the average retirement age means that each individual lost on average 8 working years.

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Information Society 2024, 7–11 October 2024, Ljubljana, Slovenia

http://doi.org/DOI_RECEIVED_AFTER_REVIEW

The premature death (dying before the age of 65) not only represents a personal and family loss, but also represents a significant loss of human capital and consequently loss of productivity and GDP, amounting to the cumulative loss of value added reflecting the burden of premature mortality. The economic burden of premature mortality can be estimated at the microeconomic or macroeconomic level [2]. This paper proposes an alternative approach to estimating economic burden of premature mortality at the macroeconomic level.

Health economics assesses the economic cost of disease using various methods [2]. At the macroeconomic (societal) level the losses are both market losses (non-health consumption) and economic welfare losses (which consider not only the market, but also non-market losses). While market losses are usually estimated using general or partial equilibrium models (both simulation and regression based), the economic welfare losses are estimated using full-income models. WHO [2] systematically summarizes the approaches to estimating macroeconomic consequences of diseases as suggested and used in the literature.

The **Cost of Illness (CoI)** approach focuses on estimating the total economic burden of a specific disease by combining both direct and indirect costs [3], [4], [5]. Direct costs include medical expenses, treatment, and travel, while indirect costs account for lost productivity due to illness, absenteeism, or premature death. This method quantifies the overall economic burden of a disease on society, often expressed as a percentage of GDP. Despite its usefulness in providing a broad estimate of the financial burden, the CoI approach has limitations. It tends to oversimplify the broader economic effects by focusing primarily on medical expenditures and labor productivity losses, without fully capturing long-term effects such as capital depletion or changes in labor supply. Additionally, it may also not consider non-market impacts [2].

Regression-based models estimate the impact of health indicators, such as life expectancy or mortality, on economic output, typically GDP. The method uses econometric models to identify statistical relationships between health and economic outcomes, relying on historical or cross-country panel data. The key advantage of regression models is their simplicity and relatively low data requirements. However, endogeneity issues—where health and income are mutually influencing—can impact the results, and the models are sensitive to the specification of the production function [2].

Calibration models combine micro-level estimates of health impacts on income with macro-level data, such as GDP, demographic data, and workforce statistics, to simulate how health changes affect national economic output. The calibration approach allows for the decomposition of health impacts across countries or regions, providing flexibility in scenarios where data might be limited. However, calibration models are primarily sensitive to mortality impacts, while morbidity (illness) effects are more challenging to capture accurately.

Full-income models approach goes beyond traditional market-based evaluations by estimating both the monetary value of lost production and the value of lives lost due to illness. It uses techniques like the Value of Statistical Life (VSL) or Willingness to Pay (WTP) to quantify social welfare losses [6], [7]. Although full-income models capture the broader societal costs of illness, including non-market impacts, they involve contentious assumptions, such as discount rates and VSL, which can lead to extreme or difficult-to-interpret results [2].

We extend the existing methodologies by building on the **National Transfer Accounts (NTA) approach to the decomposition of value added** [8], which measures the economic impact due to premature death by assessing the reduction in GDP, in other words by estimating the loss of productivity. This implies calculating the contribution that the individuals would have made to the GDP, based on their specific sector and productivity levels. This productivity loss is then multiplied by the number of years the individual would have continued working. The total losses are then aggregated across to determine the overall impact on the economy [9].

2 Methodology and data

The methodology builds on the production loss approach due to premature mortality and the consequent loss of GDP. However, instead of estimating the loss of productivity using (sectoral) averages, we acknowledge that the actual productivity of companies is highly dependent on their human capital structure, which is the core of their intangible capital [10]. Intangible capital generates a large proportion of value added in a knowledge-led economy [11], [12]. Therefore, we assess the loss of value added by assessing the contribution of individuals via their occupation, which more accurately captures the actual loss of value added due to premature death.

The methodological analysis is based on several steps and originates from the production function of a company, focusing on the contribution of individual occupations or occupational groups to the created added value. First, employees were categorized into ten broad occupational groups according to the Standard Classification of Occupations, which aligns with the International Classification of Occupations. These broad occupational groups are: (0) military professions, (1) legislators, senior officials, managers, (2) professionals, (3) technicians and associate professionals, (4) clerks, (5) service workers, sales people, (6) agricultural, forestry, fishery, and hunting occupations, (7) non-industrial labor, (8) machine operators, industrial producers and assemblers, (9) elementary occupations. Analyses show that the contributions of different occupational groups to added value vary [10], [13], [14], [15], making it sensible to account for the actual structure of employees and their real contribution when calculating the loss of added value.

The productivity of employees, measured by value added per employee, is calculated by decomposing real added value at the company level for the period 2009-2022 to the level of different occupations. The decomposition of value added follows the NTA methodology [8], which uses regression without a constant to allocate aggregate variable values (e.g., household consumption) to individuals. Similarly, we regress firm's value added on the share of broad occupational groups. Beta coefficients are provided in the appendix (Table A1). The beta coefficients are then used to calculate weights for each occupational group using the following formula:

$$weight_i = \frac{\beta_i \cdot \sum x_i}{\sum_i^{10} \beta_i \cdot \sum x_i}$$

Where i represents each occupational group i∈(1,10), β is the calculated regression coefficient for each occupational group, and x is the number of employees in each occupational group. The added value per employee (VAEreal,i) according to the occupational profile is calculated using the following formula, where TOT_ VAEreal,i represents the total real added value of the company:

$$\text{VAE}_{\text{real},i} = \text{TOT\_ VAE}_{real} * weight_i$$

In the next step, we calculate the number and average age of individuals by occupational groups that died prematurely . Based on the actual retirement age during the observed period (an average of just 59 years), the number of lost productive years was calculated (by subtracting the retirement age and the age at death by occupational groups) and multiplied by the estimated added value of each occupational profile (VAEreal,i). By summing the lost added value due to lost productive years we estimate the economic burden due to premature mortality.

The analysis was prepared using micro-data from registries covering the period 2009–2022 [1]. The database integrates several different population data sources: (1) the Statistical registry of active population database for 2009–2022, containing data on between 838,000 and 998,000 individuals annually, with data on age, profession, and employment sector; (2) cause-of-death data for 2009–2022, providing the 4-digit death cause code and death date; (3) company balance sheet data for 2009-2022 period as well. The merged database of working individuals and companies was used for the decomposition of the value added by occupational groups, while the data on the number of deaths was used to estimate the loss of value added. Due to a small number of observations, military occupations were excluded.

3 Results

The analysis is based on a population of 12.7 million working individuals in Slovenia, averaging around 900,000 annually from 2009 to 2022. During this period, approximately 14,000 individuals from this group died, around 1,000 annually, representing 0.11% of all observed individuals [1].

Table 1 presents the data on the cumulative number of premature deaths among the employed population in Slovenia between 2009-2022. On average, the individuals died at the age of 49.4 years. Individuals generally retired at 59 years, but with some differences among occupational groups. For example, managers and professionals retired at an older age, whereas the employees in elementary occupations retired younger.

The loss of productive years, calculated as the difference between the average age at retirement and the average age at death, was highest in the group of professionals, who on average lost 9 years, and was lowest among skilled agricultural, fishery and forestry workers, where the loss was only 1 year on average.

Occupational decomposition of aggregate value added at firm level allowed us to estimate the average contribution of each occupation group to the value added, taking into consideration also their relative size. Using these estimates, and the data on the average number of premature deaths, average age at death and average age at retirement by occupational groups, the estimated loss of productive years was calculated (Table 1).

Table 1: The number of employed individuals' premature deaths, average age at death and retirement, loss of productive years of life, 2009-2022

	Number of deaths	Average age at death	Average age at retirement	Loss of productive years of life
0 Armed Forces Occupations	71	44.2	55.8	11.6
1 Managers	698	53.4	61.2	7.8
2 Professionals	1,678	52.3	61.3	9.0
3Technicians and Associate Professionals	1,828	51.2	59.2	8.0
4 Clerical Support Workers	966	50.2	58.3	8.1
5 Service and Sales Workers	1,476	49.8	57.9	8.1
6 Skilled Agricultural, Forestry, Fishery Workers	836	57.1	58.2	1.0
7 Craft and Related Trades Workers	2,573	49.9	58.7	8.8
8 Plant, Machine Operators, Assemblers	1,571	50.0	58.0	8.0
9 Elementary Occupations	1,562	49.8	57.8	8.0
Total	13,259	49.4	59.0	9.6

Data: [1], own calculations.

The occupational group of professionals contributed the most to the total number of lost productive years (28%) due to the highest number of premature deaths in this occupational group. This was followed by technicians and associate professionals, where the average loss of years was also high and the relative group size was even larger. This group contributed around a fifth to all years lost.

Figure 1 presents data on the contribution of each occupational group to the total value added lost due to premature deaths. Professionals contributed most, around a fifth of all lost value added. Followed by technicians and plant and machine operators.

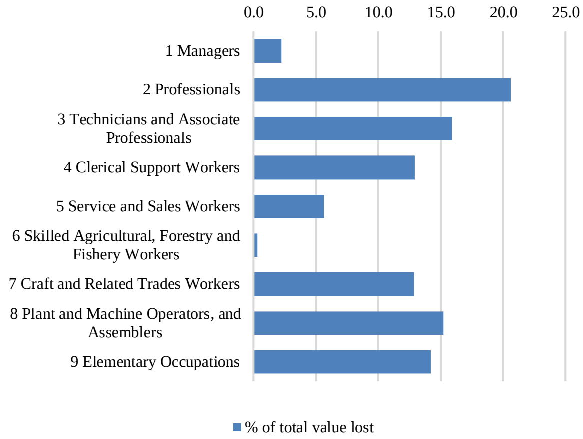

Figure 2: The contribution of occupations to total value added lost (in % of all value added lost)

4 Discussion and conclusion

This study offers a novel approach to estimating the economic burden of premature mortality in Slovenia by focusing on the loss of added value and, consequently, the potential loss in GDP. Unlike traditional approaches that might rely on aggregate data or income loss models, this study employs a more detailed decomposition method based on the added value generated by companies, the occupational structure, and the premature mortality rates. This approach allows for a more precise estimation of the economic burden by considering the specific contributions to value added of different occupational groups, which vary significantly in their productivity and value addition in the economy.

One of the key strengths of this methodology is its reliance on microdata, which provides a granular view of the economic burden of premature mortality at the level of individual occupational groups. By using data from multiple sources, including the registry of the active workforce, mortality data, and company financial statements, the study achieves a high level of specificity. This level of detail is crucial, as it acknowledges the varied impact of premature deaths across different sectors and occupations, which is often overlooked in broader, less nuanced analyses.

However, the study also has limitations that need to be considered. One significant limitation is the inability to accurately predict future retirement ages, especially given the trend of increasing retirement ages in Slovenia and elsewhere. This introduces a potential underestimation of the economic loss, as individuals might work longer in the future than currently assumed in the model. Additionally, the relatively small sample size of premature deaths within certain occupational groups may affect the robustness of the results, and the absence of control for other risk factors may also skew the findings. This also implies that the actual figures could be larger. Furthermore, while the study introduces an alternative methodology, the approach may benefit from further refinement, particularly in the decomposition method, which could explore other models, such as the log-log model.

While the proposed methodology offers a detailed and occupation-specific approach to assessing the economic burden of premature deaths, its applicability may be limited by certain assumptions and data constraints. Future research could enhance this model by incorporating more dynamic elements, such as evolving retirement patterns, changing productivity levels and broader demographic trends, to provide a more comprehensive picture of the economic impact of premature mortality. Despite these limitations, the study contributes significantly to the literature by offering a more nuanced understanding of the economic costs associated with premature mortality, which could inform both policy decisions and future research directions.

Acknowledgments

This work was partially financed by ARIS projects: projects P5-0128, P5-0441, J5-4575, J5-4540, P5-0117.

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