ESSAYS ON MEASURING AND VALUING PRODUCTIVITY LOSS DUE TO POOR HEALTH

by

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Abstract

Traditionally, productivity loss has been measured according to illness-related absence from work (absenteeism) only. However, there is increasing evidence that presenteeism (reduced intensity and/or quality of labour input) is an even greater source of productivity losses. In addition to empirical measurement issues, there are theoretical issues with regard to productivity valuation. The traditional human capital method assumes that the value of productivity loss to society should be measured as the present values of lost time according to the wage, which is supposed to be equal to the marginal productivity of labour in a competitive labour market. The alternative, friction cost method, is based on the same assumption except that it adjusts for unemployment. However, these methods ignore the effects of risk aversion and team production which cause the wage to be lower than the marginal productivity. Existing productivity questionnaires did not capture sufficient information to enable the proper measurement and valuation of productivity loss from a societal perspective. A new questionnaire, Valuation of Lost Productivity (VOLP), was developed to capture all the time input loss components (absenteeism, presenteeism, employment status changes, and unpaid work productivity loss) as well as information on job and workplace characteristics, based on which wage multipliers can be calculated to value the productivity loss attributable to the reduced time input of workers. The thesis provides evidence for the validity of the VOLP in measuring time input loss due to poor health and its feasibility in evaluating the treatment effect on productivity in people with rheumatoid arthritis. The equality between wage and marginal productivity was tested using the Workplace and Employ Survey, a linked employer-employee database in Canada. Some evidence suggests that team workers are underpaid compared with their relatively higher

productivity. In small firms, higher absenteeism results in lower productivity and wage, and the marginal productivity loss with respect to team worker absenteeism is higher than the wage loss. Furthermore, for team workers, health-related frequent reduction at work results in lower productivity and the resulted productivity loss is more than the wage differentials.

Preface

This statement is to certify that the work in this thesis was conceived, conducted and written by Wei Zhang (WZ). Each research chapter of this dissertation (Chapters 2-6) was written as a stand-alone manuscript for publication in the peer-reviewed academic literature. Three have already been published (Chapters 2-4). As the primary author, WZ led each of these chapters. The ethics approval was granted by the UBC Behavioural Research Ethics Board and the Certificate Numbers of the Ethics Certificate were H08-00589 and H13-00894.

Chapters 1 and 2

Part of Chapter 1 and a version of Chapter 2 have been published. Zhang W, Bansback N, Anis AH. Measuring and valuing productivity loss due to poor health: A critical review. Social Science & Medicine. 2011;72:185-92. WZ conducted all the literature reviews, provided major suggestions addressing the existing measurement and valuation issues, drafted the manuscript, and finalized the manuscript. Dr. Anis and Dr. Bansback provided conceptual guidance and critiques and edited the manuscript.

Chapter 3

A version of Chapter 3 has been published. Zhang W, Bansback N, Boonen A, Severens JL, Anis AH. Development of a composite questionnaire, the Valuation Of Lost Productivity (VOLP), to value productivity losses: application in rheumatoid arthritis. Value in Health. 2012;15:46-54. WZ developed the new questionnaire, the VOLP, generated the algorithm to calculate wage multipliers based on the VOLP, developed the design of the study, conducted all the analyses, interpreted the results, and wrote the final manuscript. Dr. Anis and Dr. Bansback provided valuable advice in the questionnaire development and participated in designing the study, interviewing the focus group and editing the manuscript. Dr. Boonen and Dr. Severens suggested taking the compensation mechanism into account when generating wage multipliers and edited the manuscript.

Chapter 4

A version of Chapter 4 has been published. Zhang W, Bansback N, Kopec J, Anis A. Measuring time input loss among patients with rheumatoid arthritis: validity and reliability of the Valuation of Lost Productivity questionnaire. Journal of Occupational and Environmental Medicine. 2011;53:530-6. WZ was responsible for the study design, performing the statistical analyses, interpreting the results, writing the manuscript, and revising the manuscript. Dr. Kopec provided valuable advice on analysis and edited the manuscript. Dr. Anis and Dr. Bansback participated in designing the study and editing the manuscript.

Chapter 5

WZ developed the hypotheses, analysis plans, performed the analyses and drafted and wrote the final manuscripts. Dr. Huiying Sun assisted in statistical analyses, and Dr. Anis and Dr. Bansback reviewed and edited the manuscripts.

Chapters 6 and 7

WZ was entirely responsible for the work in Chapters 6 and 7. WZ developed the hypotheses, generated the economic models based on literatures, performed all econometric analyses, and wrote the final manuscripts. Dr. Anis and Dr. Woodcock provided conceptual guidance and critiques and edited the manuscripts.

Check the first pages of chapters 1, 2, 3 and 4 to see footnotes with similar information.

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List of Abbreviations

ACR	American College of Rheumatology
ADL	Activities of Daily Living
BIC	Bayesian Information Criterion
DAS28	Disease Activity Score based on a 28-joint count
DMARDs	Disease-Modifying Antirheumatic Drugs
EQ-5D	EuroQol-5 Dimensions
ERAN	Early Rheumatoid Arthritis Network
ETN	Etanercept
FACIT	Functional Assessment of Chronic Illness Therapy
FC	Friction Cost
HAQ	Health Assessment Questionnaire
HC	Human Capital
HLQ	Health and Labour Questionnaire
ICC	Intraclass Correlation Coefficient
ICER	Incremental Cost-Effectiveness Ratio
IV	Instrumental Variable
LOCF	Last Observation Carried Forward
MDHAQ	Multidimensional Health Assessment Questionnaire
MTX	Methotrexate
NHS	National Health Service
NLS	Nonlinear Least Squares
NSAIDS	Non-Steroidal Anti-Inflammatory Drugs
PASS	Patient Acceptable Symptom State
PGA	Patient Global Assessment of disease activity
PRODISQ	PROductivity and DISease Questionnaire
QALY	Quality Adjusted Life Year
QOL	Quality of Life
QQ	Quantity and Quality instrument
RA	Rheumatoid Arthritis
RCT	Randomized Controlled Trial
SF-36	Short Form-36
UK	The United Kingdom
US	The United States
VAS	Visual Analogue Scale

VOLP	Valuation Of Lost Productivity questionnaire
WALS	Workplace Activity Limitations Scale
WES	Workplace and Employee Survey
WIS	Work Instability Scale
WLQ	Work Limitations Questionnaire
WPAI	Work Productivity and Activity Impairment Questionnaire
WPS-RA	Rheumatoid Arthritis-specific Work Productivity Survey
ZINB	Zero-Inflated Negative Binomial model

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This research project would not have been possible without the support of many people. First and foremost, I would like to thank my supervisor Dr. Aslam Anis. I am sincerely grateful to Dr. Anis for your dedicated guidance, support, encouragement, and belief. In addition to the support for my thesis research, Dr. Anis provided excellent research opportunities to develop my ideas, skills and experiences. I would also like to thank my thesis committee members, Dr. Jacek Kopec, Dr. Linda Li, and Dr. Simon Woodcock for your invaluable input and mentorship. Without your knowledge and assistance this thesis would not have been successful.

I offer my enduring gratitude to my colleagues who shared the time and knowledge with me at the Centre for Health Evaluation and Outcome Sciences. To Dr. Nick Bansback, whose collaboration and knowledge was invaluable in making this research both possible and useful. To Dr. Huiying Sun who was always available and willing to discuss methods, and who provided coherent answers to my endless questions. To Daphne Guh whose capacity for insight and penetrating thoughts taught me to question and think more deeply.

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Thank you to my friends and family who have expressed endless confidence in me. To my parents who have supported me throughout my years of education, both morally and financially. Without your support, I would not come to Canada and get good education. To my parents in-law who helped taking care of my baby girl so that I could devote time to my thesis. Special thanks are owed to my husband Bin for your love, support, and patience. Finally to my little Caitlin who brings laughter and joy into my life.

Dedication

To Bin and Caitlin

Chapter 1: Introduction[1]

1.1 Cost-of-illness studies and economic evaluations

In cost-of-illness studies, the economic burden of illness is estimated by both direct and indirect costs from a societal perspective. Direct costs consist of direct medical spending, such as physician visits and hospitalization, and direct nonmedical spending including transportation costs, the cost of home and automobile modifications and the value of informal caregiving.[1] Indirect costs are now widely referred to as productivity loss resulting from increased morbidity or early mortality.[2,3] Productivity loss represents a large share of the full economic burden of illness and can exceed the direct costs of medical care for some diseases such as cancer, depression, substance abuse, injuries and arthritis.[1,4] For example, in 2000, the societal economic costs of arthritis in Canada were estimated at over $6.4 billion with two thirds of these costs attributable to productivity loss resulting from early mortality and long-term disability.[5] The annual economic costs of illness-related absence and unemployment in the United Kingdom (UK) were estimated to be £100 billion a year, which is greater than the annual budget for the National Health Service (NHS), the publicly funded healthcare system in the UK.[6] Economic burden of illness is a measure that policy makers often use to describe the impact of disease on a population, highlight the need for disease prevention services and set priorities for resource allocation.[1]

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[1] Part of chapter 1 has been published in Zhang W, Bansback N, Anis AH. Measuring and valuing productivity loss due to poor health: A critical review. Social Science & Medicine. 2011;72:185-92.

In addition to cost-of-illness studies, productivity loss is considered in economic evaluations of health care interventions. Economic evaluations are defined as "the comparative analysis of alternative courses of action in terms of both their costs and consequences".[2] Cost-utility analysis is one popular and predominant type of economic evaluation, where costs are expressed in monetary terms but the consequences are expressed in quality adjusted life years (QALYs). The QALY is a generic outcome measure that adjusts the length of life by quality-adjustment weights.[2] The weights for health states are based on preference for the health states and anchored at perfect health and death. The convenient scale for the weights is from 0 (death) to 1 (perfect health). Weights assigned to states worse than death would be negative. To calculate the number of QALYs, the time in each health state is first multiplied by the weights for the state and then summed up. The results of cost-utility analysis are usually expressed as incremental cost-effectiveness ratio (ICER), i.e., the ratio of the change in costs to change in QALYs of a new intervention. Although both cost-of-illness and economic evaluation studies are useful to decision-makers in priority-setting, economic evaluation studies include a comparative analysis. Economic evaluation studies are therefore routinely used to determine the eligibility of a new health technology for coverage under health insurance plans.

1.2 Inclusion of productivity loss

Given that productivity loss may equal or exceed the direct costs of illness, there is a strong argument in favour of including valuations of productivity loss in a range of economic evaluations in health. However, there is considerable skepticism about considering productivity loss in economic evaluations. Their inclusion in economic evaluations is viewed as a tactic to improve the cost-effectiveness of interventions from a societal perspective. Some are of the opinion that their inclusion in cost-utility analysis results in double counting, while others raise concerns over the issues of equity, perspective, valuation methods, etc. to argue against the inclusion of productivity loss in economic evaluations.[2,3]

In the cost-utility analysis of a health intervention, if the value of productivity gains is captured by the estimated value of improved health, i.e., QALYs, then the productivity gains should not be included in the numerator of the ICER.[2,3] Otherwise, the productivity gains would be double counted. The quality-adjustment weights for health states are usually valued through a survey in a representative sample from a general population by different methods including visual analogue scale, standard gambling, time trade-off, and discrete choices. Whether productivity loss should be captured as costs or in terms of QALYS depends on whether responders to valuation surveys consider income effects and if so, how this affects the weight valuations of health states. To avoid double counting, health economists suggested asking responders to assume no health care costs or income loss as a result of illness while assessing health state valuations.[2,7,8] However, recent empirical studies[9,10] showed that a few responders included income effects when not instructed not to do so but the income effects did not significantly affect health state valuations, i.e., the quality-adjustment weights. Based on the evidence, it was suggested that productivity loss should be captured as costs alongside the QALYs in economic evaluations.[9,10]

The inclusion of productivity loss also raises equity concerns, i.e., patient groups who earn high incomes would have more potential for productivity gains and be given priority over patient groups who are unlikely to be in employment such as patients with mental illness or people who are retired.[2,3,11,12] On the other hand, from a resource allocation perspective the exclusion of productivity loss disadvantages patients with conditions of which indirect costs are substantial. To balance efficiency with equity, it was suggested that productivity loss should be first expressed in quantities such as the number of lost work days or hours and then valued as a monetary amount.[2,8] In addition, a sensitivity analysis should be conducted using more equitable estimates such as a general wage rate to value productivity changes while the base case analysis is conducted using the actual wages of the study participants.

Although a societal perspective (i.e., considering all the costs and consequences of health care for all affected groups and individuals) is preferred for economic evaluations, different perspectives, especially a health care budget perspective, are often adopted.[2,7,13] Among health economists, there is already consensus that the societal perspective should be taken when measuring health benefits. Accordingly, cost-utility analyses use QALYs to value health benefits, a measure which takes into account societal valuations of the burden of specific illnesses. It follows that the societal perspective should be taken not only when valuing health benefits, but when quantifying the cost of illness.[13] To decision-makers evaluating a new health technology, both the potential health benefits of the technology and the current cost of the illness are important; if decision-makers are to make evaluations in the best interest of society, estimates of the cost of illness should include productivity loss. Furthermore, estimating productivity loss functions to identify the illnesses that most frequently cause unemployment, which is a potential cause of future ill health as well as poverty.[6] Excluding productivity loss from cost estimates, decision-makers may not recognize and support emerging health technologies that largely reduce productivity loss and result in significant cost-savings. It has been recommended that productivity loss should be presented separately from health care costs to give the decision makers explicit information about the impact of different assumptions on the result.[2,7,8]

1.3 Empirical evidence on inclusion of productivity loss

1.3.1 National guidelines

Alongside the theoretical debate over whether to include productivity loss, many countries also provided guidance on its inclusion/exclusion in their guidelines for conducting economic evaluations.[14] The guidance on the inclusion/exclusion of productivity loss was closely tied to guidance on the appropriate choice of "perspective" for an analysis. After reviewing guidelines from 28 countries, Zhang et al.[15] found that 17 countries took a societal perspective but only 12 required productivity loss to be included in the main analysis or the base case analysis. England, Wales, New Zealand and South Africa did not want productivity loss to be included at all. Guidelines from the National Institute for Health and Clinical Excellence in England and Wales stated, "productivity costs and costs borne by patients and carers that are not reimbursed by the NHS or PSS [Personal Social Services] are not included in either the reference-case or non-reference-case analyses".[16] Productivity costs may be included only "in exceptional circumstances", i.e., "if this has been specifically agreed with the Department of Health, usually before referral of the topic".[16] New Zealand stated "indirect patient costs [should] be incorporated in the QALY estimates through the utility values".[17] The rest of countries preferred to adopt a narrower perspective and recommended productivity loss to only be included in the sensitivity or separate analysis. Even though most countries allow the inclusion of productivity loss, there was relatively little specific guidance around the types of productivity loss to be included.

1.3.2 The impact of including productivity loss in economic evaluations

Accounting for productivity loss has a significant influence on determinations of cost-effectiveness of a new intervention. For example, in an economic evaluation of a family medicine-based asthma self-management program, when the cost of productivity loss was included, the self-management program was more effective and less costly than usual care under Dutch asthma treatment guidelines.[18] When the cost of productivity loss was ignored, the asthma self-management program was no longer recognized as cost-saving. In a cost-effectiveness analysis of treatments for early rheumatoid arthritis, considering productivity loss changed the most expensive treatment strategy from being 'not cost-effective' to being 'cost-saving'.[19]

Krol et al. reviewed economic evaluations of treatments for adults with depressive disorders and found that 69% of evaluations ignored productivity costs.[20] For those 30 studies that included productivity costs, the costs accounted for 60% of total costs per treatment arm. The impact of inclusion of productivity costs on incremental costs between treatment arms was in both directions. The incremental costs decreased in 43 cases, increased in 16 cases and remained the same in 2 cases. In some cases, the absolute differences between incremental costs with and without productivity costs could be over 2000 euros. In another review by Krol et al.[21] on 249 economic evaluations of very expensive drugs, only 9% were found to include productivity costs. After inclusion of productivity costs, ICERs increased in 6 out of 36 cases and decreased in 30 cases. New treatment changed from cost-spending to cost-saving in 6 cases and an opposite change was found in 4 cases. Thus, economic evaluations that incorporate estimates of productivity loss are useful in identifying interventions with a potentially broad impact on health. Productivity loss should be included in economic evaluations at least as a separate analysis.

1.4 Research questions

In this thesis, I do not attempt to address the current issues with regard to inclusion/exclusion of productivity loss in economic evaluations. Instead, I believe that productivity loss should first be measured as comprehensively as possible and then be included/excluded according to the needs of the decision makers. Despite the recommendations made on how to report productivity loss, there is still lack of detailed methodological guidance on how it should be measured and valued. This thesis is aimed to develop methods to measure and value work productivity loss as a result of morbidity based on economic theory. The specific research questions addressed in the thesis are:

1. What are the current limitations and issues on measurement and valuation of productivity loss and how to address them?
2. Is a new questionnaire needed to measure and value productivity loss? If so, what should it capture? Is the questionnaire demonstrated to be valid and reliable to measure and value productivity loss and applicable to measure the treatment impact on productivity in an empirical study?
3. Is wage a good proxy to represent the value of productivity loss? If not, how to adjust wage to represent the value of productivity loss?

1.5 Outline of the thesis

The research chapters of this thesis are designed to be used for publication elsewhere. As such, each chapter is a separate article and some overlap and repetition exists between some of the chapters. Chapter 2 provides a critical literature review on measuring and valuing work productivity. Specifically, this chapter introduces the concept of productivity, reviews current valuation methods of productivity loss and the related issues, considers the ramifications of loss in both paid and unpaid work productivity, and addresses current controversies with regard to the measurement of productivity loss.

Chapters 3, 4 and 5 describe the development process and validation of a new questionnaire. Specifically, a new questionnaire is developed to measure productivity loss to address existing measurement limitations (Chapter 3). Its validity and test-retest reliability is investigated and its feasibility of generating multipliers which inflate wage to represent value of productivity loss is also tested (Chapter 4). In an empirical study, the new questionnaire is applied in a clinical trial to measure treatment effect on work productivity over one-year period (Chapter 5).

In chapters 6 and 7, the impacts of employees' work absence and reduction at work on their employer's output and payroll are examined using an employer-employee linked database respectively. The null hypothesis that wage equals marginal productivity is tested for both work absence and reduction at work.

Chapter 8 serves to integrate the analyses and results of the previous chapters, comment on the strengths and limitations of the research, conclude the overall significance and contribution, and discuss potential applications of the research findings.

Productivity loss should be considered to better understand the burden of illness or the benefits of a new health care intervention. There are flaws in prior methods to measure the economic impact of work loss as well as productivity reduction among employed persons. This thesis develops more rigorous methods to value productivity losses or gains from an economic perspective.

Chapter 2: Measuring and valuing productivity loss due to poor health: A critical review[2]

The objective of this chapter is to conduct a critical review attempting to provide some guidelines on how to measure and value productivity loss due to poor health. I begin with introducing the concepts of productivity and productivity loss and distinguishing between labour as an input and its impact on the final output of the firm.

2.1 Productivity and productivity loss

According to neoclassical economic theory, the concept of productivity is based on the production function, where output is a function of capital input, labour input and technology allowing for substitution between different types of inputs. Productivity is a measure of output per unit of input.[22] The term marginal productivity of an input refers to the extra output produced by one extra unit of that input. In calculating productivity loss due to poor health, only loss of labour input is relevant, as only labour input is directly affected by health problems. Labour input reflects the quantity (e.g., time) and quality (e.g., effort and skills) of the work force. In the context of this thesis, productivity loss refers to the output loss corresponding to the reduced labour input due to poor health.

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[2] A version of chapter 2 has been published. Zhang W, Bansback N, Anis AH. Measuring and valuing productivity loss due to poor health: A critical review. Social Science & Medicine. 2011;72:185-92.

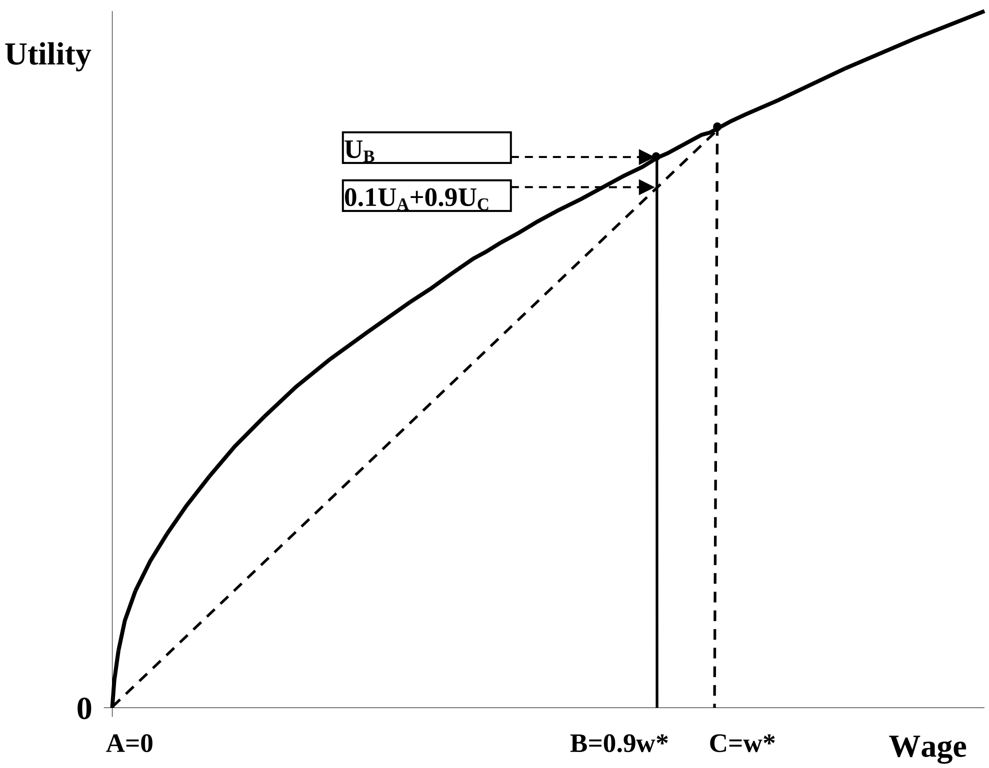
2.2 Valuation of productivity loss

2.2.1 Paid work

According to the above definition of productivity loss, to value productivity loss is to value the output loss. There are two main valuation methods for productivity loss among the employed. The human capital (HC) approach treats human beings as assets and values life and health as lost production to the economy.[23,24] It assumes that the value to society of productivity loss should be measured as the present value of lost time according to the wage rate, which is supposed to equal the marginal productivity of labour in a competitive labour market. That is, a maximizing firm will keep hiring workers until the marginal productivity is equal to the wage rate. While the Friction Cost method has been suggested as an alternative to the HC approach, it is really a refinement of the HC approach in that it attempts to adjust for worker replacement in a friction period and considers additional replacement costs. The proponents argue that when someone is away from work, productivity falls only for a limited time period until a substitute worker replaces the absent worker and production loss is minimized.[25]

Both methods above use the market wage rate as the proxy value of marginal output loss at the firm level. However, observed wage may not equal marginal productivity for many reasons. Putting aside instances of imperfect labour markets where the wage may reflect inequities such as race or gender discrimination or employer/employee market power, allowances for sick days and risk aversion of workers will compel them to accept a wage rate that is below their marginal productivity.[26] Simply stated, the market wage rate is less than the value of a worker's marginal productivity primarily due to the existence of risk aversion and unpredictability of sick days. In a perfectly competitive market, where the firm is a price taker in both the product and factor markets, profit maximizing employment is achieved where the wage rate equals marginal productivity, i.e., where the marginal cost of employing labour equals the marginal revenue to be gained from employing labour.[27] If no sick leave occurs, employers will pay employees a wage rate of w*, which is equal to marginal productivity of labour (w*= marginal productivity). When illness occurs, an absent employee will not receive any wages. Therefore, in the absence of a fixed employment contract, employees face a gamble of receiving a wage of 0 or w*. As shown in Figure 2.1, the utility of a fixed wage is higher than the expected value of the gamble. Employers therefore are able to offer employees a wage $w<w^*$ i.e., $w=w^*\times(E-a)/E$, where a is some predicted number of sick days and E is assumed total annual workdays in a fixed employment contract.[26] For example, when a is predicted at 26 days and E is 260 days (52 weeks×5 days per week), there are 3 options, A, B, C, on a wage as valued at 0, 0.9w*, and w*. Employees would prefer option B for sure to a 10/90 gamble of receiving A or C, i.e., $U_B>(0.1U_A+0.9U_C)$.

Figure 2.1. Risk aversion with respect to uncertain wages



Furthermore, the divergence between the observed wage rate and marginal productivity of workers can be accentuated if a job type involves team production, unavailability of perfect substitutes, and/or time-sensitivity of output.[26,28,29] Therefore, when an employee is absent from work, the actual productivity loss will exceed his or her wage if a substitute can not be found or the hired substitute is less productive or costs more AND if team work is involved and/or penalties occur for failure to achieve the targeted output levels. For example, it is hard to replace a cardiac surgeon because of their specialized training. The absence of the surgeon from a pre-scheduled surgery will idle the entire surgical team including nurses and the anesthetist. The productivity loss attributable to the surgeon's absence will certainly not be his or her wage alone but the value of the entire team's output. Similarly, in a firm where output is highly time sensitive, i.e., losing the customers if delivery schedules are delayed or deadline is missed, the absence of a worker will have a ripple effect and will certainly have a value much greater than his or her wage if a perfect substitute is not available.

To better value productivity loss, we need to consider whether wages adequately reflect the value of production at the margin. It requires a dataset linking employees' labour input to their employer's output. However, it is impractical and costly to set up such a dataset for each single economic evaluation study. Furthermore, in the context of clinical studies, a restriction imposed by guidelines for the ethical conduct of clinical trials is that individual level data on trial participants cannot be linked to their workplace data. Pauly et al. suggest that managers be in a much better position than employees to assess the impact of health problems on productivity because they think of output not input.[28,29] But still it is hard to recruit both participants and their managers in clinical trials due to the ethical concerns. In practice, it will be much more useful if multipliers adjusting wage to the marginal productivity can be generated for different job types and workplace characteristics. Indeed, it is easy for studies to collect information on wage, job and workplace characteristics.

2.2.2 Unpaid work

Innovations have been made in the application of the HC approach to impute value, shadow prices, for unpaid work activities such as household work, shopping, and childcare.[2] The loss of ability to do these unpaid work activities needs to be evaluated within the context of overall output changes at the societal level. There are two main methods valuing unpaid work productivity loss. Opportunity costs of the lost time spent on unpaid work activities are an individual's benefits forgone.[2] The value of productivity loss due to health is generally estimated according to the individual's market wage rate forgone. However, it is difficult to impute a value for those not in paid employment. A practical way is to use a general average wage or an average wage of people with the same age, gender and education as a proxy. The other method is the replacement cost approach which measures the value of the output produced by an equivalent market service.[2] Productivity is thus valued according to the wage rate for a market substitute, for example, a worker employed in childcare or home support sector.

2.3 Components of labour input loss

In order to value paid work productivity loss, we need to measure the effective amount of labour input loss to value the corresponding output loss. To capture the net impact of reduced labour input due to illness, a distinction is made between labour input loss due to presenteeism, absenteeism, and employment status changes including reducing routine working time, job loss (permanent or temporary), and early retirement. Presenteeism refers to the reduced intensity and/or quality of labour input due to health problems while working. Recent studies have shown presenteeism accounts for the largest component of total productivity losses for certain diseases[30–33] and thus it should not be ignored in measurement. Absenteeism commonly refers to the number of missed workdays for employed people. However, sometime, the concept of absenteeism can be extended to cover the labour input loss attributable to employment status changes.[34] Therefore, a broader concept of absenteeism can be used to refer to the number of days an individual is not able to be at work due to health problems. No matter which concept of absenteeism is used, it is preferable to measure and describe all the components separately.

Unpaid work activities usually include household work, shopping, childcare, odd jobs and chores around house and volunteer activities.[35,36] Compared with paid work, the time spent on unpaid work is more variable. It is hard for an individual especially with a chronic disease to remember how much time he or she spent on unpaid work activities when healthy, which is a variable required to calculate labour input loss for unpaid work due to health problems. Instead of measuring the variable, we can compare time spent on unpaid work by patient groups with time spent by the general population or by a control group matched for age, gender and working status. Data for the general population can be found easily from national time use surveys. It is also suggested that only the substitution effects of paid and/or unpaid help for unpaid work should be considered for valuing unpaid work productivity loss.[35–37] This is based on the assumption that if an individual performs the unpaid work in person, costs are saved that would otherwise incur for hiring a market substitute that offers an equivalent service. This also implies that some unpaid work activities are not urgent and can be done later without any significant output loss. On the other hand, some unpaid work activities must be done and the output of unpaid work will be lost if nobody takes it over. In this case, a paid or unpaid help has to be found if an individual is not able to perform the unpaid work him or herself. Nevertheless, from a societal perspective there is still a cost associated with lost unpaid work time if an individual loses leisure time to make up the work later. Therefore, there will be a loss even when a paid worker does not take over the unpaid work. Alternatively stated, from the perspective of economic theory, assuming efficient labour markets, whether one loses leisure time or time to perform unpaid work due to poor health, the productivity losses are equivalent. Therefore, three main components should be measured: 1) how much time individuals spend on unpaid work; 2) how much unpaid work is taken over; 3) how much leisure time individuals lose to do unpaid work they could not complete previously due to their health problems.

While we have introduced above several dimensions to comprehensively measure labour input loss due to illness, these dimensions are not additive. A number of important trade-offs exists:

2.3.1 Absenteeism versus presenteeism

A simple depiction of the relationship between absenteeism and presenteeism can be represented by the equation, $P=(E–A)\times p$, where P is lost workdays due to presenteeism, E is total annual workdays in a fixed employment contract, A is the broader concept of absenteeism which includes losses due to employment status changes, and p is the percent of labour input loss while working. Please note that a health condition may only affect a person's labour input on some, but not all, days. We assume this is built into "p" and thus "p" represents the average impact of the health condition. As the equation shows, the larger A is, the smaller P will be and there is a trade-off between A and P. Given a certain p, a one unit increase in A is traded off by a decrease of p in P and the total paid work productivity loss (T), the sum of P and A, will increase by 1-p. The solid black line in Figure 2.2a presents an example of the trade-off implicit in the equation of the relationship between A and P. When p is 30% and A increases from 60 days to 110 days, P decreases from 60 days to 45 days and T increases from 120 days to 155 days. The decrease of P is 15 days, which is equal to the increase in A (50 days) multiplied by 30% and the increase of T is 35 days, which is calculated by the increase of A multiplied by 1-p. When p increases from 30% to 50% and A increases from 60 days to 110 days, the changes of P and T are partially due to the trade-off between A and P and partially due to the increase of p (Figure 2.2b). That is, P

increases from 60 days to 75 days, where a 15-day decrease of *P* is due to the trade-off between *A* and *P* shown Figure 2.2a and a 30-day increase of *P* is due to the 20% increase of *p*.

2.3.2 Paid work, unpaid work versus leisure

There exists a trade-off between paid work, unpaid work and leisure. If we assume that a person needs about *m* hours per day for personal care (including sleep), then a maximum of 24 - *m* hours per day can be allocated to paid work, unpaid work and/or leisure. Depending on individual preference and the wage rate, a person will decide on how much time he or she spends on each type of activity. If the time spent on paid work is fixed, then the more time spent on unpaid work and the less is the time for leisure; if the time for unpaid work is fixed, the more time for paid work and the less is the time for leisure. For example, if paid workers have to work extra time which would otherwise be their leisure time or time for unpaid work, there is a cost to society that is equal to the value of sacrificed leisure, unpaid work or effort. This at the margin can be assumed to be equal to the workers' wage rate but is likely to be greater (which is why overtime is paid at a higher rate).

Figure 2.2. Trade-off between absenteeism and lost work days due to presenteeism

A: absenteeism; *P*: lost workdays due to presenteeism; *p* is % work productivity loss at work; T: total work productivity loss (*A* + *P*). Assume total number of annual workdays is 52 weeks×5 days per week = 260. Solid line represents *P*=(260–*A*)×*p*; Dash red skewed line and dash blue skewed line are contour lines of total work productivity loss at T1 level and T2 level, respectively.

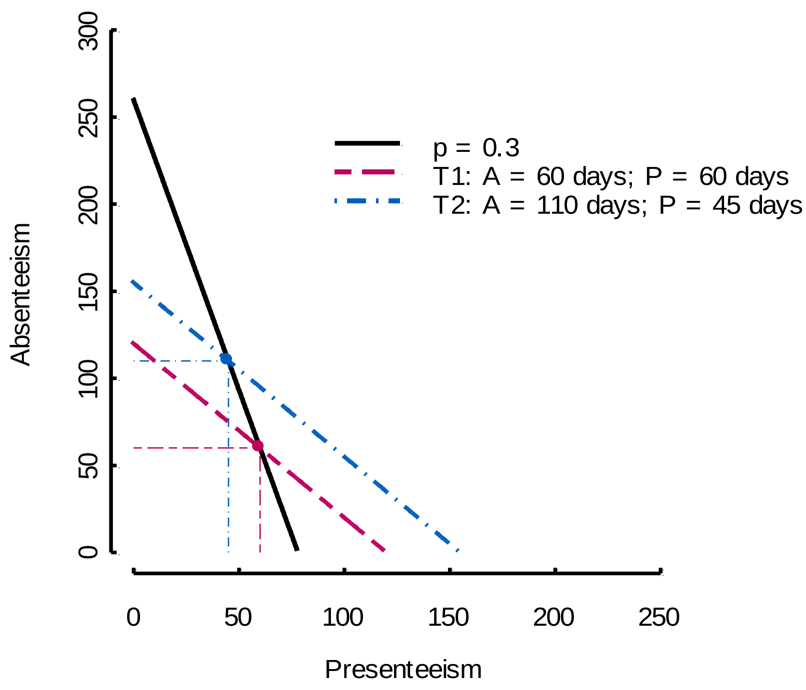


Figure 2.2a

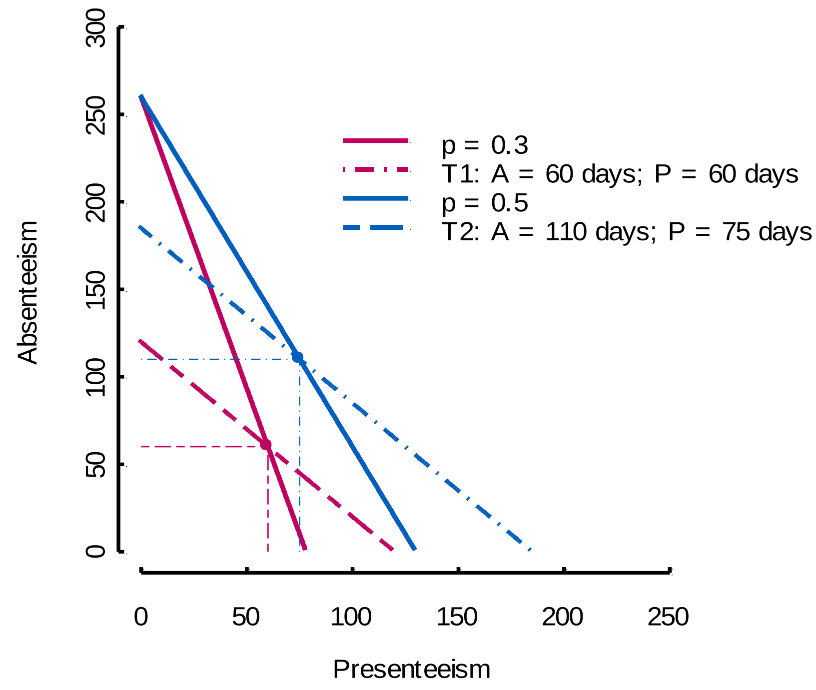
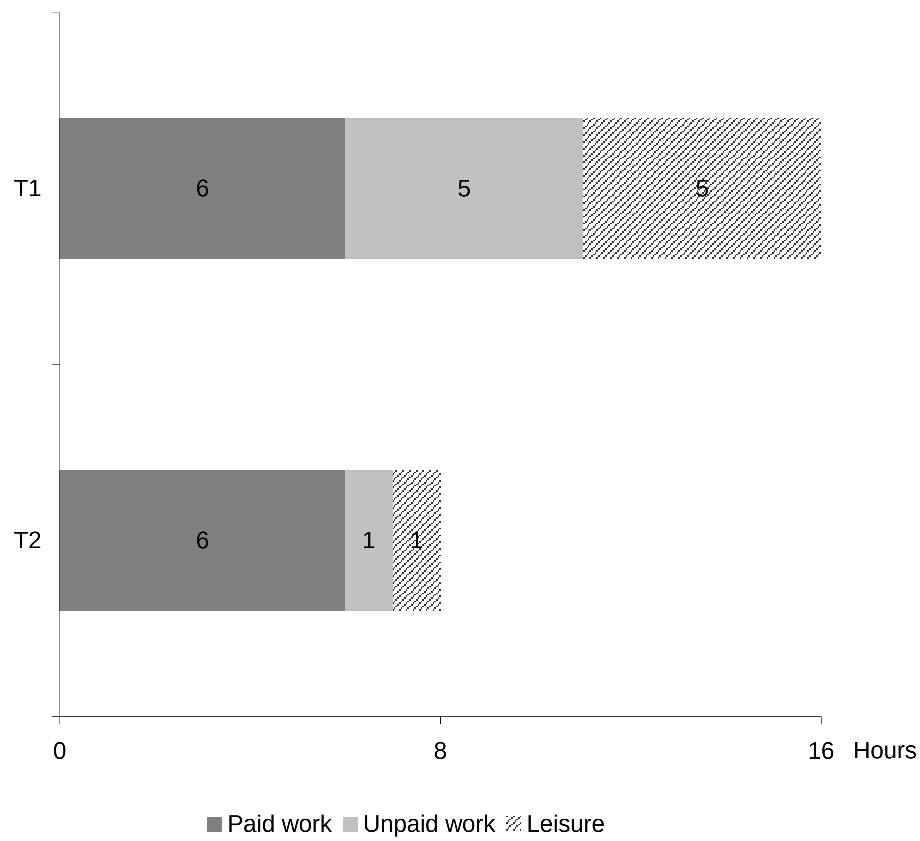


Figure 2.2b

When health problems occur, it is more likely that the total time spent on the 3 types of activities will decrease (e.g., from 16 hours to 8 hours, represented by T1 and T2 in Figure 2.3). But the reductions for the 3 types of activities do not have to be proportional. For example, a change from T1 to T2 in Figure 2.3 indicates that the time spent on paid work is still 6 hours as before, but the time spent on unpaid work and leisure both decreases from 5 hours to 1 hour. The health problem may not affect paid work but affect unpaid work and leisure. This also implies more hours spent on “being sick” and resting, i.e., personal care time increases.

Figure 2.3. Impact of health problems on paid work, unpaid work and leisure

Assume the maximum total hours spent on paid work, unpaid work and leisure are 16 hours per day. The total hours decrease from T1 to T2 because of health problems.



The trade-off between paid work, unpaid work and leisure makes the measurement of labour input loss even more complicated. If an instrument is developed to completely measure labour input loss, it should take into considerations the time spent on these 3 types of activities, the corresponding time loss as well as their trade-off. Please note that we assumed the time spent on personal care or sleep is fixed. However, people may have less productive sleep due to pain, for example, which further complicates the measurement.

2.4 Compensation mechanisms

Health economists have paid attention to the existence of compensation mechanisms in workplaces and suggested that the consideration of compensation mechanisms could potentially reduce productivity loss.[26,38–40] Jacob-Tacken et al.[39] and Severens et al.[40] found that about 70–75% of productivity loss was reduced after adjusting for compensation mechanisms by assuming that there was no productivity loss if missed work was compensated by the absent employee and/or colleagues during normal working hours, or was not compensated at all. Productivity loss only occurred when the compensation for missed work required extra working hours undertaken by the absent employee and/or colleagues, or when additional employees were hired specially to fill in. According to Pauly et al.,[26] availability of a perfect substitute for an absent employee is the key factor determining whether productivity loss exceeds the wage. When there is team production and/or a penalty associated with not meeting an output target, productivity loss could be substantially higher than the wage but could be reduced if replacements are inexpensive and are close substitutes for the absent employee.

Although good compensation mechanisms reduce productivity loss, they are not costless. Rational employers invest money in ways to reduce productivity loss only when the reduction in productivity loss due to the investment is greater than the investment itself. For example, employers may cross-train employees so that they can be perfect substitutes when one employee is absent or unproductive at work or have more employees than needed to account for expected absences.[26] When measuring the incremental loss in output to an employer, these compensation costs will not be captured and thus will understate the true cost of productivity loss.

However, by taking a societal perspective, it is still unclear to what extent compensation mechanisms diminish productivity loss.[38] For example, even if an absent employee made up lost work during normal working hours, this may be done by sacrificing the breaks or working at a faster pace, both of which are costs to society, i.e., value of leisure or effort. Therefore, the reductions in productivity loss as a result of compensation should be calculated as the net value of the costs of compensation and the gains of reduced productivity loss.[38] Accordingly, more information is required in order to estimate productivity loss. This includes job type, industry type, production process (team or individual), time sensitivity of the output, availability of perfect substitute (inside or outside of workplaces), and compensation mechanisms.

2.5 Measurement issues

2.5.1 Objective versus subjective measures

Objective measures of productivity loss usually come from the workplaces of the study subjects, for example, registry data kept by a firm for sick leave. However, objective measures are not always available for presenteeism. Productivity indicators can vary according to occupation as well as workplaces. Some jobs may even have more than one productivity measure and some jobs such as knowledge-based occupations may produce no easily quantifiable output.[41,42] Even if objective measures for productivity were available, there may be ethical concerns because the workplace of the study objects needs to be contacted and recruited in the study to obtain these measures. One feasible alternative is to develop a questionnaire to capture subjective labour input loss and then compare it with objective measures, if possible, in a validation study. The Work Limitations Questionnaire (WLQ), developed to measure the impact of chronic diseases and treatment on work performance, is one of such questionnaires.[43,44] Its work limitation measure was validated by the objectively measured work productivity while working among employees in the customer service department and return department of a large firm.[45] The number of phone calls answered per payroll hour and the number of merchandise units processed per hour were considered as the objective measures of work productivity. However, the limitation of their study is that while they established correlation between subjective and objective measures, they were unable to demonstrate whether the subjective measures are well constructed and scaled.

2.5.2 Quantity and quality of labour input

Labour input includes two aspects: quantity and quality. Recollect that in the components of labour input loss for paid work and unpaid work, absenteeism and employment status changes are solely losses attributable to the time spent working and there are no quality concerns for unpaid work activities as long as they are completed. Thus, quality of labour input has been an issue only for the perspective measuring presenteeism. Health problems, however, impact both work quantity and/or quality. For example, due to health problems individuals slow the pace at which they work and/or take more breaks (quantity). Also, they may be less careful and have to repeat work due to mistakes (quality). Although the quantity of labour input is simply measured in terms of time input, it is not straightforward and even impossible for individuals to measure the quality of their labour input.

Some attempts in the literature have been made to measure both aspects. For example, the Quantity and Quality instrument (QQ) asks individuals to separately rate the amount and the quality of the work they performed on their most recent work day compared to an ordinary day on a 0-10 scale.[46–48] However, the question is how to calculate the labour input loss considering losses in both quantity and quality. The losses in quantity and quality can be assumed to be additive or multiplicative.[48] Studies have shown that there is a high correlation between the quality and quantity, which indicates some overlap in responses.[48] In this case, the additive and multiplicative assumptions may not be appropriate and reduced labour input can be simply calculated based on quantity only. Another attempt is the WLQ.[43–45] It asks about the time frequency of difficulty in doing work without stopping to take breaks or rest periods and working the required number of hours as well as difficulty in doing work carefully and working without making mistakes.

2.5.3 Methods to measure presenteeism

Many instruments have been developed to translate presenteeism into time loss and then monetary equivalent. The methods mainly include directly estimating time loss (e.g., the Health and Labour Questionnaire,[35,36] measuring the percent of time loss while working using a 0-10 scale (e.g., the QQ questionnaire,[46–48] the Work Productivity and Activity Impairment

Questionnaire (WPAI)[49] and the Osterhaus method[50]) and a multidimensional questionnaire (e.g., WLQ.[43–45] Studies have shown that the magnitude of time loss estimates vary widely depending on the instrument chosen, which suggests a lack of comparability among instruments and creates difficulties in comparing the presenteeism estimates across studies using different instruments.[35,46,48,51,52] However, it is still too early to conclude which instrument provides a better presenteeism estimate. To find why these instruments give different estimates, we need to identify what they are actually capturing: labour input loss (work quantity and quality), quality of life (QOL) and/or psychosocial impacts such as job satisfaction and stress. A clear distinction should be made between productivity and QOL especially because of the double counting issue mentioned above. Furthermore, even though individuals are not satisfied with their job and working environment or feel stressed, they may still complete what they are supposed to do. Therefore, to estimate the value of productivity loss attributable to presenteeism, we need to tease out the impact of health on QOL and psychosocial factors and measure the output value corresponding to the labour input loss only.

2.5.4 Recall period

It is important to determine how long subjects are able to recall when relying on self-reported labour input loss. Recall inaccuracy may result from memory failure or recall difficulty if the recall period is too long. In the literature, a few studies have already addressed the recall inaccuracy with regard to labour input loss. Severens et al.[53] compared the precision and accuracy in self-reported absence from work for different recall periods: the past 2 weeks, 4 weeks, 2 months, 6 months, and the past 12 months. They considered the sick leave register data kept by a company as the gold standard and compared the absence reported by the employees in the company with the gold standard. The study demonstrated that the accuracy of patient reports on absence from work decreases when the recall period increases. It is therefore recommended a recall period of no more than 2 months be used for measuring absence from work due to illness. Similarly, Revicki et al.[54] compared self-reported missed workdays over 4 weeks and 3 months with time card records completed weekly over the same period and found self-reported missed workdays were as accurate for a 3-month recall as for a 4-week period.

The lack of precision may also increase in proportion to the recall interval when work hours are the measurement unit or when presenteeism is assessed.[55] Recall periods of 2-week and 1-week are commonly used in presenteeism measurement instruments.[42,56] Reilly et al.[55] assessed the validity and accuracy of the WPAI – irritable bowel syndrome version (WPAI:IBS), which measures both absenteeism and presenteeism. In this study, a 7-day recall period was validated by retrospective diary. No indication was found that the most recent days (e.g., day 1 (yesterday) and day 2 (the day before yesterday)) significantly affected the WPAI presenteeism score. However, there was evidence that the most severe day in the recall period did affect the WPAI presenteeism score. The authors suggested that patient-reported outcomes over an interval may not be a true average assessment and the patients are more likely to recall the salient event. Shorter recall periods might be the better way to reduce the recall inaccuracy and the effect of saliency. Wang et al.[57] used daily momentary assessment to measure the impact of depression on work performance. They showed that daily momentary assessment is a good way to prevent recall bias between the service workers who were depressed and those who were not depressed. However, as suggested by Reilly et al.,[55] we have to balance the loss in precision against the increase in cost and patient burden with daily assessments or momentary assessments.

When designing a cohort study or randomized controlled trial (RCT), the recall period is also dependent on the frequency of follow-ups. Severens et al.[53] recommended using retrospective questionnaires continuously to cover a longer time frame especially when a disease is progressive and changes in productivity loss are expected. If the time period between follow-ups is longer than the recall period, imprecision might be introduced when we need to determine productivity loss for the continuous longer time period. For example, if a one-week recall questionnaire is administered once a month, we will have to assume the loss occurring in each week in one month is same as that reported for the recall period and extrapolate the monthly work loss. Therefore, the more frequently the questionnaire is administered, the higher precision of loss estimate is. Again, we have to balance the loss in precision against the increase in cost and patient burden with frequent follow-ups.

Therefore, recall period for absenteeism and presenteeism should be determined by balancing between the loss in precision and the increase in cost and patient burden with daily assessments and frequent follow-ups. We suggest that the recall period for absenteeism be 3 months because of the acceptable recall accuracy[53,54] and the fact that 12 weeks are often used as the frequency of follow-ups in RCTs for their primary clinical outcomes. This can be aided by providing patients with an aide memoire calendar, instead of diary, which would remind them of any absences when they fill out the questionnaire. The recall period for presenteeism should be one week because a shorter recall period can reduce the recall inaccuracy and the effect of saliency.[55]

2.5.5 Generic versus disease specific

When measuring productivity loss among patients with a specific disease, another issue arises: whether loss due to general health or loss due to the disease should be considered. Labour input loss due to the disease should capture not only the loss due to the disease itself but also the impact of its co-morbidities and the side-effects and/or toxicities of treatments when treatment effects on productivity are concerned. However, patients may not be able to make a right judgment. For example, if a patient with rheumatoid arthritis (RA) is absent from work due to RA treatment drug-related toxicity, the missed workdays might not be correctly attributed to RA. Similarly, time input loss resulting from RA-related fatigue may not be attributed to RA in some patients. In contrast, labour input loss due to general health implicitly excludes loss due to personal or social reasons while capturing all potential effects of co-morbidities, adverse events, toxicities, and fatigue etc. However, data might be skewed by outliers and diluted by unrelated loss (e.g., other illnesses, car accidents). In practice, the issues can be addressed by a large sample size, a randomized controlled design, exclusion of outliers which has to be stated up front in the analysis plan, and asking patients whether another significant health problem other than the disease has an impact on work.

2.5.6 Perspectives

As mentioned above, a social perspective is preferred for economic evaluations. Consistently, productivity loss should be measured and valued from the same perspective. However, if it is not undertaking an economic evaluation, the loss can also be valued from other perspectives such as the firms and patients.[23] It is worth noticing that there are overlaps between perspectives (Table 2.1). For example, absenteeism and presenteeism are both valued from the viewpoints of firms and society. However, when an employee quits because of their health, the loss for the firm only occurs until they find a perfect substitute and for society the loss is the potential value of the human capital for the employee. Furthermore, unpaid work loss does not matter to firms but does to the society. From a patient's perspective, the loss is valued mainly by the income they lose when they are absent from work, reduce routine work time, lose a job or retire early because of their health problems. If they are present at work but unable to work, in the short term, no costs will occur. In the long run, penalties may occur for those with frequent absenteeism and presenteeism, for example, they may not get promoted or lose opportunities for advancement or raises because of their poor work performance.

Table 2.1. Perspectives for valuing productivity loss

Perspectives	Absenteeism	Presenteeism	Employment status changes*	Loss of unpaid work or leisure
Society	Valued by marginal productivity if human capital method is applied	Value labour input loss by marginal productivity	Valued by marginal productivity if human capital method is applied	Valued by opportunity cost or replacement cost
Company	Valued by marginal productivity if human capital method is applied	Value labour input loss by marginal productivity	Valued by marginal productivity until a perfect substitute is found and additional replacement cost such as hiring and training	Not applicable
Patient	Valued by the income from work in the short term; in the long run, additional penalties occur such as losing opportunities for promotion, advancement, or raises	No costs in the short term; in the long run, penalties may occur such as losing opportunities for promotion, advancement, or raises	Valued by the income from work	Valued by opportunity cost or replacement cost

*reduced routine working time, job loss, and early retirement

In addition, if not for the purpose of economic evaluations, the loss for patients does not have to be measured in terms of monetary amounts. The impact of health on their work is not limited to the reduced labour input in terms of work quantity and quality. Health problems also lead to less job satisfaction, stress and unhappiness in doing their work, which is not valued by monetary units. Therefore, from a patient's perspective, a different loss measure can be developed to comprehensively capture all aspects of health impacts on work.

2.6 Discussion

In the literature, a recent review on this topic already exists. Mattke et al.[41] reviewed the instruments for measuring the effect of ill health on productivity because of absenteeism and presenteeism, and summarized 3 different methods of measuring presenteeism as well as 3 methods for monetizing lost productivity. Our review was based on the economic theory underlying production, i.e., the concept of the production function and the associated concept of productivity. We highlighted issues associated with the measurement and valuation of productivity. Finally we made recommendations on best practice for measuring productivity in applied economic analysis. Specifically, we considered many more issues than Mattke et al.. For example, we reviewed the methods for measuring and valuing unpaid work loss due to health problems and shed light on the trade-offs between absenteeism and presenteeism and the trade-offs among paid work, unpaid work and leisure. Compensation mechanisms and the issues related to subjective measures, quantity and quality aspects of labour input, disease specific measures and different perspectives were also discussed in our review but not considered by Mattke et al.. We therefore believe the two reviews are quite distinct yet complementary.

This chapter goes beyond arguing for the inclusion of productivity loss in economic evaluations from a societal perspective. The focus is to provide some guidelines on how to measure and value productivity loss due to health problems if including productivity loss. In this chapter, we have distinguished measuring labour input change as opposed to measuring the consequences of the change in labour input on the final output of the firm and discussed different methods available to value productivity loss for both paid work and unpaid work. Then we specifically considered the ramifications of measuring both labour input loss in paid and unpaid work as well as the inclusion of presenteeism to the more traditional approach of measuring only absenteeism. Finally, we addressed measurement issues with respect to objective versus subjective measures, quality and quantity of labour input, methods to measure presenteeism, recall period, generic versus disease specific measures and different measurement perspectives, and provided the corresponding recommendations. Certainly, more attention should be paid to the methodologies of measuring and valuing productivity loss. More empirical work is needed to test the feasibility of these recommendations.

Chapter 3: Development of a composite questionnaire, the Valuation of Lost Productivity (VOLP), to value productivity losses: Application in rheumatoid arthritis[3]

3.1 Introduction

The impact of various health problems on productivity loss has been well documented in recent years.[4,32,58–64] Productivity loss has also been the attention of both cost-of-illness studies and economic evaluations of health programs where its inclusion has been found to substantially impact the final findings.[19–21] There are, however, variations in the way productivity loss is measured and valued. The most basic method to estimate productivity loss from a societal perspective is to first measure the amount of time lost, e.g., the number of lost days or hours of work, and then to value this loss according to the wage rate. While this method has largely been adopted due to ease of administration and estimation, it has some important limitations because the wage may not represent the value of lost productivity at the level of the workplace or society. This chapter first summarizes the theory behind measuring and valuing productivity losses from a societal perspective, and provides a rationale for a new instrument that was consequently developed. Next, the development and preliminary testing of this instrument is described to examine its usefulness and feasibility.

[3] A version of chapter 3 has been published. Zhang W, Bansback N, Boonen A, Severens JL, Anis AH. Development of a composite questionnaire, the Valuation Of Lost Productivity (VOLP), to value productivity losses: application in rheumatoid arthritis. Value in Health. 2012;15:46-54.

3.2 Rationale

According to the critical review in chapter 1, the concept of productivity loss due to illness is based on the concept of a production function, where output is a function of capital input, labour input and technology.[65,66] Thus, productivity loss due to illness is actually the output loss corresponding to the reduced labour input due to illness.[58] The focus of most existing productivity measurement questionnaires has been on the individual's labour input – measuring the time a person is not at work due to health (absenteeism) or is not productive while at work due to health (presenteeism). Productivity loss is then valued in monetary terms by multiplying the time loss so obtained by the relevant wage rate. Wage rate is commonly used to value work time loss because it is supposed to be equal to marginal productivity based on economic theory.

Wage, however, is not equal to the marginal productivity or does not reflect the actual value of productivity loss for the workplace or society for certain reasons. These include allowances for sick days and risk aversion of workers, as well as job and workplace characteristics such as team production, availability of perfect substitutes and time sensitivity of output.[26,58] According to Pauly et al.,[26] when an employee is absent from work, the actual productivity loss will exceed his/her wage if a substitute cannot be found or the substitute is less productive or costs more *and* if team work is involved and/or penalties occur for failure to achieve the targeted output levels according to expected time schedules. Therefore, wage is diverged from marginal productivity because of these job and workplace characteristics.

Due to the discrepancy between wage and marginal productivity, multipliers relating wage rates to marginal productivity need to be derived first to value productivity loss. Productivity loss can be then estimated by multiplying time loss and wage rate with a multiplier corresponding to the study subject's job and workplace characteristics. In order to develop multipliers and thus to value productivity loss, in addition to time loss, it is necessary to measure job and workplace characteristics such as job and industry type, interaction within a team, availability of substitutes and their substitutability. It would require detailed information from both employees and their employers. However, using standard experimental designs common in health research, such as, clinical trials, it would be impractical (both ethically and logistically) to recruit both patients and their employers/managers to participate in a study to assess the impact of an illness or the effect of a therapeutic intervention on productivity. Typically, we can only collect the information from study participants who are employees.

The only studies to date that have attempted to estimate multipliers for productivity loss are those by Pauly et al..[28,29] In these, managers instead of employees were interviewed to obtain estimates of the impact of absenteeism and presenteeism on output for different job and workplace characteristics including team production, availability of perfect substitutes and time sensitivity. The multipliers were defined as the cost of absenteeism and presenteesim to the firm as a proportion of the worker's wage, which is often greater than one. The authors argued that managers were best able to assess the impact of a worker's health problems on productivity because the managers considered work output while the worker's focus was limited to work input.[28,29] However, the impact on productivity assessed by managers might not reflect the impact on the actual productivity at the workplaces. In addition, using the multipliers by Pauly et al. in a study requires a match between each study participant's job type and the job types studied by Pauly et al. and an assumption that their study samples are representative and thus the multipliers were generalizable. With the limited number of job and firm types studied by Pauly et al., only certain jobs were covered. Furthermore, given that the data was from the US only, the multipliers may not be applicable to other countries that have different economic systems, e.g., labour market, market power of firms, and firm types. Therefore, an alternative source for deriving multipliers is required.

Many questionnaires have been developed to directly measure time loss in days or hours, or to indirectly translate the impact of health problems into percentage of time loss[67] such as the Health and Labour Questionnaire (HLQ),[35] the Work Productivity and Activity Impairment Questionnaire (WPAI)[49] and the PROductivity and DISease Questionnaire (PRODISQ).[47] Although the PRODISQ includes questions on workplace characteristics in order to adjust for possible compensation in case of absence from work due to disease, no one questionnaire captures time input loss as well as information on job and workplace characteristics, necessary for valuing output loss resulting from the time input loss. A questionnaire can be developed to address this need.

Another issue is that people make a trade-off between paid work, unpaid work and leisure. It has been suggested that a questionnaire attempting to completely measure labour input loss should take into considerations the time spent on these 3 types of activities, the corresponding time loss as well as their trade-off.[58] Therefore, in addition to time loss from paid work, a questionnaire also needs to capture time loss from unpaid work.

It is worth noticing that we are developing a questionnaire valuing productivity loss from a societal perspective instead of a workplace perspective. There are both overlaps and distinctions between workplace perspective and societal perspective.[58] Absenteeism and presenteeism are valued similarly from the viewpoints of workplace and society. When an employee quits a job due to their health, however, the loss for the workplaces only occurs until they find a perfect substitute and for society the loss is the potential value of the human capital for the employee. Furthermore, unpaid work loss does not matter to a workplace but does matter to the society.

3.3 Development of the VOLP questionnaire

3.3.1 Content development

Several comprehensive systematic reviews of questionnaires measuring productivity loss have previously been published.[41,42,56,68,69] Since our questionnaire focused on valuation instead of measurement of time loss, we did not create new questions measuring time loss if the measurement of time loss (question) was already available and captured employment status changes, such as, job loss, early retirement, or reduced routine work hours, absenteeism, presenteeism, and unpaid work activities.

As a starting point, an expert group consisting of rheumatologists, health economists, and psychometricians reviewed the content of the published questionnaires. The preliminary objective was to consider developing a questionnaire for use in patients with rheumatoid arthritis (RA), a disease that has well documented impact on productivity.[32,64,70,71] A battery of items was first sourced by selecting the questionnaires with frequent application and strong evidence of validity in arthritis and/or musculoskeletal disorders. The questionnaire battery included the RA

Work Instability Scale (WIS),[72] Workplace Activity Limitations Scale (WALS),[73] Work Limitations Questionnaire (WLQ),[43] Quantity and Quality instrument (QQ),[46–48] WPAI,[49] HLQ[17] and PRODISQ.[47] We grouped the items from different questionnaires according to the following components we thought important to measure: employment/unemployment status, absenteeism, presenteeism, unpaid work activity loss, as well as job and workplace characteristics (Table 3.1). After consideration, the questions contained within the WLQ, QQ, WPAI, HLQ and PRODISQ were considered to be most suitable for estimation of productivity loss since the RA-WIS and WALS concentrated more on “difficulties” experienced by ill workers but not on “productivity”.

Table 3.1. Questionnaire battery for measuring productivity loss

Instrument	Concept	Scale	Employment / Unemployment status	Absenteeism	Presenteeism	Unpaid work activity loss	Job and workplace characteristics			
							TP	PS	CM	TS
RA WIS	The extent of any mismatch between functional incapacity and work demands and its potential impact on job retention and security	Single scale of 23 items			Y					
WALS	Amount/level of difficulty in doing specific work related tasks	Single scale of 11 items			Y					
WLQ	Proportion of time having difficulty undertaking specific work related tasks	4 domains: • Physical • Mental-interpersonal • Time management • Output demands			Y ($)					
WPAI – GH	Degree of work and activity impairment	7 questions and 4 scores: • % health time missed • %impairment while working • %overall impairment • % activity impairment	P ($)	Y ($)	Y ($)	Y				
QQ	Quantity and quality of work	2 VAS questions: • Quantity of work done compared to normal • Quality of work done compared to normal			Y ($)					

Instrument	**Concept**	**Scale**	**Employment / Unemployment status**	**Absenteeism**	**Presenteeism**	**Unpaid work activity loss**	**Job and workplace characteristics**			
HLQ	Time amount experiencing various aspects of reduced productivity at paid and unpaid work and impediments	4 modules: • Absence from work • Productivity at work • Unpaid work • Impediments to paid and unpaid labour	Y ($)	Y ($)	Y ($)	Y ($)				
PRODISQ	Illness and productivity of individuals and productivity costs at an organizational level	7 modules: • General • Occupation, income and workplace • Absenteeism • Compensating mechanisms in the event of absence • Productivity costs during work using QQ • Productivity costs at departmental level • Administrative and management costs of absence	P ($)	Y ($)	Y ($)		P[†]		P	Y[†]

Y: measured; P: partially measured; $: potential or current utilization for cost estimation
[†]: questions intended for employers/managers to answer; if not indicated, questions for study participant to answer
RA WIS – Rheumatoid Arthritis Work Instability Scale[72]
WALS – Work Activity Limitations Scale[73]
WLQ – Work Limitations Questionnaire[43]
WPAI-GH – Work Productivity and Activity Impairment - General Health[49]
QQ – Quantity and Quality method[46–48]
HLQ – Health and Labour Questionnaire[35]
PRODISQ – PROductivity and DISease Questionnaire[47]
TP: team production; PS: availability of perfect substitutes; CM: compensation mechanisms; TS: time sensitivity

3.3.2 Item reduction

To reduce the items for each of the five components, we organized items by content, identified similar items and eliminated duplication. When choosing between items sharing similar content, we considered primarily the wording of the question and the format of the response options from the perspective of their suitability for cost estimation. That is, as shown in Table 3.1, only those items that have potential or are currently utilized for cost estimation were considered. Furthermore, we followed the guidelines on how to measure productivity that were summarized in the previous publication.[58] For example, in order to estimate the costs, it has been recommended to measure the loss in terms of time amount first and then multiply it by the value of the time.[58] In addition, job and workplace characteristics such as job and industry type, interaction within a team, availability of perfect substitute, and compensation mechanism have impacts on the value of productivity loss and thus need to be measured for valuation purpose. [58] A draft questionnaire was thus developed, named the Valuation Of Lost Productivity (VOLP)[74] based on those remaining items after reduction, adaptations and improvements of existing questions according to the expert group's recommendations. The VOLP is a generic questionnaire assessing the labour input loss due to health (any physical, mental, or emotional problems or symptoms). The questionnaire consists of 6 sections: employment status, job characteristics, absenteeism, work performance, unpaid work, and working environment (teamwork, substitutability, etc.).

The section on employment status distinguishes between working full time for pay, working part time for pay and self-employment and identifies the unemployment status (retired, homemaker, etc.), unemployment due to health and the employability for unemployed individuals.

Unemployment due to health implies complete loss of labour input for individuals in paid employment.

Absenteeism is measured by the number of absent workdays due to health in the past 3 months, a question adapted from the PRODISQ.[47] A 3-month recall period was proposed by Severens et al. and Revicki et al..[53,54]

Presenteeism, reduced work performance at work, is measured by an hour estimating method as per the HLQ.[35] Respondents are first asked to think of the work they completed during the past 7 days and answer whether they would complete the same work in less time if they did not experience any health problems. If yes, they are asked to indicate the time in hours they actually used to do all the work during the past 7 days, and the time they would use to do the same work if they did not experience any health problems. In this way, by controlling for work quality (the same work), the work quantity when an individual has health problems is compared with that when he or she was healthy. Meanwhile, a 0-10 scale measuring presenteeism from the WPAI was also included in the draft for comparison and empirical testing. A 7-day recall period is used because it has been validated and supported in previous studies.[55,58]

The impact of health on unpaid work is measured by asking how much time is spent on such activities as household work, shopping, odd jobs and chores, childcare and volunteer activities and how much time respondents get paid and/or unpaid help with their unpaid work. These questions were adapted from the HLQ[35] and a 7-day recall period was applied.

More importantly, for valuation purpose, the VOLP collects information on job characteristics and working environment in addition to the labour time input loss in terms of absenteeism, presenteeism and unpaid work loss. Job characteristics include job title, industry type, work habit, weekly work hours and days, and income. In addition, based on initial interview questions used by Pauly et al.[29] and questions from PRODISQ,[47] the VOLP asks about team dynamics (size of working team, impact of the respondent on the team's function), substitutability (whether colleagues or temporary workers can complete the same work using the same time amount), time sensitivity (whether work can be postponed easily without any consequences), compensation (whether work is taken over by others or postponed when the respondent is absent or present at work but less productive) and availability of substitutes (who - colleagues, managers, temporary workers or no one - takes over the work when the respondent is absent or present at work but less productive).

3.3.3 Pre-testing and revisions

A focus group was recruited to test the draft VOLP's feasibility by seeking patients' views on the various types of questions and response formats associated with the content and the clarity of the draft VOLP. In the draft VOLP, two alternative formats for questions on absenteeism and unpaid work were included.

A total of 15 employed people with RA were recruited for the focus group meeting. Their occupations mainly fell into the job categories of clerks, professionals, managers, or technicians. The meeting lasted approximately three hours. After an introduction by the principal investigator, the participants were asked to complete the draft VOLP. Then the participants were randomly divided into two groups. In each group, one facilitator then led an audio taped discussion regarding their preference between various types of questions, whether the questions were easily understood, and whether the questions accurately captured their loss in paid work and unpaid work. The draft VOLP was modified according to the feedback from the participants. The main changes include that 1) we confirmed that the questions asking for the loss due to general health are preferred to those asking for the loss due to the specific disease, RA; 2) for the question asking for the employability of unemployed individuals, we split the option “Yes” into two options: “Yes, I am able to work full time” and “Yes, I am only able to work part time”; 3) we asked for the compensation (whether work is taken over by others or postponed when the respondent is absent) for the most recent period of absence instead of that for the longest and the shortest period of absence; 4) as suggested by the focus group, we added one more motivating and positive question, “did you work harder than your co-workers because of your health” before asking presenteeism. Since the changes were minimal, we did not undertake additional testing of the modifications made to the questions.

3.4 Preliminary assessment study

The modified VOLP was then tested in patients with early RA who were enrolled in the Early Rheumatoid Arthritis Network (ERAN) cohort based in the UK and who reported to be in paid work at their recent follow-up. Each participant was mailed and completed the VOLP at home. Some simple debriefing questions included within the assessment were also asked to ascertain any issues or difficulties with the VOLP.

Subsequent to study initiation, a total of 354 patients who were employed during their most recent follow-up in ERAN were contacted for the study and 186 (53%) agreed to take part in the study and were sent the VOLP draft questionnaire. One hundred and fifty two completed the questionnaire, of whom 140 were working for pay (67 full-time and 54 part-time) or self-employed (n=18) and were included in our analysis (Table 3.2). The average age of the employed patients was 52 years old and 74% were female. Their disease duration was 48 months since the onset of symptom and 37 months since first rheumatology visit. Thirty one (22%) employed patients were working with light or heavy loads. Debriefing responses at the end of the questionnaire found few problems. Less than 10% (n=13) of respondents found the questionnaire to be too long, while only 15% (n=21) had some difficulties with the questions. Most comments were general (e.g., questions are repetitive, not related to/fitting their work) while 5 people specifically identified difficulties with multiplier related questions in the VOLP, yet did not offer alternatives.

Table 3.2. Demographic and job characteristics

Variables (N=140)	Mean (SD)	Median (Q1-Q3)
Age	51.6 (10.0)	52.1 (45.0-59.3)
Duration since onset of symptom (months)	48.5 (23.6)	46.0 (33.0-59.0)
Duration since first clinic visit (months)	37.2 (18.4)	35.5 (23.5-50.2)
No of work days per week	4.6 (1.1)	5.0 (4.0-5.0)
No of work hours per week	32.6 (12.7)	35.0 (22.5-40.0)
	N	**%**
Female	104	74.3
Work status		
Full time	67	47.9
Part time	54	38.6
Self-employed	18	12.9
Work habits		
Usually sit	51	36.4
Stand or walk	53	37.9
Light load	20	14.3
Heavy load	11	7.9
Job category		
Manager	20	14.3
Professionals	22	15.7
Technicians	16	11.4
Clerk	24	17.1
Services and sales	37	26.4
Agriculture and fishery	4	2.9
Craft	7	5.0
Operators	7	5.0
Elementary occupations	3	2.1
Income		
Prefer not to answer	13	9.3
Less than £10,000	30	21.4
£10,000 - £19,999	53	37.9
£20,000 - £29,999	24	17.1
£30,000 - £39,999	12	8.6
£40,000 and above	7	5.0

If the percentages do not add up to 100%, the remaining is the missing rate.

3.4.1 Compensation and availability of substitutes for absenteeism and presenteeism

Only 60 patients who were absent from work due to health in the past 3 months were asked about compensation and availability of substitutes for their most recent absence. Of them, 42% reported their work was taken over by others, 22% reported their work was postponed, and 28% reported their work was partially taken over and partially postponed. About 75% reported that co-workers, supervisors, or temporary workers mainly took over their work when they were absent (Table 3.3). All employed patients were asked about compensation and availability of substitutes for presenteeism. About 29% patients reported their work was taken over, 24% postponed and 37% partially taken over and partially postponed. A total of 97 (69%) employed patients reported co-workers, supervisors, or temporary workers would take over their work if they were at work but unable to work.

Table 3.3. Workplace characteristics

Variables	N	%
Compensation and availability of substitutes for the most recent absent period (N=60)		
Work taken over?		
Do not know	2	3.3
Taken over by others	25	41.7
Partly taken over partly postponed	17	28.3
Postponed	13	21.7
Who took over work?		
Co-workers or supervisors	42	70.0
Temp workers	3	5.0
No-one	12	20.0
Compensation and availability of substitutes for presenteeism (N=140)		
Work taken over?		
Do not know	7	5.0
Taken over by others	41	29.3
Partly taken over partly postponed	52	37.1
Postponed	34	24.3
Who took over work?		
Do not know	9	6.4
Co-workers or supervisors	90	64.3

Variables	**N**	**%**
Temp workers	7	5.0
No-one	28	20.0
Teamwork (N=140)		
Work with team?		
None of the time	22	15.7
A little of the time	25	17.9
Some of the time	33	23.6
Most of the time	31	22.1
All the time	24	17.1
No of co-workers in the team (N=111), mean (SD)	4.4 (4.1)	
Impact on team function (N=113)		
Function as usual	27	23.9
Affected a little bit	28	24.8
Affected somewhat	25	22.1
Affected quite a lot	26	23.0
Can not function	5	4.4
Substitutability (N=140)		
Co-workers doing same work?		
Yes	103	73.6
No	32	22.9
Can Co-workers do your work?		
Same	57	40.7
Need a little bit more time	16	11.4
Need somewhat more time	23	16.4
Need a lot more time	11	7.9
Can not do my work	25	17.9
Temp workers hired?		
Yes	32	22.9
No	99	70.7
Can temps do your work? (N=32)		
Same	9	28.1
Need a little bit more time	6	18.8
Need somewhat more time	10	31.3
Need a lot more time	3	9.4
Can not do my work	4	12.5
Time sensitivity (N=140)		
0 Work can be postponed easily without consequences	8	5.7
1	16	11.4
2	16	11.4
3	30	21.4
4	32	22.9
5 Can not be postponed without severe consequences	33	23.6

If the percentages do not add up to 100%, the remaining is the missing rate.

3.4.2 Teamwork, substitutability and time sensitivity

Among all employed patients, 22 (16%) patients did not work in teams while 24 (17%) patients worked in teams all the time (Table 3.3). Among those 113 patients who worked in a team at least a little of the time, 24% reported their team could function as usual when they were absent from work or when they were at work but unable to work and 4.4% reported their team could not function at all. One hundred and three (74%) patients reported that they had co-workers doing the same work as theirs but only 57 patients (41%) thought that their co-workers could complete their work using the same amount of time as they use. Thirty two (23%) patients reported their workplaces hired temporary workers from agencies who do the same work but 28% of these 32 patients thought that the temporary workers could complete their work using the same amount of time as themselves. When asked whether their work could be postponed easily without consequences, 8 (6%) answered their work could be postponed easily and 33 (24%) answered their work could not be postponed without severe consequences.

3.4.3 Multipliers accounting for teamwork and substitutability

As mentioned above, Pauly et al. generated wage multipliers for absenteeism and presenteeism for over 20 specific job types.[29] Using the VOLP itself, we also attempted to derive multipliers by assuming they are at least equal to one. We applied an additive algorithm to calculate multipliers for each employed patient according to their workplace characteristics (Table 3.4). We imputed the amount 0%, 25%, 50%, 75%, 100% to the 5-likert options for frequency of working with team and impact on team function to indicate % of the team's work that was affected. Similarly, we imputed the amount to the 5-likert options for substitutes' ability to do the work to indicate in a certain time period, % of work could not be completed by co-workers or temporary workers. We assumed the output from a team was the sum of each member's wage and the wage for each team member was the same. Thus, if one employee was absent and no substitute was available, the loss was the employee's wage plus the other team members' wages. If a substitute was available, the loss was the employee's wage and part of the other team members' wage depending on the ability of the substitute to do the work. We did not take into account time sensitivity of output when calculating multipliers from the VOLP because the associated loss can be arbitrary and was hard for employees to estimate. To get the corresponding multiplier by Pauly et al., we matched the job title of each study patient to the job type list identified by Pauly et al.. The wage multipliers according to Pauly et al. and the VOLP were presented in Table 3.5 by 9 broader job categories. Please note that there were 67 patients who were working with similar job titles to those identified by Pauly et al.. However, due to the missing data and the fact that the VOLP absenteeism multipliers could be derived only for patients who reported absence, multipliers according to Pauly et al. and the VOLP were both available among 27 patients only for absenteeism and 58 patients for presenteeism. The first row in Table 3.5 for each job category reported multipliers for the job titles available in both the VOLP and Pauly et al.. The second row reported multipliers for the job titles only available in the VOLP and the third row for those available in Pauly et al. only. For absenteeism, there were over 5 patients having multipliers using both methods in clerk job category and services and sales category. The multipliers developed from the VOLP were slightly higher. For presenteeism, in the job categories with over 5 patients having multipliers using both methods, the multipliers from the VOLP were smaller than those from Pauly et al.

Table 3.4. Calculating multipliers from the Valuation of Lost Productivity questionnaire

Teamwork

- Frequency of working with team (X): none of the time=0%, 2=25%, 3=50%, 4=75%, all the time=100%
- Number of team members potentially affected (Y)
- Impact on team function (Z): function as usual=0%, 2=25%, 3=50%, 4=75%, can not function 5=100% (indicating % of the team's work that was affected)

Substitutability

- Can co-workers do your work? (C): same=0%, 2=25%, 3=50%, 4=75%, can not do my work=100% (indicating in a certain time period, % of work can not be completed by co-workers)
- Can temps do your work? (T): same=0%, 2=25%, 3=50%, 4=75%, can not do my work=100% (indicating in a certain time period, % of work can not be completed by temps)

Multipliers depending on availability of substitutes

Who took over work?

1) Co-workers or supervisors: <u>Multiplier= (1+C*X*Y*Z)</u>
2) Temp workers hired from external agency: <u>Multiplier= (1+T*X*Y*Z)</u>
3) No-one: <u>Multiplier=(1+X*Y*Z)</u>

For example,

- *If an employee does not work with team (X=0), or his absence/presenteeism does not affect team function (Y=0), or his co-worker/supervisor/temp as a substitute does his work perfectly (C=0), then Multiplier=1;*
- *If an employee spends 25% of work time (X=25%) working with 4 other team members (Y=4) and his absence/presenteeism has 25% impact on team work (Z=25%);*
    - *If the co-worker/supervisor/temp as a substitute can not complete 25% of the work within a certain time period (keeping team idle) (C=25% or T=25%), then Multiplier=(1+25%*25%*4*25%)=1.06;*
    - *If no one substitutes for him, then Multiplier=(1+25%*4*25%)=1.25.*

Multipliers when considering compensation mechanisms

- If lost work is not compensated or can not be compensated without cost (the cost is assumed to be equal to the wage), then productivity loss will be lost work time multiplied by wage and the multipliers depending on the availability of substitutes, i.e., the multipliers above;
- If lost work can be fully or partially compensated without cost, then productivity loss will be zero or uncompensated lost work time multiplied by wage and the multiplier for scenario when no one takes over work, i.e., (1+X*Y*Z).

Table 3.5. Multipliers for absenteeism and presenteeism

Job category	Absenteeism			Presenteeism		
	N	**VOLP**	**Pauly *et al.***	**N**	**VOLP**	**Pauly *et al.***
Manager	1	2.41	1.89	5	1.63	2.36
	5	4.68	–	15	2.78	–
	4	–	1.82	0	–	–
Professionals	3	1.64	1.52	8	1.40	2.29
	7	1.97	–	12	1.32	–
	5	–	1.70	0	–	–
Technicians	2	1.00	1.36	4	1.09	2.41
	7	1.78	–	10	1.55	–
	3	–	1.71	1	–	1.59
Clerk	6	1.54	1.52	15	1.35	2.03
	6	1.27	–	7	1.25	–
	10	–	1.52	1	–	2.43
Services and sales	11	1.81	1.33	20	1.31	1.84
	5	1.07	–	12	1.08	–
	11	–	1.43	2	–	1.59
Agriculture and fishery	0	–	–	1	1.00	2.66
	2	1.00	–	3	1.03	–
	1	–	1.35	0	–	–
Craft	2	2.69	1.70	1	4.38	3.50
	1	1.63	–	2	1.31	–
	3	–	1.70	4	–	2.63
Operators	1	1.19	1.89	3	1.06	2.03
	2	1.00	–	2	2.13	–
	2	–	1.28	0	–	–
Elementary occupations	1	1.19	1.05	1	1.38	1.47
	1	1.00	–	1	1.00	–
	1	–	1.05	1	–	1.47

For each job category, the first row reported multipliers for the job titles available in both the VOLP and Pauly et al. [15]; The second row reported multipliers for the job titles only available in the VOLP and the third row for those available in Pauly et al. [15] only.
"–": not available; VOLP: Valuation Of Lost Productivity.

3.5 Discussion

The VOLP questionnaire was developed for valuation of productivity loss from a societal perspective according to accepted principles in the economic evaluation literature. We developed the VOLP for users who want to measure health-related time loss for the individual as well as the multipliers for valuing the societal loss using one complete questionnaire. Since the VOLP is a composite questionnaire, questions might also be separated for use depending on the study purposes. For example, questions on absenteeism, presenteeism and unpaid work activity loss could be used to measure the time lost because of health problems. The validity and reliability of the VOLP measuring time loss have been tested in the following chapter.[75] Questions on job and workplace characteristics including team dynamics, availability of substitutes, and substitutability can be used to generate multipliers for valuation purpose. These questions might be combined with other questionnaires which are also able to measure lost time such as WPAI,[49] HLQ[35] and PRODISQ[47] (which were used in developing the questions in the VOLP). When questions are used separately or combined with another questionnaire, care should be taken to ensure the consistency of recall periods and question wordings between VOLP questions and other questionnaires. The validity of using the VOLP questions separately outside the context of the whole questionnaire may also need to be further examined.

In this study, using the VOLP questionnaire we measured the job and workplace characteristics of employed people with RA. Most employed patients' work would be taken over or partially taken over if they were absent from work (70%) or present at work but sick (66%) (Table 3.3). This indicated there are good compensation mechanisms in most workplaces. However, these questions could not indicate whether the compensation was done during normal working hours or extra working hours. Therefore, lost work could not be corrected for compensation mechanisms as done by Jacob-Tacken et al.[39] and Severens et al.[40] who assumed that no loss would occur if missed work was compensated by the absent worker later during normal working hours and/or his/her colleagues during normal working hours.

The majority of employed workers work in a team at least a little of the time. When they are absent or when they are at work but unable to work at full capacity, this can affect the function of the entire team. Over half of the workplaces in our study did not have regular employees or temporary workers who were perfect substitutes of the study workers with absenteeism or presenteeism. On time production or time sensitivity of output i.e., the work can not be postponed easily without consequences was also noted. These findings confirmed that when one employee is absent or present at work but unable to work at full capacity, the output loss at their workplace exceeded the output of the employee alone because the entire or partial output of the workers team may be lost.

It is worth noting that the concept of teamwork can be very broad. In the management literature, a variety of team design features have been found positively correlated with team performance.[76] Stewart[76] classified team design features into three broad categories: group composition (aggregated characteristics, heterogeneity, team size), task design (interdependency, autonomy) and organizational context (leadership, training). In the VOLP, we did not incorporate all these categories. Instead, we only measured three aspects related to team production: frequency of working with a team, team size and impact on team function.

In this chapter, we proposed a different method of deriving wage multipliers. We used the VOLP itself to generate multipliers based on an assumption that each team member is paid similarly to the study subject and thus their output was additive. The additive algorithm is presented in the Table 3.4. The advantage of the method is that no external data are required to value productivity loss. Furthermore, the VOLP can be used in clinical trials, where it is infeasible and unethical to ask both patients and their managers questions about productivity. In studies of Pauly et al.,[26,28,29] the managers instead of the employees rated the teamwork, availability of perfect substitute and time sensitivity factors. Managers were thought to be in a better position to consider and understand output than the employees. The VOLP did not ask employees to value the output directly but just to answer output-related workplace characteristics questions. The low number of missing responses (Table 3.3) suggests good awareness of employees about their workplace characteristics. However, it is still possible that the personality or cognitive characteristics of employees (e.g., self enhancing biases) would influence the validity of the measures on team function and substitutability.

Multipliers based on employees' self-reported responses have potential limitations. They cannot capture time sensitivity because it is hard for employees themselves to estimate the magnitude of the corresponding impact. Also, the additive assumption of output is questionable. Furthermore, it is not recommended to generalize the study results (multipliers by job categories) to other study populations with different cultures. In practice, the VOLP should be used to obtain the multiplier for each study participant. One alternative to overcome these limitations as in Pauly et al., i.e., was to survey a large, representative sample of managers in different countries. But either managers or employees do not know the actual productivity. Another method is to use the existing population-based datasets linking employees' input to their employers' output. Such databases can be used to test the null hypothesis that wage is equal to marginal productivity. If the hypothesis is rejected, the wage multipliers might be developed for a wide variety of job types. An advantage of this method is that such population-based dataset provide actual productivity estimates. The Workplace and Employee Survey (WES) conducted by Statistics Canada[77] is such a database that we can use for future investigation. Importantly, for both alternative methods described, it will be still necessary to collect detailed information about job type and workplace characteristics from study participants. Hence, the VOLP has the ability to value productivity loss using internal responses and/or using multipliers for different job and workplace characteristics developed from external data.

We propose that from a theoretical standpoint, using a societal perspective, marginal productivity is more likely to be equal or higher than wage and so multipliers relating wage to marginal productivity should be equal or great than 1. Our multipliers have taken into account the additional impact of absenteeism and presenteeism on the work team. The magnitude of the impact depends on the availability of substitutes and their substitutability (Table 3.4). There are strong theoretical grounds for the multiplier being greater than 1 when taking into account the effects of teamwork.[26] Of course, it will be important to validate this theoretical model with empirical evidence of actual/objective measures of productivity. We plan to use WES data to examine this in the following chapters.

Importantly, compensation mechanisms could also have an impact on productivity loss. In the literature, different assumptions have been made in terms of the effect. It has been suggested that compensation mechanisms in workplaces could reduce quantity of lost work and thus productivity loss.[39,40] Others have argued that compensation mechanisms themselves are not costless.[38,58] For example, the absent worker or colleagues who take over the work might have to sacrifice their leisure time or take more effort to make up the lost work even during normal working time. Based on economic theory, the value of lost leisure time and effort has been assumed to be equal to wage.[38] We did not incorporate such effect of compensation mechanisms into our multipliers. However, when considering compensation mechanisms, our multipliers are still relevant. For example, if lost work is not compensated or can not be compensated without cost and the cost is assumed to be equal to wage, then productivity loss will be lost work time multiplied by wage and the multipliers depending on the availability of substitutes. If lost work can be fully compensated without cost, there would not be any productivity losses, i.e. the loss would be zero. If lost work can be partially compensated without cost, then productivity loss would be the uncompensated lost work time multiplied by wage and the multiplier developed for the scenario when no one takes over the work (Table 3.4).

If a worker is absent from work or is at work but sick, we conclude that from the societal perspective, the output loss of the workplace may be more than the wage of the employee alone depending on workplace characteristics. We developed a measure to capture the essential information in order to measure the actual output loss attributable to absenteeism and presenteeism. While our study demonstrates the feasibility of the VOLP, differences between multipliers from the VOLP, existing studies (e.g. Pauly et al.) and other sources of data (e.g. WES), should be investigated. The VOLP provides a new practical approach to value productivity loss associated with health from a societal perspective.

Chapter 4: Measuring time input loss among patients with rheumatoid arthritis: Validity and reliability of the Valuation of Lost Productivity questionnaire[4]

4.1 Introduction

A wealth of literature showed that Rheumatoid Arthritis (RA) has a significant impact on an individual's ability to perform paid work.[64,78–82] Patients could stop work due to the disease. Studies showed that after five years since the onset of the disease, approximately 30-40% of RA sufferers (who were initially employed) were no longer working.[78,79] Patients still in paid employment might also take sickness absence and/or reduce their performance while working. Sick leave was found significant in the first year of RA with an average of 113 days and was about 82 days per person-year within the first 3 years.[80] In addition, one recent study showed that employed patients with moderate and severe RA need work an average of 2 extra hours in 2 weeks to catch up on tasks that they were unable to complete in normal working hours.[81] In another study, employed patients with RA reported 5.9 days with productivity reduced by at least half and 92.9% of them reported interference of RA with their work productivity.[82]

In addition to paid work, RA places burden on unpaid work such as housework, shopping and childcare. Patients might have to give up the unpaid work activities and find help from their family or professional caregivers. For example, in a clinical trial with a treatment period of 12

[4] A version of Chapter 4 has been published. Zhang W, Bansback N, Kopec J, Anis A. Measuring time input loss among patients with rheumatoid arthritis: validity and reliability of the Valuation of Lost Productivity questionnaire. Journal of Occupational and Environmental Medicine. 2011;53:530-6.

weeks, patients with moderate and severe RA reported 10.6 hours of unpaid help and 1.9 hours of paid help in 2 weeks at baseline and 7.2 hours of unpaid help and 1.6 hours of paid help at study end.[81] Other studies showed about 40-50% of RA patients need help with their household work.[37,83]

However, cost-of-illness studies or economic evaluations usually require estimating the costs associated with the loss on paid work and unpaid work. In order to estimate the costs, it has been recommended that the loss be measured in terms of time amount first and then multiply it by the value of the time (e.g., wage).[2,58] In addition, it has been suggested that job and work characteristics such as job and industry type, interaction within a team, availability of perfect substitute, and compensation mechanism have impacts on the value of productivity loss and thus need to be measured for valuation purpose.[58] Labour input loss includes presenteeism, absenteeism, employment status changes (including reducing routine working time, job loss and early retirement), as well as loss in unpaid work. Presenteeism refers to reduced labour input due to health problems while working and absenteeism refers to the number of missed workdays for employed people. Many questionnaires have been developed to measure absenteeism and presenteeism in arthritis or musculoskeletal disorders[69] and only a few measure the impact on unpaid work such as the Health and Labour Questionnaire (HLQ),[35,36] the Work Productivity and Activity Impairment Questionnaire (WPAI),[49,84] and the Rheumatoid Arthritis-specific Work Productivity Survey (WPS-RA).[82] However, no one questionnaire has measured all the four components of labour input loss in time amount and collected information on job and workplace characteristics, which is necessary for valuation.

Consequently, a questionnaire, the Valuation of Lost Productivity questionnaire (VOLP), was developed to fill in the gap. The questionnaire was designed to help value productivity loss in cost-of-illness studies and economic evaluations. The objective of this Chapter is to examine the validity and test-retest reliability of the time input loss measured by the VOLP among RA patients.

4.2 Methods

4.2.1 VOLP

The VOLP is a generic questionnaire assessing the labour input loss due to health (any physical, mental, or emotional problems or symptoms). It consists of 6 sections: employment status, job characteristics, absenteeism, work performance, unpaid work and working environment. The detailed development and content of the VOLP has been described in Chapter 3.[85]

The main VOLP outcomes to be validated in this Chapter were absenteeism, presenteeism, and unpaid work loss. Absenteeism was measured by the number of absent workdays due to health in the past 3 months, a question adapted from the PROductivity and DISease Questionnaire (PRODISQ).[47] Presenteeism was measured by a direct hour estimating method applied in the HLQ.[35,36] Respondents were first asked to think of the work they completed during the past 7 days and answer whether they would complete the same work in less time if they did not experience any health problems. If yes, they were asked to indicate the time in hours they actually used to do all the work during the past 7 days, and the time they would use to do the same work if they did not experience any health problems. The percentage time loss while working due to health among actual work time in the past 7 days was calculated by dividing the difference between hours actually used to complete work with health problems in the past 7 days and hours used to complete the same work without health problems by hours actually used to complete work with health problems. Unpaid work loss was measured by the number of hours of getting help on unpaid work activities including household work, shopping, odd jobs and chores, childcare and volunteer activities due to health in the past 7 days. These questions were adapted from the HLQ.[35,36]

4.2.2 Study design

Patients with RA were recruited from the Early Rheumatoid Arthritis Network (ERAN) cohort based in the UK. Those who reported having paid work at their recent follow-up with ERAN were contacted to consider participation via an invitation letter and provided with a Patient Information Sheet explaining the additional assessments. Each patient who agreed to participate in the study was required to complete the VOLP on two occasions. On the first occasion, everyone completed the VOLP alongside with other questionnaires (described later) at home. Following receipt of the first questionnaire, the second questionnaire was dispatched by post to the study subjects by the study coordinator, with instructions for completion exactly 2 weeks after the date of the first completion. The second questionnaire included a shortened version of the VOLP (absenteeism, presenteeism and unpaid work only). Additional transition questions were asked about whether their health, work performance or ability to do unpaid work has changed within the previous month. Questionnaires were returned to a central ERAN study administrator via prepaid post or courier. The site study coordinator followed up late returns (>1 week after post date).

4.2.3 Other questionnaires

According to Zumbo,[86] validity is the explanation for the test score variation and validation is the process of developing and testing the explanation using psychometric or statistical methods. The construct validity was first tested by measuring the correlations between the VOLP and clinical outcomes. We selected a number of instruments measuring clinical outcomes of RA that showed to be correlated with work productivity in the literature[79,87–90] and asked all the participants to complete them alongside the VOLP at the first assessment. The Multidimensional Health Assessment Questionnaire (MDHAQ)[91] is a validated 1-page questionnaire including a measure of functional disability, pain, and patient global estimate of health impact. Functional disability was measured by 10 activities of daily living (ADL), each of which was scored 0-3, 0="without any difficulty", 1="with some difficulty", 2="with much difficulty" and 3="unable to do." To be consistent with the Health Assessment Questionnaire score (HAQ), a function score of 0-3 was generated by taking the average of the 10 ADL scores. Both pain and patient global estimate of health impact were measured using a visual analogue scale (VAS). Two additional VAS scales were used to measure patient assessment of fatigue problem and patient global assessment (PGA) of disease activity. Previous studies have found a strong correlation between PGA and the Disease Activity Score using 28 joint count, indicating that PGA is a good measure of disease activity.[92] All the VAS scales were presented as 21 circles and an arithmetic scale of 0-10 in 0.5 unit increments was printed below the circles.

In addition, the WPAI questionnaire measuring work and activity impairments due to general health was also included to assess the construct of the VOLP.[49,93] The WPAI has a 7-day recall period. Three outcomes can be generated from the WPAI to correspond to the three VOLP main outcomes: 1) number of hours missed from work due to health problems; 2) percent impairment while working due to health problems; 3) percent activity impairment due to health problems.

4.2.4 Analyses

Previous studies showed that productivity outcome data were skewed to the right with relatively more 0s or low lost-hour estimates because some people did not miss work, reduce work productivity while working, or get help with their unpaid work.[52,81] Due to the highly skewed nature of productivity outcome data, Spearman's correlation coefficient was used to assess construct validity. The ability of the VOLP to discriminate between worse and better health status was studied by dividing the study sample into groups according to the median of each clinical outcome of RA. Wilcoxon tests were used to identify whether VOLP outcomes vary with different health status. The effect size, the standardized mean difference between two groups on a measured outcome, was also calculated.

Kappa statistic for categorical variables was used to examine test-retest reliability.[94] Each VOLP outcome was first divided into 2 categories (0 vs. >0) because they were highly skewed with 0 as the majority. The category with outcome>0 was further divided into two groups according to the median of the corresponding VOLP outcome when it is greater than 0. Kappa statistic >0.6 is considered as substantial/perfect, 0.4-0.6 as moderate and <0.4 as fair/poor.[95] The possible systematic difference between two assessments was tested by Wilcoxon signed-rank test. Furthermore, the absolute difference between two assessments was categorized at different levels using the 0-10 days for absenteeism, 0%-20% for presenteeism and 0-10 hours for unpaid work loss, respectively. For each level of difference, the cumulative percentage of the respondents was determined and plotted. Since labour input loss changes over time and the actual duration between the first assessment and the second assessment was not exactly 2 weeks as instructed, the analysis was conducted among all respondents as well as among the respondents who answered the questionnaires two times within 21 days and reported no changes in work performance or ability to do unpaid work in the past month.

4.3 Results

A total of 354 patients who were in employment at the most recent follow-up in ERAN were contacted for the study and 186 (53%) agreed to participate in the study and were sent the questionnaires. 152 completed the VOLP and other questionnaires at the first assessment and 116 of them completed the shortened version of the VOLP at the second assessment. The average age was 52 years old and 72% were female (Table 4.1). The disease duration was about 49 months since onset of symptom and 38 months since first rheumatology visit. Patients had relatively mild functional disability (Mean=0.6, Standard Deviation (SD)=0.5), pain (3.6, SD=2.5), disease severity (3.5, SD=2.6) and fatigue (4.6, SD=2.9). At the first assessment, of the 140 patients who were working for pay or self-employed, 60 (43%) reported absence from work in the past 3 months (absenteeism) due to their health with an average of 10 absent workdays (Table 4.2). Among 125 patients who actually worked in the past 7 days, about 5% of their actual work time was lost due to their health problems (presenteeism) though only 27 (22%) patients reported such loss. In addition, 45 patients got help (12 hours) with their unpaid work from families, neighbours, or paid help due to health problems in the past 7 days (unpaid work loss).

Table 4.1. Demographic, clinical and job characteristics

Variables (N=152)	Mean (SD)	Median (Q1-Q3)
Age	52.3 (10.1)	53.0 (45.7-59.7)
Duration since onset of symptoms (months)	48.6 (23.2)	46.0 (33.0-59.5)
Duration since first clinic visit (months)	37.5 (18.2)	35.7 (23.5-50.9)
Function (0-3)	0.6 (0.5)	0.5 (0.2-0.9)
Pain (0-10)	3.6 (2.5)	3.0 (1.5-5.5)
Health impact (0-10)	3.0 (2.4)	2.5 (1.0-5.0)
Fatigue (0-10)	4.6 (2.9)	5.0 (2.0-7.0)
PGA (0-10)	3.5 (2.6)	3.0 (1.5-5.5)
No of work days per week	4.6 (1.1)	5.0 (4.0-5.0)
No of work hours per week	32.6 (12.7)	35.0 (22.5-40.0)
	N	**%**
Female	110	72.4
Working for pay or self employed	140	92.1
Work status		
Full time	67	47.9
Part time	54	38.6
Self-employed	18	12.9
Work habits		
Usually sit	51	36.4
Stand or walk	53	37.9
Light load	20	14.3
Heavy load	11	7.9
Job category		
Manager	20	14.3
Professionals	22	15.7
Technicians	16	11.4
Clerk	24	17.1
Services and sales	37	26.4
Agriculture and fishery	4	2.9
Craft	7	5.0
Operators	7	5.0
Elementary occupations	3	2.1
Income		
Prefer not to answer	13	9.3
Less than £10,000	30	21.4
£10,000 - £19,999	53	37.9
£20,000 - £29,999	24	17.1
£30,000 - £39,999	12	8.6
£40,000 and above	7	5.0

Health impact: patient global estimate of health impact; PGA: patient global assessment of disease activity; SD: standard deviation; Q1: the first quartile; Q3: the third quartile

Table 4.2. VOLP outcomes at the first assessment and the second assessment

Variables	First assessment N	Mean (SD)	Median (Q1-Q3)	Second assessment N	Mean (SD)	Median (Q1-Q3)
Among patients who were working for pay or self-employed	*140*			*112*		
Absenteeism (in the past 3 months)						
No of absent workdays due to health	138	4.4 (10.5)	0 (0-3.0)	110	3.7 (8.5)	0 (0-3.0)
No of absent workdays (>0 absent workdays)	60	10.1 (13.9)	4.0 (2.0-13.0)	44	9.3 (11.4)	3.8 (2.0-10.5)
Among patients who went to work in the past 7 days	*125*			*101*		
Presenteeism (in the past 7 days)						
% time loss while working due to health among actual work time	101	4.9 (9.5)	0 (0-5.6)	88	4.9 (9.4)	0 (0-7.2)
% time loss while working (>0 time loss)	27	18.4 (9.3)	17.1 (12.5-25.0)	27	15.8 (10.8)	12.5 (9.3-20)
Among all patients	*152*			*116*		
Unpaid work loss (in the past 7 days)						
No of hours of getting help with unpaid work due to health	136	4.0 (8.3)	0 (0-2.8)	112	3.2 (6.2)	0 (0-4.0)
No of hours of getting help (>0 hours)	45	12.1 (10.5)	9.0 (3.0-20.0)	40	9.0 (7.6)	6.0 (3.5-13.0)

SD: standard deviation; Q1: the first quartile; Q3: the third quartile

The response rates for absenteeism and unpaid work loss were relatively high (Table 4.2). At the first assessment, they were 138/140=98.6% and 136/152=89.5%, respectively. At the second assessment, the response rates were 110/112=98.2% and 112/116=96.6%, respectively. The VOLP presenteeism had low response rates at the first assessment (101/125=80.8%) as well as the second assessment (88/101=87.1%).

The correlation analyses showed that the correlations between the VOLP outcomes and the clinical outcomes were in the logical direction ($r=0.24-0.42$, p values <0.01) (Table 4.3). Absenteeism was more correlated with function, pain, health impact, and disease activity than the other two VOLP outcomes. Presenteeism had a higher correlation with fatigue than absenteeism and unpaid work loss. Function had the highest correlations among clinical outcomes with all three VOLP outcomes. The correlation between the VOLP and the WPAI was higher than the correlations between the VOLP and clinical outcomes. The number of absent workdays in the past 3 months was highly correlated with the number of work hours missed from work measured by the WPAI ($r=0.57$, $p<0.01$). The correlation between the % time loss while working and the WPAI impairment while working was 0.42 ($p<0.01$) and that between the number of hours of getting help with unpaid work activities and the WPAI activity impairment was 0.39 ($p<0.01$).

Table 4.3. Spearman correlations between VOLP outcomes and clinical outcomes and WPAI outcomes

	No of absent workdays due to health	% time loss while working due to health among actual work time	No of hours of getting help with unpaid work due to health
Function	0.42	0.39	0.38
Pain	0.36	0.25*	0.31
Health impact	0.39	0.29	0.32
Fatigue	0.30	0.34	0.24
PGA	0.31	0.27	0.29
WPAI†	0.57	0.42	0.39

Health impact: patient global estimate of health impact; PGA: patient global assessment of disease activity; WPAI: work productivity and activity impairment questionnaire
†Correlations between the VOLP outcomes and the corresponding WPAI outcomes
*Spearman correlation p value=0.013; otherwise p values <0.01

When the patients were divided into two groups according to the median of each clinical outcome variable, each VOLP outcome was significantly lower among patients with better clinical outcome versus patients with worse clinical outcomes except presenteeism among patients with more pain (p>0.1) (Table 4.4). For example, patients with low functional disability (lower than median) had significantly fewer absent workdays (2 vs. 8 days), lost a lower percentage of actual work time while working (3% vs. 9%), and needed less help with unpaid work (2 vs. 7 hours) than those with high functional disability. According to the effect size, the VOLP outcomes were able to discriminate between patients with better clinical outcomes and those with worse clinical outcomes (0.34-0.65). All three VOLP outcomes have higher ability to discriminate function (highest effective size) than other clinical outcomes.

Table 4.4. VOLP outcomes between two patient groups defined by the median of each clinical outcome

		Function	Pain	Health impact	Fatigue	PGA
No of absent workdays due to health	Better	2.1 (4.8)***	2.3 (6.1)***	1.8 (4.8)***	2.0 (5.0)***	2.3 (6.0)***
	Worse	7.7 (14.7)	6.8 (13.3)	6.9 (13.4)	7.2 (13.9)	6.9 (13.7)
	Effect size	*0.56*	*0.44*	*0.51*	*0.51*	*0.45*
% time loss while working due to health among actual work time	Better	2.7 (6.7)***	3.6 (8.2)	3.3 (7.7)**	3.1 (7.2)**	3.2 (7.6)**
	Worse	8.6 (12.0)	6.8 (10.8)	7.0 (11.1)	7.6 (11.6)	7.4 (11.3)
	Effect size	*0.65*	*0.34*	*0.39*	*0.49*	*0.45*
No of hours of getting help with unpaid work due to health	Better	2.4 (7.5)***	2.4 (7.5)***	2.2 (6.4)***	2.5 (6.5)***	2.4 (7.3)***
	Worse	6.5 (8.9)	6.0 (8.7)	6.1 (9.7)	6.0 (9.8)	6.3 (9.0)
	Effect size	*0.51*	*0.44*	*0.48*	*0.43*	*0.49*

Health impact: patient global estimate of health impact; PGA: patient global assessment of disease activity
Better and worse health status were categorized using the median of each of the clinical outcomes described in Table 1
***Wilcoxon test p value≤0.01; **Wilcoxon test p value≤0.05; *Wilcoxon test p value≤0.1

When the VOLP outcomes were classified into two categories (0 vs. >0), the Kappa was greater than 0.6 except for unpaid work loss. The Kappa for absenteeism, presenteeism and unpaid work loss was 0.73, 0.63, and 0.39, respectively, among all respondents whereas it was 0.80, 0.76 and 0.35, respectively, among respondents reporting no changes in work performance or ability to do unpaid work in the past month. The VOLP outcomes were further classified into three categories using 0 and 5 days as the cutoffs for absenteeism, 0 and 15% for presenteeism, and 0 and 10 hours for unpaid work loss. If all respondents were considered, the Kappa was substantial for absenteeism (0.84) but not for presenteeism (0.57) or unpaid work loss (0.49). However, among respondents reporting no changes in work performance or ability to do unpaid work, the Kappa was substantial for absenteeism (0.91) and presenteeism (0.61) but not for unpaid work (0.43). All of the above Kappa statistics were significantly different from 0 (p values<0.01). According to Wilcoxon signed-rank test, VOLP outcomes were not significantly different between the first assessment and second assessment (Table 4.5).

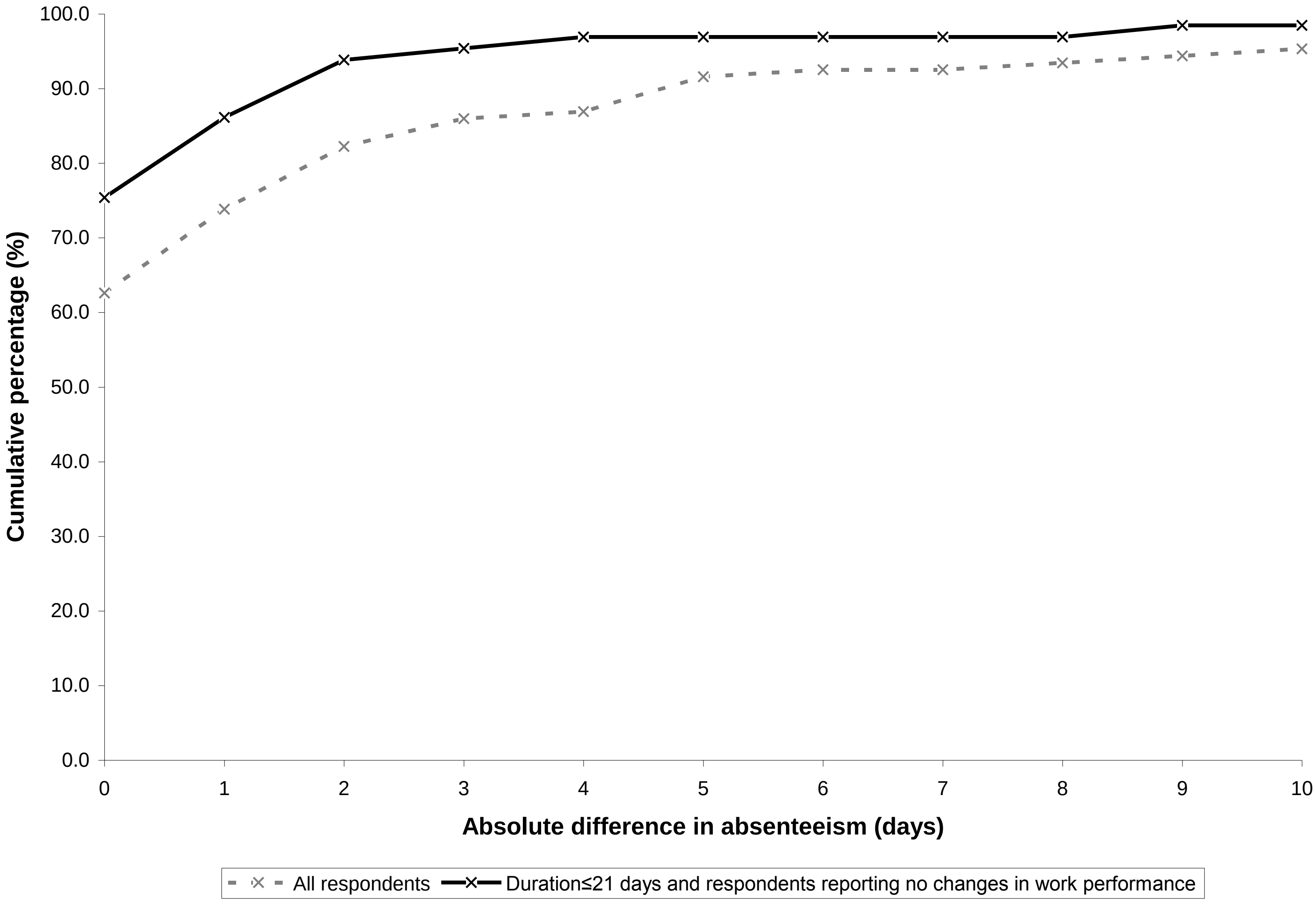
Table 4.5. VOLP outcome differences between the two assessments

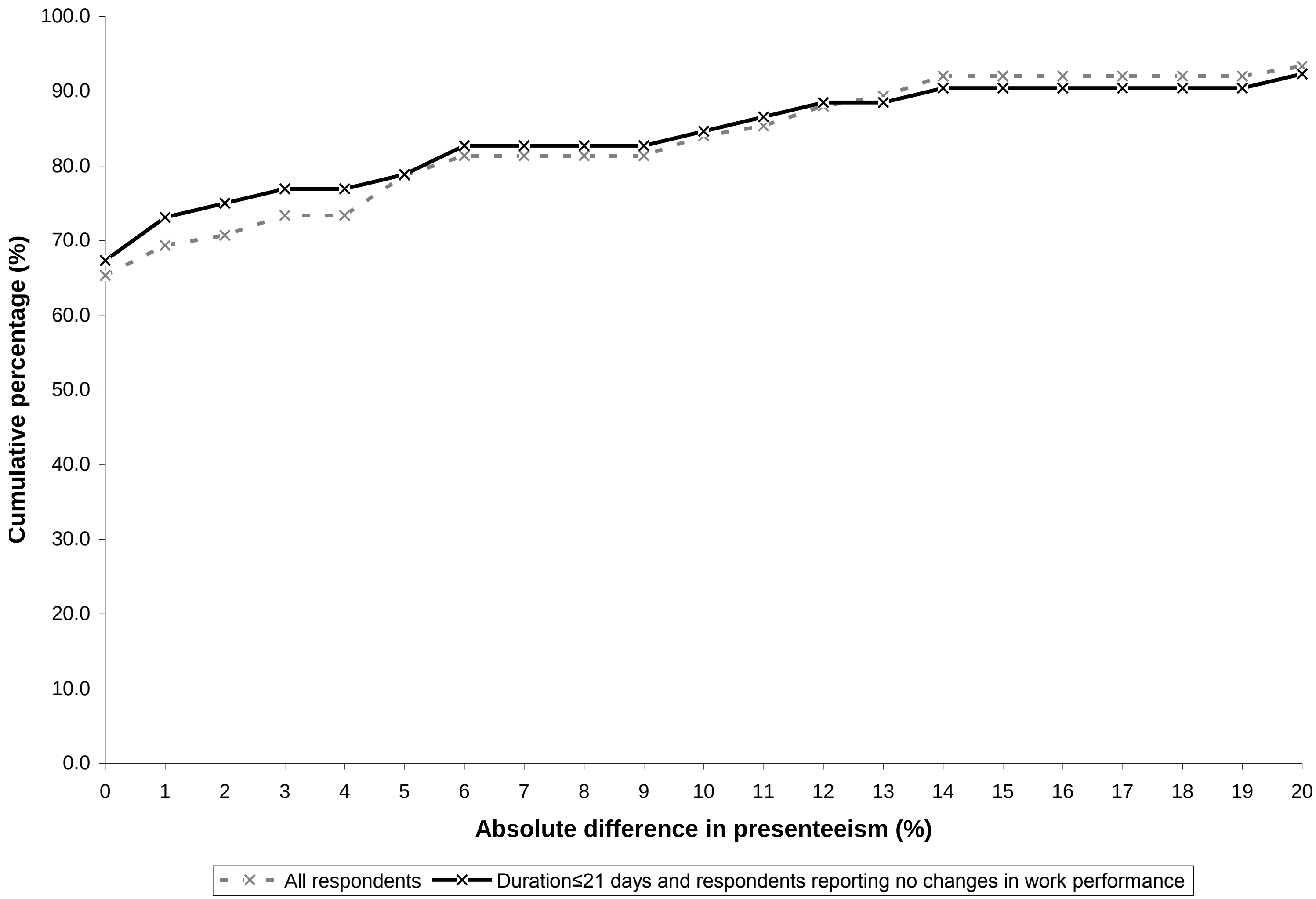
	N[†]	First assessment		Second assessment		Differences		
		Mean (SD)	Median (Q1-Q3)	Mean (SD)	Median (Q1-Q3)	Mean (SD)	Median (Q1-Q3)	p value[‡]
All respondents								
No of absent workdays due to health	107	4.26 (10.65)	0 (0−3)	3.79 (8.62)	0 (0−3)	-0.46 (8.92)	0 (0−0)	0.239
% time loss while working due to health among actual work time	75	4.99 (9.62)	0 (0−6.25)	4.18 (8.96)	0 (0−5.41)	-0.80 (9.85)	0 (0−0)	0.420
No of hours of getting help with unpaid work due to health	104	4.14 (8.15)	0 (0−3)	2.89 (5.93)	0 (0−3.50)	-1.25 (7.19)	0 (0−0)	0.214

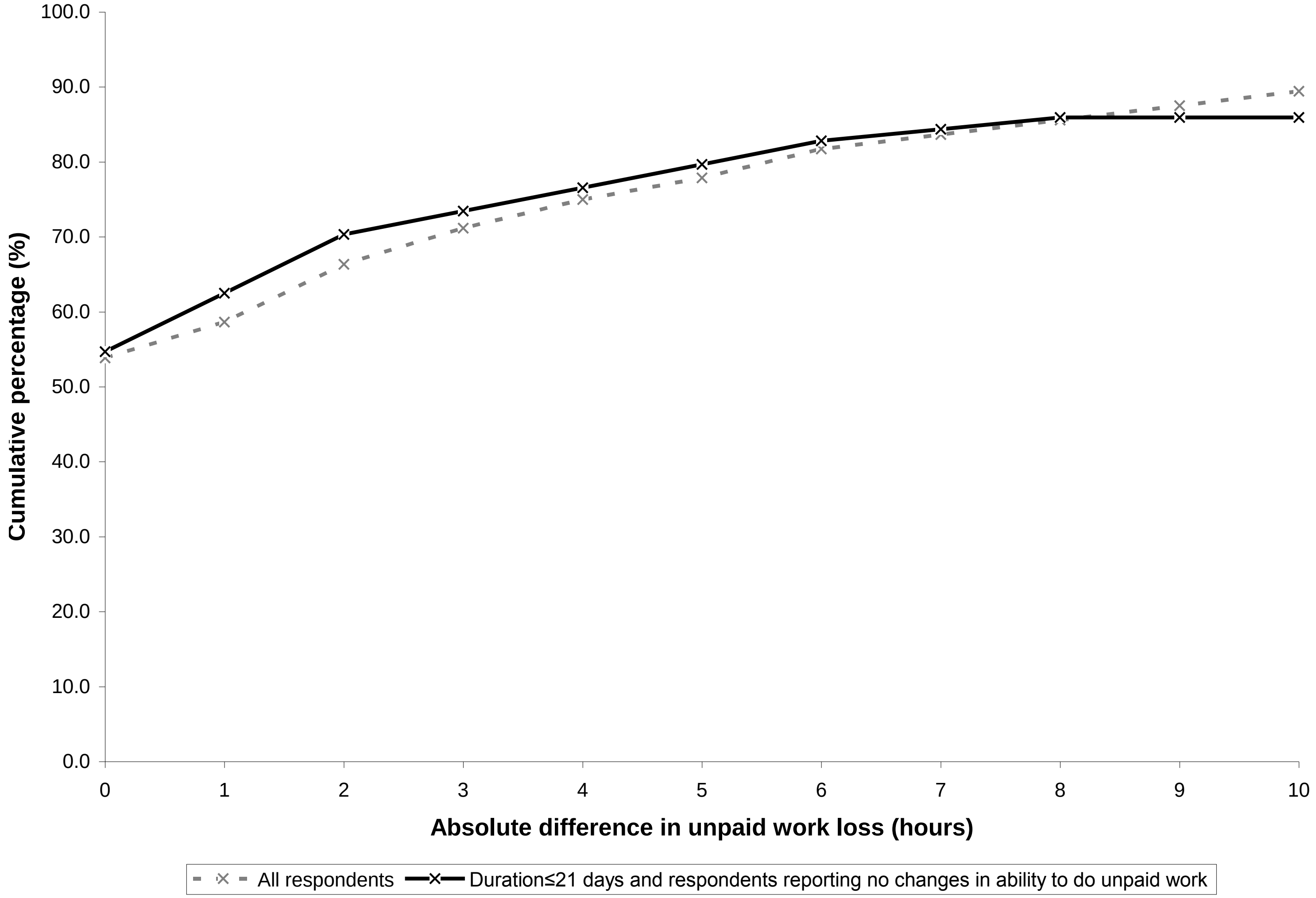
[†]Those who responded at both assessments; [‡]Wilcoxon singed-rank test

Figure 4.1 presents the cumulative percentages of respondents who reveal any difference between assessments at difference levels for absenteeism, presenteeism and unpaid work loss, respectively. About 63, 65, and 54% among all respondents reported absenteeism, presenteeism and unpaid work loss, respectively, at the second assessment perfectly matched those at the first assessment. The percentages increased to 75, 67, and 55%, respectively, when analyses were restricted to respondents who responded to two assessments within 21 days and reported no changes in work performance or ability to do unpaid work in the past month. If an accepting of a maximum difference between assessments was 5 days for absenteeism in 3 months, 10% for presenteeism in one week (=4 hours for a 40-workhour week) and 5 hours for unpaid work loss in one week, the percentages among all respondents were 92, 84 and 78%, respectively. Similarly, the percentages increased to 97, 85, and 80%, respectively, if restricting to respondents who responded to two assessments within 21 days and reported no changes in work performance or ability to do unpaid work.

Figure 4.1. Cumulative percentage of respondents regarding their absolute difference in VOLP outcomes between first assessment and second assessment




100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Cumulative percentage (%)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Absolute difference in presenteeism (%)
All respondents
Duration≤21 days and respondents reporting no changes in work performance


100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Cumulative percentage (%)
0
1
2
3
4
5
6
7
8
9
10
Absolute difference in unpaid work loss (hours)
All respondents
Duration≤21 days and respondents reporting no changes in ability to do unpaid work

4.4 Discussion

The VOLP questionnaire was developed for valuation of productivity loss according to the recommendations provided in the literature and guideline.[2,7,8,58] In this study, we tested the validity and test-retest reliability on measuring labour input loss including absenteeism, presenteeism and unpaid work loss. While the VOLP outcomes are associated with all the clinical outcomes (0.24-0.42), they correlate more with functional disability and better discriminate function disability than other clinical outcomes. The literature consistently showed that physical functional disability measured by the HAQ has impact on the ability to work.[79,87,88] Pain and poor physical functioning were also found to be associated with both increased sick leave and reduced productivity at work.[89,90] Our study confirmed the relationship between pain and function and labour input loss.

As expected, the VOLP was shown to be more correlated with the WPAI than the clinical outcomes. It is also not surprising to see that the correlations between the VOLP and the WPAI for both presenteeism and unpaid work loss are not as high as that for absenteeism, which may indicate that the two questionnaires measure different constructs on presenteeism and unpaid work loss. For unpaid work loss, the VOLP measures the help with unpaid work obtained from others but the WPAI measures the overall impairment on daily activities.[49,93] The moderate correlations between the two measures may indicate that people with impairment on their unpaid work activities may not necessarily seek help from others. As mentioned before, to estimate the cost, we need to measure the amount of time lost. The VOLP estimates the time loss for valuation purpose and the WPAI provides a scale representing the impairment levels. They can be used for different purposes. For presenteeism, a previous study comparing different measurement methods found that the correlation between the estimate using the 0-10 scale method (WPAI) and the estimate using the direct hour estimating method (HLQ) was 0.37,[52] which is similar to what we found between the WPAI and the VOLP. A further study will be conducted to find out the specific construct the VOLP actually measures in terms of its presenteeism. Specifically, does it only measure work productivity related constructs or measure quality of life and psychosocial factors, or both?

This study was one of a few studies that conducted test-retest reliability of a work productivity questionnaire. There were two other studies assessing test-retest reliability of the WPAI.[96,97] In one study, the second assessment by the same observer was made at most one hour after the first assessment on the same day.[96] The other study used one week.[97] Completing two assessments on the same day may not be able to tease out the memory effect. But in practice, it is difficult to recruit many people to complete questionnaires at the same time and then return at the same time to complete the questionnaires again. In our study, we decided to dispatch questionnaires by post to the study subjects. We think a two-week period between two assessments is a feasible time period for study subjects to return the first questionnaire and then receive the second questionnaire. We also asked participants at the second assessment whether there had been any changes in their work performance and their ability to do unpaid work in the past month because if work performance changed over time, it would lead to changed labour inputs. However, the actual duration between two assessments varied from 4 to 71 days with a median of 14 (interquartile range: 13-20). Based on this fact, we also conducted analyses for duration$\leq$21 days and respondents who reported no changes in work performance and unpaid work ability.

The reliability of absenteeism and presenteeism was confirmed by high Kappa statistics among respondents reporting no changes in work performance. Figure 1 also showed that there were a high percentage of perfect agreement between assessments (75% for absenteeism and 67% for presenteesim) and a high agreement between assessments (97% and 85%, respectively) at an acceptable difference level (5 days for absenteeism and 10% for presenteeism) among respondents who responded to two assessments within 21 days and reported no changes in work performance or ability to do unpaid work. The findings suggest we should pay attention to the extreme outliers and might consider excluding them in analyses. Unpaid work loss not only has the similar outlier problem but also shows a moderate reliability. A possible explanation is that the need for help fluctuates and is arbitrary and the amount of help not only relates to the ability to do unpaid work but also some other factors such as the availability of family members and the ability of the patients to pay for help.

Traditionally, test-retest reliability for continuous measures was assessed using the Intraclass Correlation Coefficient (ICC).[98] However, our data was highly skewed with 0 as the majority and thus ICC was not applicable. Instead, Kappa statistic for categorical variables was used to measure agreement between assessments by dividing the outcomes into categories.[94,95] However, the Kappa statistic may be affected by the way to categorize the outcomes. For example, a perfect Kappa can be calculated when respondents reported 20 absent workdays at the first assessment and 5 days at the second assessment if both numbers are classified into one category. Therefore, we also adopted a method used by Severens et al. in analyzing the difference between registered and reported data on sick leaves.[53] Using this method, we take into account the absolute difference between two assessments, which is not done using Kappa.

There were several limitations to this study. The VOLP presenteeism had high invalid response rates at the first assessment (24/125=19.2%) and second assessment (13/101=12.8%) (Table 2). In our previous study, we also found a high missing rate with the HLQ presenteeism estimate (17%) which uses a similar direct hour estimating method.[52] This indicates that the respondents might not understand the question or they had difficulty in providing the hour estimates directly. Also, in five previous studies in which the HLQ was employed, the overall response rates ranged from 58% to 81%, which suggests that it is difficult to estimate loss in time amount.[35,36] Thus, further investigations of this issue are needed.

Another limitation is that productivity outcomes were self-reported and we did not have objective measures of productivity (e.g., records from employers) as a validation criterion. A lack of panel data is also a major limitation. In a future study, a panel data will be used to test the responsiveness (i.e., the ability of a questionnaire to accurately measure changes over time) of the VOLP among patients with RA.

In conclusion, the study provides evidence on the validity of VOLP in measuring time input loss among people with RA and that it is able to discriminate between patients with different RA clinical outcomes especially different functional disability levels. The lower correlations between the VOLP and clinical outcomes indicate labour input might be additionally influenced by a variety of non-health related contextual factors. Study results provide important evidence of the substantial reliability of absenteeism and presenteeism. However, researchers should be aware of the extreme outliers.

Chapter 5: An empirical application of VOLP

5.1 Introduction

Rheumatoid arthritis (RA) is a systemic inflammatory disorder with a prevalence rate of about 1% and an annual incidence of 3 per 10,000 adults.[99] It has been demonstrated that RA has a substantial effect on work productivity and the effect can occur at the very early phase of the disease. Eberhardt et al. showed that the work disability rate increased from 28% at baseline to 35% after 5 years in an early RA cohort with mean disease duration of 11 months at baseline.[79] Similarly, using a multinational database, Sokka et al. found among 1,756 patients whose symptoms had begun during the 2000s and who were working, 20% of them had stopped working at 2 years and 32% at 5 years.[100] Furthermore, patients with recent-onset RA who are still in paid-employment often take sick leave. Merkesdal et al. reported an average of 82 days of sick leave per person-year within the first 3 years of RA.[80] The ability to work is one of the most valued areas for RA patients.[101] Developing effective treatments and strategies to improve patient work productivity in patients with early RA is therefore an important priority.

Recently, clinical trials have demonstrated that initial aggressive treatment of RA with a combination of disease-modifying antirheumatic drugs (DMARDs) or early intervention with a combination of biologic therapy with methotrexate (MTX) can reduce duration of sick leave and RA-related work disability.[34,102,103] However, these studies focused on measuring job loss and absent workdays, which provides only partial evidence of the effect of early intervention on overall productivity.

According to economic theory, production or output, is typically determined by three factors: capital input, labour input and technology.[58] Thus, productivity loss due to health problems is the output loss due to reduced labour input attributable to poor health. Productivity loss is typically measured according to time loss, i.e., the time a person is not at a job (job loss/stopping work) or absent from work (absenteeism), reduces productivity while at work (presenteeism), or gets help with unpaid work due to poor health. Productivity loss is then monetized into productivity costs by multiplying time loss by the wage rate and a multiplier that adjusts the wage rate to account for actual output loss due to reduced labour input.[9,10]

To date, no studies have measured the impact when considering all the different types of labour input components that affect productivity and the corresponding monetary value among people with early RA.[103,104] Thus, it is still unknown whether overall productivity gains accrue to patients with early active RA receiving early intervention. The objective of this Chapter was therefore to comprehensively evaluate the impact of open label treatment with a combination of etanercept (ETN) and MTX on work productivity in patients with early active RA over 52 weeks. Specifically, it was to assess changes in productivity loss over 52 weeks and to compare total productivity loss over 52 weeks between patients who quickly responded to treatment and those who did not.

5.2 Methods

5.2.1 Study design

This study is based on phase 1 data from the PRIZE trial. This trial is an ongoing, 3-phase study to evaluate the efficacy of combined ETN and MTX therapy in patients with early RA (phase 1) and to assess whether efficacy (remission) can be maintained with ETN dose reduction or biologic-free (phase 2) or drug-free (phase 3).[105] The main inclusion criteria were that subject 1) was ≥18 years or older; 2) satisfied the 1987 American College of Rheumatology (ACR) Revised Criteria for RA; 3) had symptom (swollen joints) onset 12 months or less from date of enrolment; 4) had active disease as indicated by a Disease Activity Score based on a 28-joint count (DAS28) > 3.2; 5) demonstrated functional status of class I, II, or III as defined by ACR revised criteria; 6) was MTX-naïve; 7) was in paid employment or in unpaid but measurable work, such as caring for a family and home.

Phase 1 was a 52-week open-label, single-arm period in which all subjects were treated with ETN 50 mg once weekly plus MTX. Subjects who were not in sustained remission or who did not have low disease activity at the week 39 visit, i.e., DAS28>3.2 were withdrawn from the study and treated in accordance with local clinical practice.

5.2.2 Valuation of Lost Productivity (VOLP) questionnaire and outcomes

The VOLP questionnaire was developed for measurement and valuation of productivity loss from a societal perspective according to accepted principles in the economic evaluation literature.[85] It is a generic and patient-reported outcomes measure assessing productivity loss due to health (any physical, mental, or emotional problems or symptoms). It is the first questionnaire to measure all the time input loss components (absenteeism, presenteeism, employment status changes, and unpaid work productivity loss) as well as information on job and workplace characteristics, necessary for valuing productivity loss attributable to reduced time input of workers. From the VOLP, we estimated the time loss due to health problems as well as the wage multipliers that enable the valuation of productivity loss. It has been validated in people with RA.[75] In this study, the VOLP was measured approximately every 13 weeks.

The paid work productivity loss obtained from the VOLP included three components: 1) absenteeism: the number of absent days in the past 3 months, which were transformed into absent hours according to the self-reported number of work hours and days per week; the percentage of time loss was also calculated as the number of absent hours divided by the number of usual work hours; 2) presenteeism: the frequency of patients who stated they would complete the same work in less time if they did not experience any health problems in the past 7 days; the percentage of time loss while working in the past 7 days was calculated by dividing the difference between hours actually used to complete work with health problems in the past 7 days and hours used to complete the same work without health problems by hours actually used to complete work with health problems; 3) employment status changes due to health including stopping work, starting work, changing job or work hours.

Paid work productivity loss (hours) in the past 3 months was the sum of the time loss from the three components above. If patients were working, paid work productivity loss in the past 3 months was absent hours in the past 3 months (absenteeism) plus the actual work hours in the past 3 months (i.e., usual work hours minus absent hours) multiplied by percentage of time loss while working (presenteeism) by adjusting for changes in work hours during follow-up visits. If patients stopped working, paid work productivity loss in the past 3 months were equal to the hours they used to work in 3 months.

In this study, the main VOLP outcomes of interest at each visit were 1) Paid work productivity loss (hours) in the past 3 months at each visit; 2) Unpaid work productivity loss (hours) in the past 7 days at each visit, quantified by the number of hours of getting help on unpaid work activities in the past 7 days; 3) Total costs of lost productivity in the past 3 months at each visit, the sum of the costs of paid and unpaid work productivity loss.

The main VOLP outcomes of interest during the one-year study period were 4) Paid work productivity loss (hours) in the one-year study period; 5) Unpaid work productivity loss (hours) in the one-year study period; 6) Total costs of lost productivity in the one-year study period. These three outcomes were the sum of the corresponding outcomes at weeks 13, 26, 39 and 52. The Last Observation Carried Forward (LOCF) method was applied for any missing follow up to calculate these productivity loss outcomes.

In addition, we calculated the percentage of paid work time loss for each visit as well as the one-year study period as the number of paid work hour loss divided by the number of usual working hours.

5.2.3 Costing of productivity loss

Since this trial was conducted in multiple countries, we cost the paid work loss by converting the patients self-reported income into Euros in 2010 using Purchasing Price Parties obtained from World Bank.[106] For unpaid work productivity loss, we used the 2010 hourly earnings (Euro) reported by the Eurostat for service and sales workers in each country.[107] The VOLP enables the calculation of wage multipliers for absenteeism and presenteeism based on the workplace characteristics (team work status, availability of substitutes, and their substitutability).[85] Costs incorporating these multipliers represent productivity loss instead of wage loss. In this study, we presented costs with and without multipliers.

5.2.4 Analyses

Our study focused on the subjects who were employed at baseline and who had at least one follow-up with VOLP (weeks 13, 26, 39, and 52). The main VOLP outcomes of interest (paid work productivity loss in the past 3 months, unpaid work productivity loss in the past 7 days, and costs of lost productivity in the past 3 months) at the week 52 visit were compared to those at baseline to assess the productivity gained in patients receiving the combination therapy. Since the protocol allowed some patients to discontinue at week 39, we also compared the main VOLP outcomes of interest at week 39 to those at baseline. For categorical variables, McNemar's test was used to examine percentage changes while the paired t-test was used for the comparison of continuous variables. Since the continuous VOLP outcomes were highly skewed with inflated zeros, bootstrapping methods were used to test hypotheses.[108–110]

Patients were categorized into two groups, early responders versus non-responders, according to their disease activity at week 13 (DAS28≤3.2 vs. DAS28>3.2). The descriptive statistics of the paid work productivity loss, unpaid work productivity loss, and total costs of lost productivity during the one-year study period were presented by the two groups of patients. Bootstrapping was used to test for differences in VOLP outcomes over one year across groups.

Since many patients had no productivity loss, we used zero-inflated models to compare paid and unpaid work productivity loss (hours) during one year. Zero-inflated negative binomial models (ZINB) were chosen according to the Vuong test.[111] For total costs of lost productivity in the one-year study period, a two-part model (a logistic regression for the probability of no costs and a generalized linear model with gamma distribution and log link for nonzero costs) was performed for the comparison.

Our analytical objective was to measure the association of early response status with one-year productivity loss. To ensure an unbiased coefficient of response status variable, the model was adjusted for potential confounders and the unbalanced characteristics between responders and non-responders at baseline. Based on previous review papers on the predictors/variables related to work disability in RA,[87,112] there was evidence showing socio-demographic variables, clinical variables and work related factors were associated with work disability in RA. Therefore, in terms of covariate selection, we first divided all baseline patient characteristics variables except response variable (responders vs. non-responders) into five groups: Group 1: demographics – age, sex, body mass index, smoking status, alcohol use, and country (west Europe or not); Group 2: medication and medical history – RA duration, prior uses of corticosteroids, non-steroidal anti-inflammatory drugs (NSAIDS), and disease modifying anti-rheumatic drugs (DMARDS), and number of diseases reported in the medical history; Group 3: clinical outcomes – patient general health, patient/physician global assessment of disease activity, DAS28, Health Assessment Questionnaire (HAQ), swollen joint count, tender joint count, pain, Functional Assessment of Chronic Illness Therapy (FACIT), Patient Acceptable Symptom State (PASS);

Group 4: quality of life (QOL) measures – EuroQol-5 Dimensions (EQ-5D) and short form-36 (SF-36); Group 5: job/workplace characteristics – working status and work habit.

For each of the three total productivity loss outcomes, baseline variables were first selected within each group of the independent variables (group variable selection).[89] The selection criteria for group variable selections included entry criterion p value ≤0.2 and the smaller Bayesian Information Criterion (BIC).[113] The smaller the BIC is, the better the model fit. The final model selection was then constructed among the variables selected in each group in the first step and the corresponding baseline VOLP outcome. The selection criteria for the final model selections were p value ≤0.1 and the smaller BIC. In the ZINB and two-part model, covariates included in the two parts of the models could be different as long as they met the criteria. Using the variable selection method, we can avoid over-adjustment and address the issue that the variables within the same group were usually highly correlated (multicollinearity issue).

Furthermore, to improve the interpretation of the coefficients of the ZINB and two-part models, we first computed the expected values for responders and non-responders, respectively, while holding the model covariates at their mean value. Then, we computed the difference in expected values between responders and non-responder, which we refer to as the marginal effects. Bootstrapping methodology was used to calculate the confidence intervals.

5.3 Results

Among the total of 306 patients participating in phase 1, 204 reported they were employed at baseline, 101 were unemployed and 1 patient's employment status was missing (Figure 5.1). 196

employed patients who had at least one follow-up with VOLP were included in our final analysis. Among them, 154 completed the phase 1 and 42 did not, including 19 patients who were withdrawn due to not achieving low disease activity at week 39 and 23 patients who discontinued for reasons including adverse events, subject request, investigator judgment, protocol violation, or sponsor's decision.

Figure 5.1. Study cohort flowchart

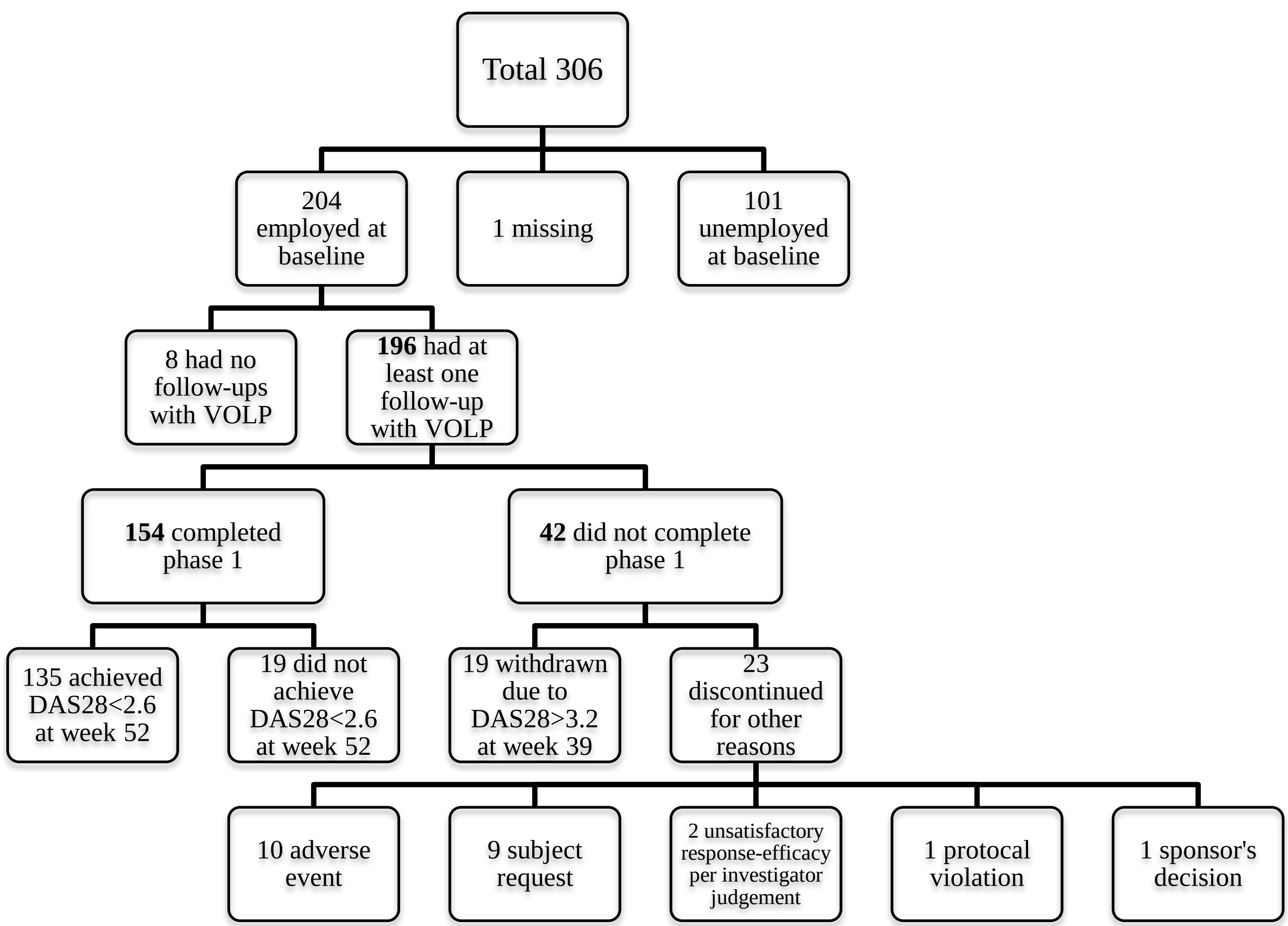


Table 5.1 reports the descriptive statistics (non-missing N, mean, SD, and N [%] for categorical variables) of baseline patient characteristics variables. These baseline patient characteristics variables were categorized into five groups: demographics, medication and medical history, clinical outcomes, QOL measures and job/workplace characteristics.

Average age of study participants was 46 years and 68% were female. The patients had a high disease activity (DAS28=5.91), moderate functional disability (HAQ=1.22), and low utility (EQ-5D=0.49). About 62% were working full time and 11% did heavy work or carried very heavy loads. Average working time was 36.01 hours per week or 4.87 days per week. The estimated wage multiplier implied that the productivity loss was 1.58 or 1.55 times more than the wage loss due to absenteeism and presenteeism, respectively.

Table 5.1. Baseline patient characteristics

Variable	N	Mean (SD) or N (%)
Demographics		
Age, years	196	46.43 (11.39)
Female	196	134 (68.4)
Body Mass Index	196	26.39 (4.89)
Smoking status		
Non smoker	196	100 (51.0)
Has stopped	196	41 (20.9)
Smoker	196	55 (28.1)
Current alcohol use	196	91 (46.4)
West European country	196	130 (66.3)
Medical/Medication History		
RA duration, months	196	6.38 (2.84)
Prior corticosteroids use	191	73 (38.2)
Prior NSAID use	191	134 (70.2)
Prior DMARDs use	191	25 (13.1)
Number of diseases[†]	196	2.4 (2.32)
Clinical Outcomes		
Patient general health score	196	52.47 (22.71)

Variable	N	Mean (SD) or N (%)
Pain assessment score	196	59.04 (21.70)
Patient global assessment score	196	58.4 (23.04)
Physician global assessment score	196	56.43 (16.37)
DAS28	196	5.91 (1.04)
HAQ	194	1.22 (0.64)
Swollen joint count	196	10.29 (5.62)
Tender joint count	196	13.37 (7.02)
FACIT score	193	29.59 (12.07)
PASS (acceptable)	194	48 (24.7)
Quality of Life		
EQ-5D index	190	0.49 (0.30)
EQ-5D VAS	191	52.65 (21.48)
SF-36 mental component summary score	192	43.48 (10.75)
SF-36 physical component summary score	192	34.12 (7.69)
Job/Workplace		
Employment status		
Full time	196	121 (61.7)
Part time	196	43 (21.9)
Self-employed	196	32 (16.3)
Work habit		
Usually sit	193	69 (35.8)
Stand/walk	193	74 (38.3)
Light loads	193	29 (15.0)
Heavy loads	193	21 (10.9)
Number of work hours per week	196	36.01 (11.90)
Number of work days per week	196	4.87 (0.92)
Multiplier for absenteeism‡	101	1.58 (1.64)
Multiplier for presenteeism	196	1.55 (1.72)
Annual income (€)	196	21588.4 (17159.9)

DAS28: disease activity score based on a 28-joint count; HAQ: health assessment questionnaire; FACIT: functional assessment of chronic illness therapy; PASS: patient acceptable symptom state; EQ5D: EuroQol-5 Dimensions; SF-36: short form-36;

†Counting all diseases recorded in medical history categories: cardiovascular history, medical history, RA extra-articular manifestations, and medical history other;

‡Only for patients who had any absent hours at baseline.

Table 5.2 presents descriptive statistics of VOLP outcomes by visits. The bolded row shows the numbers of non-missing values used to generate the statistics for each outcome. Decreasing numbers of non-missing values were partially due to the missing responses and partially due to discontinuation. The employment status change due to their poor health was about 10.4%, 7.9%, 6.1% and 1.9% at weeks 13, 26, 39, and 52, respectively. The percentage of patients who stopped work due to their health became smaller over the follow-ups and there were also a few patients who re-started working after their initial work stoppage. At baseline, about 58% of patients reported being absent from work over the past 3 months. On average, the absent hours were 75.7 hours, which accounted for about 17% of their usual working time. About 39% of patients reported that they would complete the same work in less time if they did not experience any health problems. The percentage of time loss while working due to health in the past 7 days was 8%.

Both absenteeism and presenteeism showed a declining trend over the 52-week follow up. Overall, paid work loss was about 111.7 hours over the past 3 months at baseline, accounting for 25% of usual working time, and decreased to 60.1 hours at week 52, which accounted for 13% of usual working time. Similarly, unpaid work loss was 6.3 hours per week at baseline and declined to 1.8 hours per week at week 52. When incorporating multipliers, total costs of lost productivity over the past 3 months were €3,483 at baseline and €843 at week 52. All the three main VOLP outcomes of interest declined over the 52 weeks.

Table 5.2. The descriptive statistics of VOLP outcomes by visits

Variable	Baseline	Week 13	Week 26	Week 39	Week 52
Components of paid work productivity loss in the past 3 months					
Follow-up (N)		**193**	**189**	**180**	**157**
Employment status change, N (%)†		23 (11.9)	25 (13.2)	15 (8.3)	11 (7)
Stop working		12 (6.2)	8 (4.2)	4 (2.2)	3 (1.9)
Start working			4 (2.1)	4 (2.2)	2 (1.3)
Change job		1 (0.5)	5 (2.6)	2 (1.1)	2 (1.3)
Change hours		11 (5.7)	12 (6.3)	5 (2.8)	4 (2.5)
Health related status change, N (%)†		20 (10.4)	15 (7.9)	11 (6.1)	3 (1.9)
Stop working		10 (5.2)	5 (2.6)	2 (1.1)	1 (0.6)
Start working			3 (1.6)	4 (2.2)	
Change job		1 (0.5)	1 (0.5)	1 (0.6)	
Change hours		10 (5.2)	7 (3.7)	4 (2.2)	2 (1.3)
Employed	**196**	**181**	**173**	**165**	**143**
Absenteeism (N)	**173**	**154**	**152**	**146**	**130**
Any absent hours, N (%)	101 (58.4)	45 (29.2)	41 (27)	26 (17.8)	15 (11.5)
Percentage of time loss (SD)	0.17 (0.25)	0.09 (0.22)	0.07 (0.22)	0.05 (0.17)	0.03 (0.13)
Absent hours (SD)	75.73 (113.36)	35.15 (91.10)	25.05 (75.27)	16.69 (72.08)	12.04 (48.82)
Presenteeism (N)	**191**	**166**	**160**	**155**	**136**
Any presenteeism, N (%)	75 (39.3)	46 (27.7)	37 (23.1)	37 (23.9)	24 (17.6)
Presenteeism % time loss (N)	**180**	**153**	**147**	**140**	**130**
Percentage of time loss (SD)	0.08 (0.14)	0.05 (0.12)	0.04 (0.12)	0.03 (0.09)	0.03 (0.08)
Paid work productivity loss in the past 3 months (N)	**162**	**153**	**155**	**145**	**135**
Any paid work loss, N (%)	124 (76.5)	73 (47.7)	68 (43.9)	49 (33.8)	40 (29.6)
Percentage of time loss (SD)	0.25 (0.26)	0.2 (0.32)	0.19 (0.34)	0.15 (0.31)	0.13 (0.29)
Paid work loss, hours (SD)	111.71 (116.84)	89.29 (152.60)	83.36 (151.73)	71.7 (156.43)	60.11 (140.91)
Stop working: hour loss (SD)		30.65 (119.48)	36.11 (129.30)	34.92 (132.2)	33.46 (129.61)

Variable	Baseline	Week 13	Week 26	Week 39	Week 52
Absenteeism: absent hours (SD)	76.75 (115.71)	35.28 (91.39)	24.09 (74.64)	16.01 (72.15)	11.30 (47.90)
Presenteeism: hour loss (SD)	34.97 (58.07)	19.76 (53.65)	16.33 (53.55)	11.94 (36.81)	11.45 (39.55)
Unpaid work productivity loss in the past 7 days (N)	**167**	**176**	**165**	**166**	**143**
Any unpaid work loss, N (%)	86 (51.5)	44 (25.0)	38 (23.0)	34 (20.5)	24 (16.8)
Unpaid work loss, hours (SD)	6.27 (11.11)	3.44 (9.37)	2.73 (7.49)	2.85 (10.68)	1.79 (5.86)
Total costs of lost productivity in the past 3 months (N)	**141**	**143**	**135**	**135**	**124**
Any costs of lost productivity, N (%)	121 (85.8)	79 (55.2)	65 (48.1)	51 (37.8)	44 (35.5)
Total costs with multiplier, € (SD)	3483.48 (8482.03)	1777.72 (4734.99)	1477.86 (3919.60)	987.46 (2835.20)	842.77 (2242.33)
Total costs without multiplier, € (SD)	1895.41 (2625.98)	1272.74 (2730.02)	1056.88 (2411.70)	754.86 (2128.80)	685.90 (1682.31)

Bolded numbers are the numbers of non-missing values used to generate the statistics below;
†Patients might report changing both job and working hours

Table 5.3 presents the change of productivity loss from baseline to week 39 and from baseline to week 52, separately. The analyses only included patients whose outcomes at baseline and week39/52 were both observed. Our study showed significant gains in paid and unpaid work productivity at week 52. Patients gained 33.4 hours per 3 months in paid work and 4.2 hours per week in unpaid work. When applying multipliers, the total monetary gains in paid work and unpaid work were about €1,322 per 3 months. Significant paid and unpaid work productivity gains were also observed at week 39. Because patients whose DAS28>3.2 at week 39 discontinued from the study, patients who stayed in week 52 were different from patients who were included at week 39. Therefore, the comparison results only apply to patients who stayed in the study until week 39 or throughout the one year period. For more information, we also compared the three main VOLP outcomes at week 13/26 with those at baseline and found that significant productivity gains already started at week 13.

In terms of VOLP outcomes during the one-year study period, overall, paid work productivity loss was 295 hours (about 17% of usual working time), unpaid work productivity loss was 162 hours, and the total costs were €5,223 when incorporating the multiplier, and €4,154 without (Table 5.4). Paid work productivity loss during the one-year study period was also decomposed into three components, i.e., hour loss from absenteeism, presenteeism and work stopping. These three estimates may not add up to the estimated paid work productivity loss because the latter was adjusted for work hour changes during follow-ups. It showed that time loss from absenteeism was similar to that from work stopping, both of which account for about 36% of overall paid work hour loss. Time loss from presenteeism was lower and accounted for about 21% of overall paid work hour loss.

Table 5.3. Change of productivity loss from baseline to each follow-up visit

Week 13	N†	Week 13 – Baseline	P value
Any paid work productivity loss in the past 3 months (%)	130	-30.8	<0.01
Paid work productivity loss in the past 3 months (hours)	130	-22.93	0.09
Any unpaid work productivity loss in the past 7 days (%)	151	-25.8	<0.01
Unpaid work productivity loss in the past 7 days (hours)	151	-2.74	<0.01
Any costs of lost productivity in the past 3 month (%)	108	-29.6	<0.01
Total costs of lost productivity in the past 3 months with multiplier (€)	108	-1829.91	0.05
Total costs of lost productivity in the past 3 months without multiplier (€)	108	-661.93	<0.01
Week 26	**N†**	**Week 26 – Baseline**	**P value**
Any paid work productivity loss in the past 3 months (%)	131	-33.6	<0.01
Paid work productivity loss in the past 3 months (hours)	131	-29.04	0.05
Any unpaid work productivity loss in the past 7 days (%)	143	-26.6	<0.01
Unpaid work productivity loss in the past 7 days (hours)	143	-3.47	<0.01
Any costs of lost productivity in the past 3 month (%)	100	-37.0	<0.01
Total costs of lost productivity in the past 3 months with multiplier (€)	100	-2238.99	0.03
Total costs of lost productivity in the past 3 months without multiplier (€)	100	-1000.76	<0.01
Week 39	**N†**	**Week 39 – Baseline**	**P value**
Any paid work productivity loss in the past 3 months (%)	125	-44.0	<0.01
Paid work productivity loss in the past 3 months (hours)	125	-34.13	0.03
Any unpaid work productivity loss in the past 7 days (%)	145	-29.7	<0.01
Unpaid work productivity loss in the past 7 days (hours)	145	-3.88	<0.01
Any costs of lost productivity in the past 3 month (%)	107	-44.9	<0.01
Total costs of lost productivity in the past 3 months with multiplier (€)	107	-2643.36	0.02
Total costs of lost productivity in the past 3 months without multiplier (€)	107	-1203.18	<0.01
Week 52	**N†**	**Week 52 – Baseline**	**P value**
Any paid work productivity loss in the past 3 months (%)	116	-42.2	<0.01
Paid work productivity loss in the past 3 months (hours)	116	-33.43	0.03
Any unpaid work productivity loss in the past 7 days (%)	125	-33.6	<0.01
Unpaid work productivity loss in the past 7 days (hours)	125	-4.22	<0.01
Any costs of lost productivity in the past 3 month (%)	95	-47.4	<0.01
Total costs of lost productivity in the past 3 months with multiplier (€)	95	-1322.42	0.02
Total costs of lost productivity in the past 3 months without multiplier (€)	95	-1033.42	<0.01

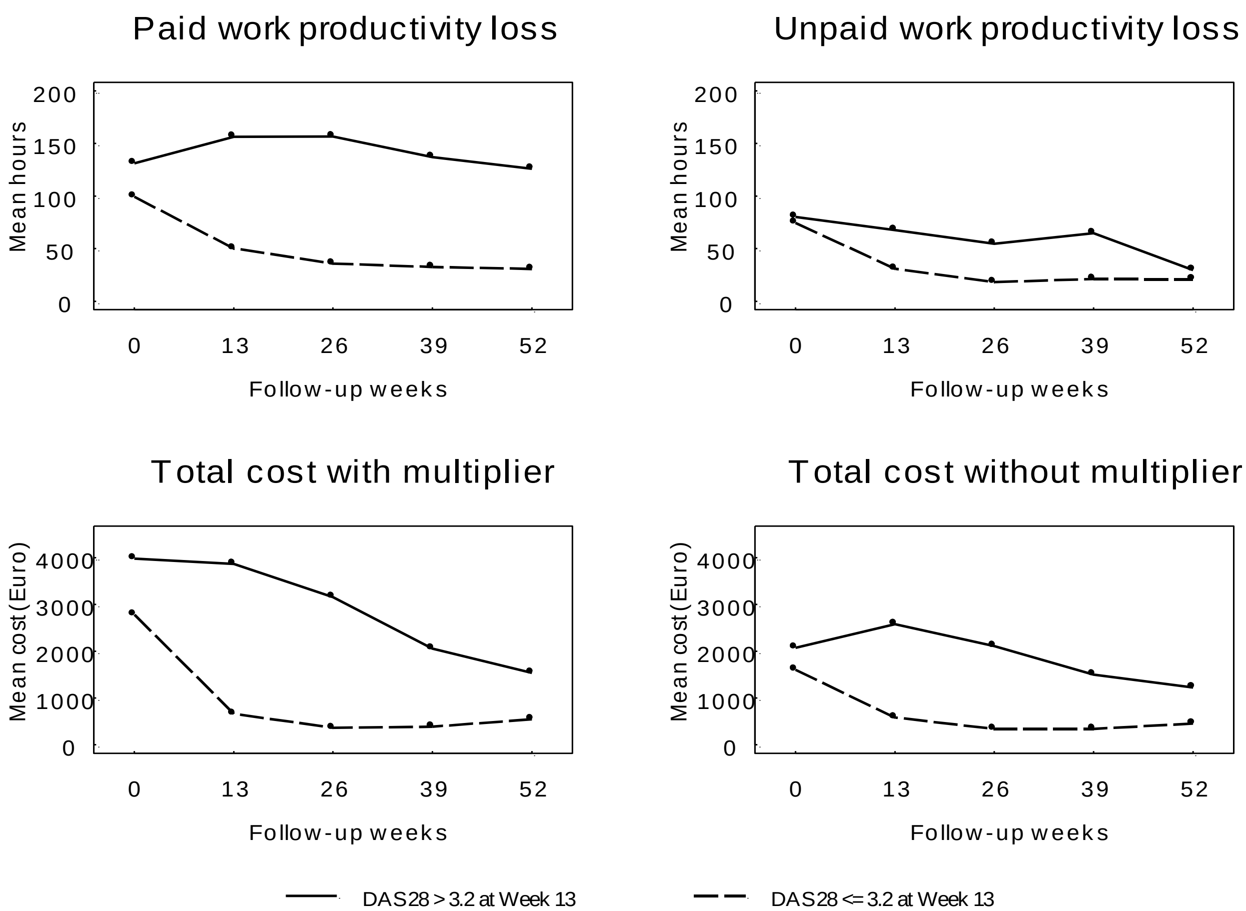
†The number of patients whose outcomes at baseline and week 13, 26, 39 or 52 were both observed

Table 5.4. Total productivity loss during the one-year study period

Variable	N	Mean (SD)/N(%)
Any paid work productivity loss, N (%)	187	116 (62.0)
Percentage of paid work time loss (SD)	187	0.17 (0.27)
Paid work productivity loss, hours (SD)	187	294.97 (506.97)
Stop working: hour loss	187	105.33 (410.76)
Absenteeism: absent hours	187	106.89 (245.16)
Presenteeism: hour loss	187	62.66 (145.21)
Any unpaid work productivity loss, N (%)	192	78 (40.6)
Unpaid work productivity loss, hours (SD)	192	161.96 (433.01)
Any costs of lost productivity, N (%)	184	129 (70.1)
Total costs with multiplier, € (SD)	184	5522.67 (12854.38)
Total costs without multiplier, € (SD)	184	4154.30 (8777.17)

The difference in productivity loss between responders and non-responders is clearly shown in Figure 5.2. The difference in productivity loss between early responders and non-responders was obvious. For responders, each outcome dropped at week 13 and subsequently flattened. For non-responders the outcomes dropped only slightly or even increased (e.g., paid work productivity loss) at week 13 and subsequently dropped relatively sharply. This seems to correspond to the progress of disease activity of non-responders. This might be explained by that disease activity of non-responders at week 13 might be improving after week 13, and that those with high disease activity at week 39 withdrew from the study.

Figure 5.2. Plots of 3-month productivity loss and costs at each visit by response at week 13



Paid and unpaid work productivity losses during the one-year period for responders (155 and 93 hours, respectively) were both significantly lower than that for non-responders (522 and 254 hours) (Table 5.5). Total costs of lost productivity for responders (€1,993 with multiplier and €1,735 without multiplier) were significantly smaller than those for non-responders (€10,676 and €7,814, respectively).

Table 5.5. Total productivity loss during the one-year study period by response at week 13

	Responder	Non-responder	P value
Paid work productivity loss (N)	**111**	**71**	
Paid work productivity loss, hours (SD)	155.47 (316.35)	521.71 (663.55)	<0.01
Unpaid work productivity loss (N)	**114**	**73**	
Unpaid work productivity loss, hours (SD)	93.28 (290.97)	254.48 (570.43)	0.02
Total costs of lost productivity (N)	**111**	**69**	
Total costs of lost productivity with multiplier, € (SD)	1993.48 (4802.50)	10676.20 (18594.00)	< 0.01
Total costs of lost productivity without multiplier, € (SD)	1734.68 (3746.66)	7814.31 (12527.63)	< 0.01

Table 5.6 presents model results of comparing one-year total work productivity loss between responders and non-responders. ZINB was used to compare paid and unpaid work productivity loss. The first part model showed that early responders were more likely to have zero paid (marginally significant) and unpaid work productivity loss (significant). The second part model showed that early responders also had significantly lower paid work hour loss than non-responders. Similarly, using a two part model, it showed that responders were more likely to have no costs of lost productivity and had marginally significantly lower nonzero costs (with multiplier) than non-responders. To help understand our model results, we first computed the expected values for responders and non-responders, respectively while holding the covariates at

their mean value shown in Table 5.1. Then, we computed the marginal effects, i.e., the difference in expected values between responders and non-responder.

Table 5.6. Regression models to compare total work productivity loss during the one-year study period by response at week 13

Variable	Estimate (responders vs. non-responders)	Standard Error	P-value
Part 1			
Paid work productivity loss[1]	0.7573	0.4117	0.07
Unpaid work productivity loss[2]	1.5961	0.4294	<0.01
Costs of lost productivity[3]	2.2889	0.6068	<0.01
Part 2			
Paid work productivity loss[4]	-0.6684	0.2089	<0.01
Unpaid work productivity loss[5]	-0.0386	0.2624	0.88
Total costs of lost productivity with multiplier[6]	-0.4552	0.2689	0.09
Total costs of lost productivity without multiplier[7]	-0.2849	0.2501	0.25

Note: Zero-inflated negative binomial model for paid and unpaid work productivity loss; Two parts model for total costs of lost productivity: logistic regression for the probability of no costs and generalized linear model with gamma distribution and log link for non-zero costs;
Covariates included in the models were selected according to the observed data;
[1]Adjusted for baseline SF-36 Mental Component Summary Score, prior use of corticosteroids, and baseline paid work productivity loss; [2]Adjusted for baseline any unpaid work productivity loss, prior use of corticosteroids, FACIT, and sex; [3]Adjusted for baseline any costs of lost productivity, work habits, and sex; [4]Adjusted for EQ-5D VAS, patient acceptable symptom state, baseline paid work productivity loss, and work habits; [5]Adjusted for baseline unpaid work productivity loss; [6]Adjusted for baseline total costs of lost productivity, SF-36 Physical Component Summary Score, and work habits; [7]Adjusted for baseline total costs of lost productivity, SF-36 Physical Component Summary Score, and work habits.

Table 5.7 presents the expected values and the marginal effects. For one-year paid work productivity loss, while holding covariates at their mean value at baseline, the expected probability of being zero loss was 44% for responders and 27% for non-responders; the expected paid work hour loss in part 2 of the ZINB model was 266 hours and 519 hours, respectively; overall, the expected paid work productivity loss was 149 hours and 380 hours, respectively, with a 231-hour significant difference. Similarly, the difference in unpaid work productivity loss was significant and equaled 122 hours. For total costs of lost productivity with multipliers, responders had a 32% higher probability of having no costs than non-responders. Overall, responders saved €3,670 in productivity compared with non-responders.

Table 5.7. Expected values by response at week 13 and marginal effects using sample means shown in Table 5.1 from the regression models

	Responder Mean (CI)	Non-responder Mean (CI)	Difference Mean (CI)
Paid work productivity loss			
Probability of paid loss = 0 (part 1)	0.440 (0.304, 0.563)	0.269 (0.124, 0.376)	0.171 (0.013, 0.368)
Mean Loss for part 2 in hours	266 (174, 344)	519 (312, 724)	-253 (-469, -49)
Mean overall loss in hours	149 (91, 205)	380 (225, 558)	-231 (-415, -77)
Unpaid work productivity loss			
Probability of unpaid loss = 0 (part 1)	0.786 (0.670, 0.908)	0.427 (0.294, 0.61)	0.359 (0.149, 0.545)
Mean Loss for part 2 in hours	320 (183, 470)	332 (184, 369)	-13 (-117, 217)
Mean overall loss in hours	68 (25, 120)	190 (89, 219)	-122 (-166, -4)
Total costs of lost productivity			
Probability of total costs = 0 (part 1)	0.376 (0.027, 0.510)	0.058 (0.001, 0.123)	0.319 (0.023, 0.466)
With multiplier			
Mean costs for total costs for part 2 in €	4259 (2706, 6404)	6713 (3285, 9721)	-2455 (-5362, 1505)
Mean overall costs in €	2656 (1583, 4915)	6326 (3090, 9246)	-3670 (-6350, 171)
Without multiplier			
Mean costs for total costs for part 2 in €	3504 (2460, 4779)	4659 (2451, 5986)	-1155 (-2733, 1458)
Mean overall costs in €	2185 (1442, 3864)	4390 (2320, 5749)	-2205 (-3586, 445)

CI: confidence interval

5.4 Discussion

The PRIZE study is the first clinical trial to measure the one-year impact of biologic treatment on all the labour input loss components that affect overall productivity and the corresponding monetary value among people with early RA.[103,104] This study found that paid and unpaid work productivity was significantly improved over 52 weeks. We also compared patients who responded to treatment at week 13 with those who did not to help confirm that it was the achievement of clinical response that produced these changes. Productivity loss and costs at each visit for responders at week 13 were lower than non-responders. For one-year productivity loss, responders had 231 hours less loss from paid work and 122 hours less loss from unpaid work than non-responders, which amounts to an output value of €3,670 saved by responders compared with non-responders.

Several previous clinical trials have examined the impact of early aggressive treatment on work productivity in terms of absenteeism among patients with early RA. The PREMIER trial assessed the effect of adalimumab plus MTX on absenteeism compared with MTX monotherapy among patients with disease duration < 3 years.[114,115] The number of missed workdays due to RA in the first year was 11.1 days and 24 days, respectively.[115] The COMET study measured the effect of ETN+MTX versus MTX on absenteeism among patients with disease duration < 2 years and found that the one-year missed workdays due to health were 14.2 days versus 31.9 days.[34] In the study of Puolakka et al., patients with recent-onset RA (<2 years) were randomly assigned to receive combination therapy of DMARDs or single DMARD.[102] During the 5 years of follow-up, they found 23 days of sick leaves per patient-observation year in combination therapy group and 48 days in single therapy group. Our study population was patients with RA ≤ 1 year and found that the number of missed work hours due to health during the one-year study period was about 106.9 hours (Table 5.4), amounting to 14.5 days. Thus, the absenteeism estimates from our study were closer to those from the treatment arm in above studies even though the design, treatment, RA population, and definition of absenteeism differed across studies.

Only one previous clinical trial has estimated presenteeism and unpaid work productivity loss in terms of time loss and costs.[103,104] The PREMIER study measured presenteeism according to a visual analog scale scored from 0 to 100 but did not translate it into time loss and then the associated costs.[114] The COMET study did not directly measure presenteeism among its study participants.[34] The only study that measured and estimated the cost of absenteeism, presenteeism and unpaid work productivity loss was a sub-study of CanAct trial.[81] However, this study only evaluated the 12-week impact of adalimumab on work productivity and was not restricted to patients with recent-onset RA. Thus, it was not appropriate to compare its findings with ours.

The main limitation of our study is its single-arm design. By looking at the change in productivity loss over 52 weeks only, we cannot determine whether the change is attributable to the treatment or the natural fluctuations of worker productivity over time especially due to regression towards the mean. Therefore, we compared one-year productivity loss between responders and non-responders by adjusting for potential confounders. We found that treatment response was associated with a reduction in productivity loss. In this study, if the response was induced by the treatment of ETN plus MTX, then it could be inferred that the cost of ETN therapy can be viewed as being partially offset by cost savings accruing to responders. However, it is possible that the cost savings would apply to any treatment that induces similar clinical response.

In this study, based on the human capital approach we valued productivity loss by incorporating multipliers that adjust wage to represent the actual impact of the resulting reduced labour input on productivity. As an alternative valuation method, the friction cost (FC) method only takes account of productivity loss during the time it takes to replace an absent worker (“friction period”) if absent workdays exceed the period.[25] Productivity loss estimates could be further undervalued if the potential impact of compensation mechanisms is also considered.[39,116] That is, no productivity loss would occur if missed work could be compensated for during normal working hours and the absent worker or colleagues who take over the work do not have to sacrifice their leisure time or take more effort to make up the lost work.[58] In the literature, the choice of valuation method has been fiercely debated and there is no current consensus on appropriate methodology. It should be noted that if applying FC method and considering potential impact of compensation mechanisms in our study, the estimated costs of productivity loss would be smaller.

Furthermore, many studies have found that estimates of time loss attributed to presenteeism varied widely among different measurement methods.[52,58] Measuring loss using a 0-10 scale usually provides the highest estimate while directly asking for time loss gives the lowest estimate. The former estimate can be almost 8 times greater than the latter.[52] Further studies are required to validate which method captures the actual productivity loss from presenteeism from the perspective of economic valuation. In VOLP, we applied the latter method to estimate the time loss, i.e. the most conservative estimate.

Our results suggest that patient productivity loss was significantly improved for those who remained on treatment at week 39 or week 52. Over the one-year treatment, early responders at week 13 suffered significantly less productivity loss than non-responders, which suggests this saving was related to treatment response. Future studies should examine treatment effects on paid and unpaid work productivity comprehensively, as this appears to be an important component to improve.

Chapter 6: Wage, marginal productivity and absenteeism

6.1 Introduction

Productivity losses related to some diseases are substantial and may even exceed the direct costs of medical care. In 1998, direct costs associated with cardiovascular disease in Canada totaled $6.8 billion, whereas indirect costs (relating to mortality, and short and long-term disability) amounted to $11.7 billion.[117] Productivity losses therefore represented more than 60% of the total economic burden of cardiovascular disease in Canada. In the case of arthritis, productivity losses accounted for approximately 67% of the total economic burden of the disease.[118] Total costs of absence and unemployment due to illness in the United Kingdom (UK) are estimated to be £100 billion a year, an amount greater than the current annual budget for the National Health Service, which is the publicly funded healthcare system in the UK.[6]

Given that productivity losses may equal or exceed the direct costs of illness, there are compelling arguments in favour of including productivity losses in a range of health economics studies. The valuation of productivity losses is required in cost-of-illness studies, which estimate the economic burden of specific illnesses, as well as economic evaluation studies, such as cost-effectiveness studies. Cost-effectiveness studies compare the incremental cost of one health intervention (e.g., a health technology or health program) over another relative to their incremental effectiveness. While both cost-of-illness and cost-effectiveness studies are useful to decision-makers in priority-setting, only cost-effectiveness studies include a comparative analysis. Cost-effectiveness studies are therefore routinely used to determine the eligibility of health technologies, such as pharmaceuticals, for coverage under national or provincial health plans. The precise measurement and inclusion of productivity losses in such analyses would lead to better resource allocation decisions.

Evidence suggests that productivity losses, when accounted for, have a significant influence on determinations of cost-effectiveness. For example, in an economic evaluation of a family medicine-based asthma self-management program, the self-management program was deemed more effective and less costly than usual care when the cost of productivity loss was included.[18] When the cost of productivity loss was ignored, the asthma self-management program was no longer recognized as cost-saving. In a cost-effectiveness analysis of treatments for early rheumatoid arthritis, the most expensive treatment strategy regarded as ‘not cost-effective’ became ‘cost-saving’ after including productivity losses.[19] Thus, cost-effectiveness analyses that incorporate estimates of productivity loss are useful in identifying interventions with a potentially broad impact on health.

Despite robust arguments in favour of including productivity loss in health economic evaluations, there are still limitations in current methods for the valuation of productivity loss. Existing methods quantifying productivity loss use wage (e.g., the ‘going rate’ of pay) as the proxy value for marginal productivity.[23,24] However, the use of wage as a proxy prevents accurate estimation of productivity loss for many reasons, as wage may not equal marginal productivity. For one, in imperfect labour markets, wage may not equal marginal productivity due to inequities, such as race or gender discrimination, whereby an identifiable group routinely receives lower wage. More commonly, risk-averse workers might willingly accept a wage that is lower than their marginal productivity in exchange for job security, e.g. allowances for sick days.[26]

A difference between wage and marginal productivity of workers also exists if a job involves team production, if the output is time-sensitive, or if perfect substitutes for workers are not readily available.[26,29] For example, the absence of a cardiac surgeon from a pre-scheduled surgery might keep the entire surgical team idle. Productivity loss attributable to the surgeon's absence will therefore not be his or her wage alone, but the value of the entire team's output.[58] Similarly, in a firm where output is highly time-sensitive, such as in operations where customers may be lost if delivery schedules are delayed, the absence of one worker will have a value much greater than his or her wage if future business is affected. Finally, a difference between wage and marginal productivity will develop if a perfect substitute for an absent worker is not readily available, in the case where the hired substitute is less productive or costs more. In both cases of team production and time-sensitive output, losses will increase as long as a perfect substitute for the absent worker is unavailable.

An emerging method used to examine the relationship between wage and marginal productivity is to use population-based datasets that link employees' input to their employers' output. For example, Hellerstein and Neumark[119] used Israeli labour market data to test whether the wage gap between men and women exceeds the gap (if any) in marginal productivity. Hellerstein et al.[120] used US population data to estimate wage and marginal productivity for worker groups with different age, sex, and race characteristics, while Hægeland and Klette[121] analyzed the difference in wage and productivity across Norwegian workers by sex, education and work experience. Van Ours and Stoeldraijer[122] identified 13 studies on age and productivity using employer-employee linked data. The databases used in these studies contain data on a firm's output, capital, materials, other expenditures, payroll, industry as well as workers' age, sex, education, and occupation. The availability of this data allows researchers to test the equality between wage and marginal productivity for groups of workers with different characteristics.

This Chapter tests the equality of wage and marginal productivity losses due to absenteeism for team workers and non-team workers. The systematic objectives of this study are: 1) to measure the impact of employee absenteeism and team participation on marginal productivity; 2) to measure the impact of employee absenteeism and team participation on wage; 3) to use the above to test the null hypothesis that wage and marginal productivity losses due to absenteeism are equal.

In economic literature, heavy interest lies in uncovering factors that determine or affect worker absence either by modeling absence based on labour supply alone or with the incorporation of labour demand.[123–126] Few studies have sought to estimate the cost of absenteeism. Allen[127] described the nature of a trade-off workers and employers are willing to make between wages and expected absence. Absenteeism was treated as a job characteristic creating compensating differentials and the cost of this characteristic was estimated with a hedonic wage equation using individual worker level data. Productivity loss was also directly estimated using a manufacturing production function at plant level. Coles et al.[126] brought forward the idea of the shadow cost of absenteeism, which refers to the relatively high wage paid by firms requiring a low level of absenteeism to compensate workers for attending work reliably. Using individual worker level data, they measured and compared the equilibrium relationship between the wage rate and the absence rate in firms operating just-in-time technology and in firms that do not. However, no studies have been conducted to test the equality of wage and marginal productivity with respect to absenteeism.

The setup of this Chapter is as follows: in section 6.2, we describe our employer-employee linked data, define main variables, and present the setup of our analysis methods. In section 6.3, we present our findings and parameter estimates. Section 6.4 summarizes the findings and the impact and implications that present.

6.2 Methods

6.2.1 Data

The Workplace and Employee Survey (WES) conducted by Statistics Canada in 1999-2005 is a survey of Canadian employers and employees.[77] The WES is one of only a few linked employer-employee databases worldwide and the only one in Canada. The WES has been used to estimate age-based wage and productivity differentials,[128] and to compare wages and marginal productivity for workers with different levels of education and technology use.[129,130] The sampling frame for the WES included all Canadian workplaces in the Statistics Canada Business Registry that had paid employees in March of the survey year. Employers in Yukon, Nunavut, the Northwest Territories and those operating in crop production, animal production, fishing, hunting and trapping, private households, religious organizations and public administration were excluded from the survey. The sampling frame for employees comprised all employees working or on paid leave in March from the targeted workplaces. Workplaces were first randomly selected from the Business Registry, and then employees were sampled from an employee list provided by the selected workplace. A maximum of 24 employees were sampled from each selected workplace. In workplaces with fewer than 4 employees, all employees were selected. The WES was administered at a single workplace at least two years in a row. The workplace and employee samples were refreshed in odd years (1999, 2001, 2003, and 2005) to reflect attrition, firm births, and employee turnover.

For this study, we first restricted the sample to workplaces with more than one employee interviewed. Then we focused on the for-profit firms with a positive output value. During the second survey years (even years), over 11% of the surveyed employees had a different employer or had left their employer and did not have a new employer, which affected almost 30% of the surveyed workplaces. Since employee attrition from the WES during the second survey year is high and the attrition is likely non-random,[131] data from even-numbered years were not used. Therefore, our analysis is based on the pooled data during the odd years only, i.e., 1999, 2001, 2003, and 2005.

6.2.2 Variable definition

6.2.2.1 **Outcome variables**

Firm output is defined as value added, where value added is measured as annual gross operating revenues minus expenses on materials.[129,130] Expenses on materials are equal to the annual gross operating expenditures minus total gross payroll and expenditures on non-wage benefits and training. Wage is defined as annual payroll, as reported by workplaces in the WES survey.

6.2.2.2 **Independent variables of interest**

Absence rate: Absenteeism is defined as the absence rate of employees, which is defined as the number of days of total leave taken by employees, including paid sick leave, other paid leave (e.g., education leave, disability leave, bereavement, marriage, jury duty, union business) and unpaid leave in the past twelve months or since the employee started his/her current job (if less than twelve months), divided by the total number of 'usual workdays' over the same time period.[124] The total number of usual workdays is equal to the number of days per week employees usually work multiplied by the number of weeks per year they usually work. The absence rate for a firm is the average absence rate for the employees surveyed for that firm. *Attendance rate* is defined as 1 minus absence rate.

Team Work: WES data contains information on employees' participation in "a self-directed work group (semi-autonomous work group or mini-enterprise group) that has a high level of responsibility for a particular product or service area".[77] Workers are divided into two categories based on their participation frequency ('frequently' or 'always' versus 'occasionally' or 'never' for participation in any team work). Each worker represented in the WES data therefore belongs in one of two work groups: 1) participating in a team (frequently or always) or 2) not in a team (occasionally or never).

6.2.2.3 **Covariates**

Labour and capital are important factors in the production function. However, the WES does not measure a firm's capital. Therefore, we use the imputation approach of Turcotte and Rennison (2004) to approximate this value.[128–130] The firm's capital stock is approximated using the average capital stock in the last five years in the firm's industry. The industry capital stock corresponds to the geometric (infinite) end-year net stock of non-residential capital reported in Table 031-0002 of CANSIM from Statistics Canada.[132] The firm's capital stock is then calculated by dividing the industry capital stock by the number of firms in each industry represented by the WES. A total of 837 unique industries indicated by the North American Industry Classification System (NAICS) codes in 6 digits were identified in the WES data (1999-2005). However, the net stock information from Statistics Canada was only available for 247 industries indicated by different levels of NAICS codes (2-6 digits). Hence, to impute a net stock estimate, we had to aggregate some industries (6-digit NAICS codes) in the WES data into a higher industry level (2-5 digits). A total of 247 unique capital stock estimates were finally imputed into the WES data.

In addition, we controlled for variables of other workforce characteristics: age, sex, education, occupation, race, immigrant and an indicator for membership in union or collective bargaining agreement, as well as variables of workplace characteristics: an indicator for international market, an indicator for foreign country ownership, region, industry and calendar year dummies. More details on the definition of the variables we used in the study can be found in Appendix B.

6.2.3 Statistical analyses

6.2.3.1 **Production function**

We have extended the Cobb-Douglas production function to capture productivity effects related to the absence rate and team work at the firm level.[119,120,133] The detailed steps for extending the Cobb-Douglas production function have been documented in Appendix C.

For each workplace, consider a Cobb-Douglas production,

$$\ln Q_j = \alpha \ln L_j^A + \beta \ln K_j + \eta F_j + \mu_j \quad (1)$$

where Q is output, measured as value added by firm j, L^A is an aggregate function of productive labour of each type of worker, K is the capital stock, F_j is a matrix of firm characteristics, α and β are the elasticity of output with respect to labour and capital, respectively, η is a vector of parameters for firm characteristics and μ_j is the error term. We use the log of value added as the dependent variable to address the endogeneity issue by avoiding estimation of a coefficient on materials.[120,129,130]

With the assumption of perfect substitution among all types of workers and different marginal productivity for each worker type, the aggregate function of productive labour can be written as

$$L^A = \sum_{d=0}^{D_I - 1} \lambda_d (1-a)^{\theta_d} L_d \,; 0 \le a \le 1 \text{ and } \theta_d > 0; \quad (2)$$

where $D_I = \prod_{i=1}^{I} V_i$ is the total number of worker types, I is the total number of worker characteristics, V_i is the total number of categories workers are divided into by each characteristic i, a is the absence rate in a firm based on the assumption that the absence rate is the same across different worker types, $\lambda_d (1-a)^{\theta_d}$ is the marginal productivity for type d workers, λ_d is the marginal productivity for worker type d when the absence rate = 0, θ_d is the parameter of (1-absence rate), i.e., the attendance impact on the marginal productivity for type d workers and L_d is the number of type d workers in a firm. This is a convenient form of estimation because it simplifies to the standard model $L^A = \sum_{d=0}^{D_I-1} \lambda_d L_d$ if a = 0 (no absence) and $L^A = 0$ if a = 1 (no attendance). Using this form, it can also be shown that the condition, $\frac{\partial L^A}{\partial a} < 0$, will hold.

If we assume that attendance impacts on marginal productivity are the same ($\theta_d = \theta$) for different type d, then the productive labour function can be rewritten as

$$L^A = (1 - a)^\theta \sum_{d=0}^{D_I-1} \lambda_d L_d \qquad (3)$$

In our study, attendance rate and team work participation are our independent variables of interest. We also need to control for other worker characteristics including age, sex, education, occupation, race, immigrant and membership in union or collective bargaining agreement. If we distinguish types of workers according to all these characteristics, there will be too many worker types, i.e., many L_d in equation (3). If we distinguish types of workers according to two characteristics (I=2) team work participation and age, for example, workers are divided into two categories by team work participation $V_1 = 2$: 1) participating in a team (G) and 2) not in a team (N) and 3 age categories $V_2 = 3$: 1) less than 35 (R); 2) between 35 and 55 (C); 3) over 55 (O). A firm's workforce can therefore be fully described by $D_2 = V_1 \times V_2 = 2 \times 3$, which generates 6 combinations of these characteristics (NR, NC, NO, GR, GC, GO). If we distinguish types of workers according to three characteristics (I=3): team work participation (2 categories), age (3 categories) and sex (2 categories), then there will be D_3 = 2×3×2 =12 different worker types. However, our sample of workers from each workplace is not large enough to allow fine distinctions based on all these worker characteristics. In this study, we are only interested in the attendance rate and team participation and therefore need to simplify the function to address a simpler distinction.

To simplify the equation, we apply the two restrictions that Hellerstein et al.[119,120] made on the form of L^A. First, we assume that the proportion of one type of worker defined by one characteristic is constant across all other characteristic groups, which is referred to as the *equiproportionate restriction*.[119,120] For example, older workers are equally represented in team workers and non-team workers. Second, we assume the relative marginal productivity of two types of workers within one characteristic group is equal to those within another characteristic group, which is referred to as the *equal relative productivity restriction*.[119,120] For instance, the relative marginal productivity of older workers versus younger workers among team workers is the same as those among non-team workers.

After applying these restrictions, the "restricted model" for the production function (equations 17-19 from Appendix C) then becomes

$$L^A = (1-a)^{\theta} \lambda_{0,I} L(1 + (\gamma_G - 1)P_G) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{iv}\right) \tag{4}$$

and

$$\begin{aligned} \ln Q_j = \beta_0 + \beta \ln K_j + \alpha \ln L_j + \alpha\theta \ln(1 - a_j) + \alpha \ln(1 + (\gamma_G - 1)P_{Gj}) \\ + \alpha E_j + \eta F_j + \mu_j \end{aligned} \tag{5}$$

where

$$E_j = \sum_{i=1}^{I-1} \ln\left(1 + \sum_{v=1}^{V_i-1} (\gamma_{iv} - 1)P_{ivj}\right) \quad (6)$$

θ is the parameter of attendance rate for any worker type, $\lambda_{0,I}$ is the marginal productivity for the reference group when work force is divided by I characteristics and absence rate = 0, i = 1, 2, …, I-1 indicates worker characteristics other than team work participation, v_i = 1, 2, …, V_i-1 represents worker categories divided according to the worker characteristic i, γ_G is the relative marginal productivity of team workers compared to non-team workers, $\gamma_{iv} = \frac{\lambda_{iv}}{\lambda_{i0}}$ is the relative marginal productivity of one worker type iv to the worker type $i0$ for each characteristic i, P_G is the proportion of team workers among all workers, $P_{iv} = \frac{L_{iv}}{L}$ is the proportion of the worker type iv among all workers, and β_0 is a constant term that incorporates $\alpha \ln \lambda_{0,I}$.

If we assume that the attendance impact on the marginal productivity for team workers (G) is different from that for non-team workers (N), then the productive labour function (equation 20 from Appendix C) can be rewritten as

$$L^A = (1-a)^{\theta_G} \sum_{d=0}^{\frac{D_I}{2}-1} \lambda_{Gd} L_{Gd} + (1-a)^{\theta_N} \sum_{d=0}^{\frac{D_I}{2}-1} \lambda_{Nd} L_{Nd} \quad (7)$$

where θ_G is the parameter of attendance rate for team workers, θ_N is the parameter of attendance rate for non-team workers, λ_{Gd} is the marginal productivity for the worker type d in team workers when absence rate = 0, λ_{Nd} is the marginal productivity for the worker type d in non-team workers when absence rate = 0.

If we make the same two restrictions, the relatively "complete model" (equations 21 and 22 from Appendix C) becomes

$$L^A = \lambda_{0,I}(1-a)^{\theta_N} L\big(1 + \big(\gamma_G (1-a)^{\theta_G - \theta_N} - 1\big)P_G\big) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{iv}\right) \tag{8}$$

and

$$\begin{aligned} \ln Q_j &= \beta_0 + \beta \ln K_j + \alpha \ln L_j \\ &\quad + \alpha\theta_N \ln\big(1 - a_j\big) + \alpha \ln\left(1 + \left(\gamma_G \big(1 - a_j\big)^{\theta_G - \theta_N} - 1\right) P_{Gj}\right) \\ &\quad + \alpha E_j + \eta F_j + \mu_j \end{aligned} \tag{9}$$

6.2.3.2 **Wage equation**

Applying the same approach as in the case of marginal productivity, wage effects can be estimated through the relationship between payroll and average absence rate and share of workers participating in a team at the firm level. The aggregate wage can be written as the sum of the wage for each worker type incorporating the absence rate:

$$w = \sum_{d=0}^{D_I - 1} w_d (1-a)^{\zeta_d} L_d \tag{10}$$

where $w_d(1-a)^{\zeta_d}$ is the wage for the worker type *d*, w_d is the wage for the worker type *d* when absence=0, and ζ_d is the parameter of attendance rate, i.e., the attendance impact on wage for worker type *d*. If workers were paid even when absent, we would expect ζ_d to be close to zero, indicating no significant impacts of absence on payroll at firm level.

If we assume that the attendance impacts on wage for different worker type *d* are the same ($\zeta_d = \zeta$) and apply the two restrictions, then the "restricted model" for wage equation (equations 24-26 from Appendix C) becomes

$$w = w_{0,I}(1-a)^{\zeta} L(1+(\phi_G - 1)P_G)\prod_{i=1}^{I-1}\left(1+\sum_{v=1}^{V_i-1}(\phi_{iv}-1)P_{iv}\right) \tag{11}$$

and

$$\begin{aligned}\ln w_j = \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j + \zeta \ln\left(1-a_j\right) + \ln\left(1+(\phi_G-1)P_{Gj}\right) \\ + E_{wj} + \eta_w F_j + \mu_{w,j}\end{aligned} \tag{12}$$

where

$$E_{wj} = \sum_{i=1}^{I-1}\ln\left(1+\sum_{v=1}^{V_i-1}(\phi_{iv}-1)P_{ivj}\right) \tag{13}$$

ζ is the parameter of attendance rate for any worker type, $w_{0,I}$ is the wage for the reference group when work force is divided by *I* characteristics and absence rate = 0, ϕ_G is the relative wage of team workers compared to non-team workers, $\phi_{iv} = \frac{w_{iv}}{w_{i0}}$ is the relative wage of one worker type *iv* to the worker type *i0* for each characteristic i, β_{w0} is a constant term that incorporate $\ln w_{0,I}$, α_w, β_w are the elasticity of wage with respect to labour and capital, respectively, η_w is a vector of parameters for firm characteristics and $\mu_{w,j}$ is the error term.

If we assume the attendance impact on wage differs by team participation and apply the two restrictions, the relatively "complete model" (equations 27 and 28 from Appendix C) becomes

$$w = w_{0,I}(1-a)^{\zeta_N} L\big(1 + \big(\phi_G (1-a)^{\zeta_G - \zeta_N} - 1\big) P_G\big) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1) P_{iv}\right) \qquad (14)$$

and

$$\begin{aligned} \ln w_j &= \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j \\ &\quad + \zeta_N \ln\big(1 - a_j\big) + \ln\left(1 + \left(\phi_G \big(1 - a_j\big)^{\zeta_G - \zeta_N} - 1\right) P_{Gj}\right) \qquad (15) \\ &\quad + E_{wj} + \eta_{\mathrm{w}} F_j + \mu_{w,j} \end{aligned}$$

where ζ_G is the parameter of attendance rate for team workers, and ζ_N is the parameter of attendance rate for non-team workers.

6.2.3.3 **Estimation of the equations**

Our analysis begins with the restricted models, followed by the complete models, which relax the restrictions for attendance and team work participation. The production function and wage equation are simultaneously estimated. The equality of marginal productivity and wage is tested by comparing the attendance parameters, θ and ζ and the team participation parameters, $(\lambda_G - 1)$ and $(\phi_G - 1)$.

Different methods are used to estimate the equations. In the first method, we used nonlinear least squares (NLS)[119,120] to present pooled cross-section estimates (1999, 2001, 2003, and 2005 data). The estimated results can be interpreted as follows: workers with lower attendance rate (higher absence rate) will be estimated less productive if a firm with lower attendance rate (higher absence rate) produces less on average than a comparable firm with higher attendance rate (lower absence rate). With NLS estimates, we are unable to determine whether a positive association between productivity and attendance is because lower-attendance workers sort into lower-productivity workplaces (with low-attendance and high-attendance workers being about equally productive), or because lower-attendance workers are less productive than high-attendance workers within workplaces.

Furthermore, the least squares estimates are likely to be biased. A potential source of bias is unobserved workplace-level heterogeneity that may be correlated with the quantities of labour inputs. For example, a consistently poor working environment or conditions may not only affect productivity and wages, but also worker health, leading to an increase in the number of sick days.

The second method addresses these sources of unobserved heterogeneity by estimating the equations in first differences to remove workplace-level fixed effects.[122,134,135] The coefficient on attendance rate in this specification estimates the rate at which output declines within a firm when the firm's attendance rate falls.

We used the WES employer weight to compute the average or frequency of workplace characteristics.[136] Since our analysis linked workplace and employee characteristics, we used the WES linked weight to compute the average employee characteristics at the firm level including absence rate, proportion of team participation and proportions of other workforce characteristics that were calculated based on employee data. Similarly, the linked weight was used to estimate the equations. In addition, standard errors were estimated per Statistics Canada's recommended procedure,[136] using 100 sets of provided bootstrap sample weights. All data analyses were conducted using SAS.

6.2.3.4 **Additional analyses**

Further analyses were conducted to assess the robustness of effects. First, we repeated our analyses among two sub-samples: small firms with less than 20 employees and large firms (the remainder) to examine whether the equality between wage and marginal productivity varies by firm size. Second, we used a different specification of the absence rate (specification II listed in Appendix C). Third, we estimated the results using the translog production function.[119,120] Results for the second and third analyses are shown in Appendix D. Finally, we conducted sensitivity analyses to examine the impacts of the assumptions made in our main analyses on the final parameter estimates. Our main estimates assume that the firm-average absence rate is common to all worker types. To test the impact of this assumption, we allowed the average absence rate to differ for team workers and non-team workers in each firm (Appendices D.3 and D.4). We also relaxed the equiproportionate restriction between occupation, age, sex, education (> university bachelor versus bachelor and below) and team participation, respectively.

6.3 Results

For the pooled time series-cross section NLS estimates, we obtained 18,381 observations on 7,766 unique workplaces. For the first differences estimates, there were 9,811 observations on 4,901 unique workplaces. There were 7,784 observations for small firms and 10,597 for large firms. Table 6.1 illustrated the transition from the gross workplace sample to our final sample in detail.

Table 6.1. Transition from the gross sample to the final sample

	Observations	Workplaces
Gross sample	43832	9372
At least one employee without attrition*	36579	8875
Value added >0	31786	7931
For profit	30416	7812
Odd years	**18381**	**7766**
First differences	**9811**	**4901**
Small firms	**7784**	**3870**
Large firms	**10597**	**4385**

*In even survey years, employees who had a different employer or left his employer and did not have a new employer were considered as attrition

Table 6.2 provides weighted descriptive statistics for variables used in our analysis with consideration to the survey weights. The average number of employees per firm was 15 and most firms (85%) fell in the category of 1-19 employees. At the workplace level, the average absence rate was low (2%) and the share of workers in team work was 8%. The average age was 40 years old and the share of female workers was 54%. Only 38% of workplaces had at least 5 employees surveyed.

Table 6.2. Descriptive statistics at workplace level

Variables	Weighted mean	Standard deviation
Value added (,000)	1393.333	38.705
Log value added	12.526	0.026
Total wage (,000)	524.346	10.281
Log wage	11.892	0.021
Employment	14.982	0.242
Capital stock (,000)	1254.673	59.224
Absence rate	0.019	0.001
Proportion of workers participating in a team	0.079	0.003
Other workforce characteristics		
Age	40.472	0.175
Proportion of workers by age		
Age <35	0.353	0.006
35 ≤ Age < 55	0.525	0.007
55≤ Age	0.123	0.005
Proportion of female workers	0.542	0.007
Proportion of workers by level of education		
< High school	0.130	0.005
High school graduate only	0.203	0.007
Under university bachelor (completed/some college or university)	0.539	0.007
University bachelor	0.092	0.003
> University bachelor	0.035	0.002
Proportion of workers by occupation		
Managers/professionals	0.269	0.005
Technical/trades/marking/sales/clerical/administrative	0.463	0.007
Production workers	0.200	0.006
Others	0.068	0.004
Proportion of ethnic minorities	0.187	0.006
Proportion of immigrants	0.179	0.006
Proportion of employees with bargaining agreement	0.046	0.002
Workplace characteristics	**%**	
Establishment size		
1-19 employees	84.7	
20-99 employees	13.5	
100-499 employees	1.6	
500 employees or more	0.2	
Number of employees surveyed		
1	12.3	
2	16.8	
3	22.9	
4	9.9	
>=5	38.0	
International market	5.1	
Foreign country owned	3.3	

Variables	**Weighted mean**	**Standard deviation**
Industry		
Forestry, mining, oil, and gas extraction	1.5	
Labour intensive tertiary manufacturing	3.3	
Primary product manufacturing	1.2	
Secondary product manufacturing	2.0	
Capital intensive tertiary manufacturing	2.6	
Construction	8.2	
Transportation, warehousing, wholesale	12.1	
Communication and other utilities	1.3	
Retail trade and consumer services	33.7	
Finance and insurance	5.3	
Real estate, rental and leasing operations	4.2	
Business services	13.2	
Education and health services	9.7	
Information and cultural industries	1.7	
Region		
Atlantic	8.3	
Quebec	21.0	
Ontario	37.2	
Alberta	11.7	
British Columbia	14.9	
Manitoba	3.0	
Saskatchewan	3.8	
Year		
1999	25.2	
2001	24.2	
2003	24.2	
2005	26.3	

Table 6.3 presents parameter estimates using NLS and first differences methods using restricted models. Additional controls reduced the NLS estimate of the relative productivity of team workers versus non-team workers. With the additional controls, the NLS estimate of the attendance impact on marginal productivity for all workers (0.46) was similar to its impact on wage (0.47). This coefficient can also be interpreted as an elasticity. That is, if the attendance rate decreased by 1%, the productivity declined by 0.95*0.46%=0.44% and wage declined by 0.47%, where 0.95 is the output elasticity of labour. This means that a decrease in attendance rate from 0.9 to 0.8 is associated with a 5.0 percent decline in output and 5.4 percent decline in wage. Team workers were 26% more productive and earned 8% more than non-team workers. This difference is statistically significant at the 5% level in the specification with all controls. This implies that on average, the higher wages paid to team workers are considerably less than their productivity differential relative to non-team workers.

Table 6.3. Parameter estimates using restricted models

	NLS		First differences	
	Production	**Wage**	**Production**	**Wage**
Baseline controls†				
Log (total no. of employees)	0.94 (0.02)***	1.04 (0.01)***	0.60 (0.08)***	0.69 (0.04)***
Log (capital)	0.04 (0.01)***	0.05 (0.01)***	-0.03 (0.03)	0.00 (0.01)
Attendance rate	0.42 (0.12)***	0.41 (0.07)***	0.42 (0.40)	0.05 (0.11)
Team	0.66 (0.19)***	0.40 (0.08)***	0.08 (0.14)	-0.01 (0.04)
Difference in attendance rate parameters	0.01 (0.10)		0.37 (0.36)	
Difference in team parameters	0.26 (0.14)*		0.09 (0.13)	
All controls‡				
Log (total no. of employees)	0.95 (0.02)***	1.08 (0.01)***	0.61 (0.08)***	0.70 (0.04)***
Log (capital)	0.00 (0.01)	-0.03 (0.01)***	-0.03 (0.03)	-0.01 (0.01)
Attendance rate	0.46 (0.13)***	0.47 (0.07)***	0.44 (0.38)	0.05 (0.11)
Team	0.26 (0.11)**	0.08 (0.05)	0.08 (0.15)	-0.01 (0.04)
Difference in attendance rate parameters	-0.01 (0.10)		0.38 (0.34)	
Difference in team parameters	0.18 (0.09)**		0.09 (0.14)	

†Model adjusted for employment, capital stock, and years; ‡Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, international market, foreign owned, region, industry and year; First differences estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, and year; Standard error in the bracket; ***$p \leq 0.01$; **$0.01 < p \leq 0.05$; *$0.05 < p \leq 0.1$

Introducing workplace fixed effects into the equations changed parameter estimates. The attendance parameter in the production function remained the same, 0.44, and that of wage became smaller, 0.05, but neither of these estimates is statistically significant. The productivity differentials between team workers and non-team workers also decreased to 0.08, and the wage differentials became negative. Again, these first differences parameters were not statistically significant. As previously mentioned, NLS method estimates reflect a combination of both between and within workplace effects, and first differences method estimates within workplace effects. For parameters whose first differences estimates were smaller than their NLS estimates, it indicated that most of the estimated wage or productivity differentials largely existed between workplaces. Using NLS and first differences, the attendance parameters of productivity and wage were not statistically distinguishable.

In the complete models, attendance parameters were estimated for team workers and non-team workers separately (Table 6.4). Additional controls did not markedly change the attendance parameters. For non-team workers, the parameters were slightly smaller than those estimated in the restricted model. For team workers, the estimated parameter of the production function using NLS was 2.38 and that of wage was 1.43, both of which were much larger than that for non-team workers. In this specification, the attendance (absenteeism) effects on wages and productivity depend both on the estimated parameters and the proportion of employees that work in a team. Figure 6.1 plots the rate at which productivity and wages decline for a 0.1 increase in the absence rate, at various levels of the firm's absence rate and proportion of team workers. The attendance parameter for team workers denotes that for firms with all (100%) employees participating in teams, productivity decreases by 23.4% if absence increases from 0.1 to 0.2 but wages decrease by 15.5% (Figure 6.1). For firms with 20% of employees participating in teams, productivity decreases by 8.6% and wages decrease by 7.2%. Correspondingly, the difference between the attendance impact on marginal productivity and the impact on wage for team workers was also larger than that for non-team workers (0.95 versus -0.02) (Table 6.4). The first difference estimates were similar to the NLS estimates but much less precisely estimated. In none of these specifications is the gap statistically significant.

Table 6.4. Parameter estimates using complete models

	NLS		First differences	
	Production	**Wage**	**Production**	**Wage**
Baseline controls†				
Log (total no. of employees)	0.94 (0.02)***	1.04 (0.01)***	0.60 (0.08)***	0.69 (0.04)***
Log (capital)	0.04 (0.01)***	0.05 (0.01)***	-0.03 (0.03)	0.00 (0.01)
Attendance rate with no team	0.37 (0.12)***	0.38 (0.07)***	0.27 (0.39)	0.01 (0.11)
Attendance rate with team	2.78 (1.44)*	1.83 (0.84)**	2.72 (2.08)	0.71 (0.62)
Team	0.75 (0.17)***	0.45 (0.08)***	0.13 (0.17)	0.00 (0.04)
Difference in attendance parameters with no team	-0.01 (0.10)		0.27 (0.35)	
Difference in attendance parameters with team	0.95 (0.95)		2.02 (1.85)	
Difference in team parameters	0.30 (0.12)**		0.13 (0.16)	
All controls‡				
Log (total no. of employees)	0.95 (0.02)***	1.08 (0.01)***	0.61 (0.08)***	0.70 (0.04)***
Log (capital)	0.00 (0.01)	-0.03 (0.01)***	-0.03 (0.03)	-0.01 (0.01)
Attendance rate with no team	0.43 (0.13)***	0.45 (0.07)***	0.29 (0.37)	0.01 (0.11)
Attendance rate with team	2.38 (1.40)*	1.43 (0.75)*	2.73 (1.92)	0.71 (0.64)
Team	0.32 (0.12)**	0.10 (0.05)**	0.14 (0.18)	0.00 (0.04)
Difference in attendance parameters with no team	-0.02 (0.10)		0.28 (0.33)	
Difference in attendance parameters with team	0.95 (1.00)		2.02 (1.70)	
Difference in team parameters	0.21 (0.10)**		0.14 (0.17)	

†Model adjusted for employment, capital stock, and years; ‡Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, international market, foreign owned, region, industry and year; First differences estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, and year; Standard error in the bracket; ***$p \leq 0.01$; **$0.01 < p \leq 0.05$; *$0.05 < p \leq 0.1$

Figure 6.1. Rate at which output and wages decline for a 0.1 increase in the absence rate, at various levels of the firm's absence rate and proportion of team workers

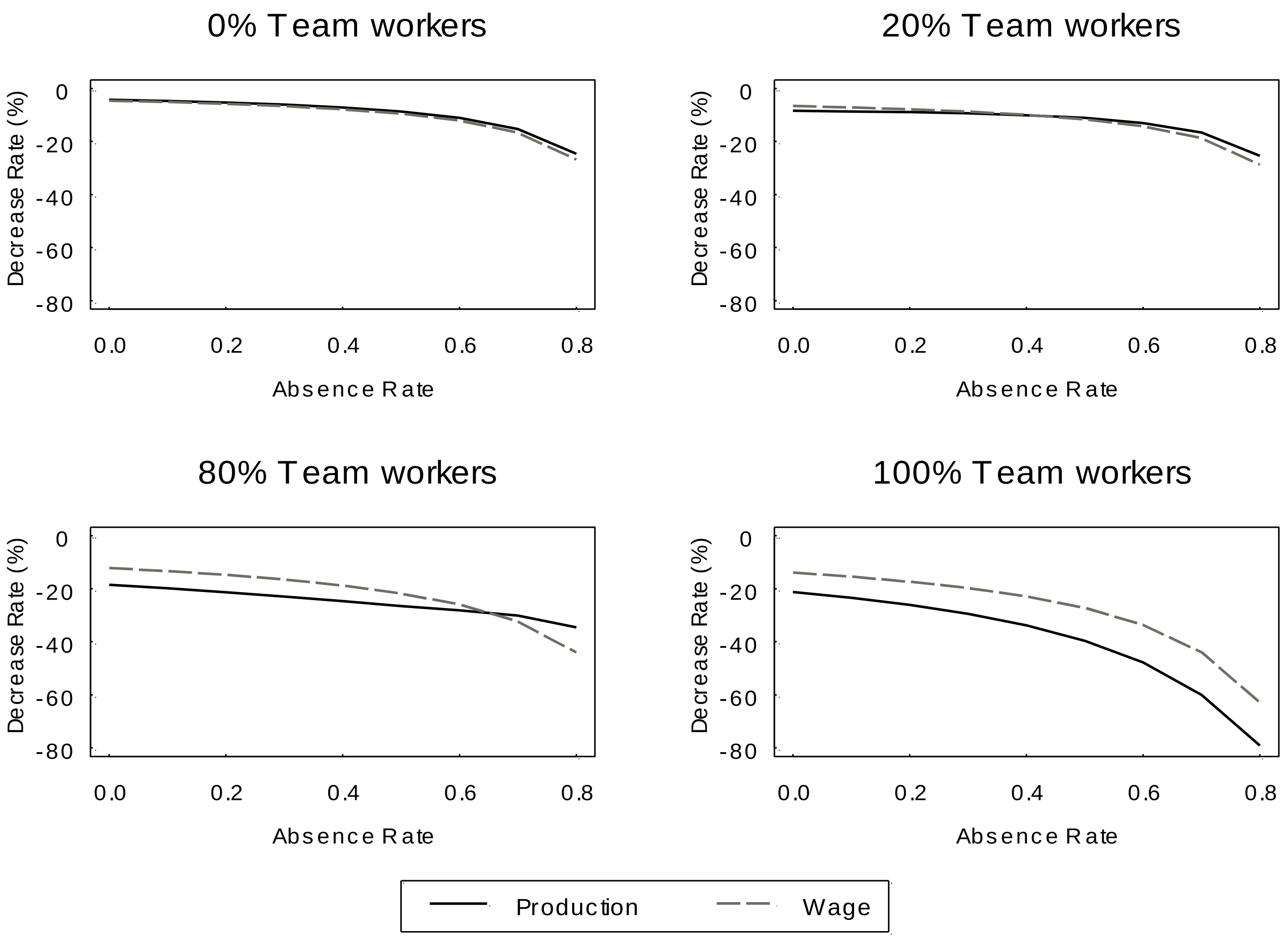


Table 6.5 and Table 6.6 present estimates from sub-samples of small and large firms. The first difference estimates from the sub-samples (Appendix D.4) were similar to the NLS estimates but much less precisely estimated. Here we only presented the NLS estimates. In the restricted models, both output and wage decreased as attendance decreased and the attendance impacts in large firms were bigger than those in small firms (Table 6.5). Similar to the results for the full sample, the attendance parameters in the wage and production functions were not significantly distinguishable. In both small and large firms, team workers were more productive and earned more than non-team workers, and the relative productivity was higher than the relative wage. Although the difference between relative productivity and wage was higher in small firms, marginal significance was found in large firms.

In the complete models, the attendance impacts of non-team workers on output and wage were much bigger in large firms than in small firms (Table 6.6). On the contrary, the attendance impacts of team workers on output and wage were bigger in small firms. The non-significant attendance parameter for team workers implies that in a large firm with 100% team workers, absenteeism did not have any impacts on productivity and wage. On the other hand, absenteeism significantly reduced productivity and wage in a small firm with 100% team workers and the productivity reduction was significantly higher than the wage reduction. The difference between the relative productivity and wage of team workers versus non-team workers was bigger and marginally significant in small firms.

Table 6.5. Parameter estimates using restricted models among small firms (less than 20 employees) and large firms (all others)

	NLS (small firms)		NLS (large firms)	
	Production	**Wage**	**Production**	**Wage**
Baseline controls†				
Log (total no. of employees)	0.87 (0.03)***	1.04 (0.02)***	1.07 (0.02)***	1.02 (0.02)***
Log (capital)	0.03 (0.01)***	0.04 (0.01)***	0.09 (0.01)***	0.08 (0.01)***
Attendance rate	0.44 (0.13)***	0.38 (0.07)***	1.20 (0.57)**	1.19 (0.42)***
Team	0.53 (0.23)**	0.27 (0.09)***	0.82 (0.14)***	0.70 (0.11)***
Difference in attendance rate parameters	0.06 (0.11)		0.01 (0.35)	
Difference in team parameters	0.26 (0.18)		0.11 (0.10)	
All controls‡				
Log (total no. of employees)	0.88 (0.03)***	1.07 (0.02)***	1.10 (0.02)***	1.03 (0.02)***
Log (capital)	0.00 (0.02)	-0.03 (0.01)***	0.00 (0.01)	-0.01 (0.01)
Attendance rate	0.51 (0.14)***	0.46 (0.07)***	0.80 (0.51)	0.75 (0.34)**
Team	0.21 (0.15)	0.02 (0.05)	0.25 (0.09)***	0.13 (0.06)**
Difference in attendance rate parameters	0.05 (0.12)		0.05 (0.32)	
Difference in team parameters	0.19 (0.13)		0.12 (0.07)*	

†Model adjusted for employment, capital stock, and years; ‡Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, international market, foreign owned, region, industry and year;
***$p \leq 0.01$; **$0.01 < p \leq 0.05$; *$0.05 < p \leq 0.1$

Table 6.6. Parameter estimates using complete models among small firms (less than 20 employees) and large firms (all others)

	NLS (small firms)		NLS (large firms)	
	Production	**Wage**	**Production**	**Wage**
Baseline controls†				
Log (total no. of employees)	0.87 (0.03)***	1.04 (0.02)***	1.07 (0.02)***	1.01 (0.02)***
Log (capital)	0.03 (0.01)***	0.04 (0.01)***	0.09 (0.01)***	0.08 (0.01)***
Attendance rate with no team	0.39 (0.14)***	0.36 (0.08)***	1.95 (0.80)**	1.66 (0.58)***
Attendance rate with team	6.34 (2.25)***	3.01 (1.03)***	-0.57 (0.76)	-0.02 (0.70)
Team	0.75 (0.27)***	0.35 (0.10)***	0.71 (0.15)***	0.63 (0.12)***
Difference in attendance parameters with no team	0.04 (0.11)		0.29 (0.36)	
Difference in attendance parameters with team	3.33 (1.59)**		-0.55 (0.70)	
Difference in team parameters	0.40 (0.21)*		0.08 (0.10)	
All controls‡				
Log (total no. of employees)	0.88 (0.03)***	1.07 (0.02)***	1.10 (0.02)***	1.03 (0.02)***
Log (capital)	0.00 (0.02)	-0.03 (0.01)***	0.00 (0.01)	-0.01 (0.01)
Attendance rate with no team	0.47 (0.14)***	0.44 (0.06)***	1.32 (0.70)*	1.08 (0.47)**
Attendance rate with team	4.97 (1.87)***	2.25 (0.95)**	-0.76 (0.73)	-0.33 (0.64)
Team	0.33 (0.18)*	0.06 (0.06)	0.19 (0.10)*	0.09 (0.07)
Difference in attendance parameters with no team	0.03 (0.12)		0.24 (0.37)	
Difference in attendance parameters with team	2.72 (1.49)*		-0.43 (0.72)	
Difference in team parameters	0.27 (0.16)*		0.10 (0.07)	

†Model adjusted for employment, capital stock, and years; ‡Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, international market, foreign owned, region, industry and year; ***$p \leq 0.01$; **$0.01 < p \leq 0.05$; *$0.05 < p \leq 0.1$

In Appendix D, we present the parameter estimates for all covariates that were included in the models for Table 6.3 to Table 6.6. We have also included the results from additional analyses using alternative specifications including the translog production function (full sample) and a different absence rate specification (full sample and sub-samples). The results from these alternative specifications were similar to what we obtained above. When we considered different absence rates for team workers and non-team workers, the attendance and team parameters did not change too much and the findings were similar, which suggests our main analyses are robust (Appendices D.3 and D.4). When the equiproportionate restriction was dropped, the parameters changed slightly. Nevertheless, the qualitative nature of the results stayed the same after relaxing these assumptions.

6.4 Discussion

This study was the first to test the equality of the estimated absenteeism impacts on marginal productivity and wage using linked employer-employee data. Following similar methodologies to Hellerstein et al.[119,120] and Crepon et al.[134,135], we estimated the relationship between attendance rate and productivity and wage simultaneously, then tested the equality of the attendance rate parameters in the two equations. When we performed a pooled cross-sectional analysis using NLS, we found that lower attendance resulted in lower output and wage and a non-significant wage-productivity gap with respect to attendance. When we introduced workplace fixed effects by relating changes in the attendance rate to changes in productivity and wage, the effect of attendance on wage became much smaller and the wage-productivity difference became larger especially for workers participating in a team but it was still not statistically significant. The attendance impacts varied with firm size. Compared with large firms, the impacts of non-team workers in small firms were smaller but those of team workers were bigger. A significant difference was found between the attendance impacts of team workers on productivity and wage in small firms. In large firms, the absenteeism of team workers had non-significant impacts on both productivity and wage. The NLS approach consistently revealed that team workers were more productive and earned more than non-team workers and the relative marginal productivity of team workers to non-team workers were significantly larger than the relative wage. The study findings support the literature which states that the resulted productivity loss arising due to worker absence could exceed the wage if they are involved in team work.[26,29]

Why did the attendance (absenteeism) impact of team workers on output differ between small firms and large firms? One possible explanation is that large firms might hire extra employees in case of the absence of a team worker to maintain a certain output level.[26] On the other hand, small firms can not afford to hire extra employees and thus if a team worker is absent, the output of the entire team could be affected and the impact on the output is higher than the wage paid to the absent team worker.

As mentioned before, no previous studies have tested the equality of wage and marginal productivity with respect to absenteeism by simultaneously estimating production and wage functions at the plant level. There were, however, several studies that estimated the impact of absenteeism on productivity using plant-level data. Allen[127] estimated the effect of absenteeism on the output per man hour in the U.S. manufacturing sector in 1972 and found that the elasticity of the absence rate was -0.015, i.e., if the absence rate increased from 0.1 to 0.2 then the output per manhour decreases by 1%. Mefford[137] examined the effect of unions on productivity in 31 plants of a large multinational firm from 1975-82. He also included the absence rate into the production function and found that the elasticity of the absence rate was -0.033, i.e., if the absence rate increased from 0.1 to 0.2, then productivity decreases by 2.3%. Compared to these two studies, the direction of effect in our study was consistent but with a greater effect size.

In terms of team impact, our findings arrived at similar qualitative conclusions compared to previous studies. Hamilton et al.[138] found that a particular worker's productivity increases roughly 14% after joining a team. This is consistent with our findings in that team workers were more productive than non-team workers. Coles et al.[126] used just-in-time as an indicator of an assembly line production process and reported an association between higher wages and lower absence rates; however, the relationship was almost twice as steep in just-in-time firms contrasted to non-just-in-time firms. We have consistently demonstrated that the attendance rate parameter for team workers was much higher than that for non-team workers in the wage equation.

Our study was limited by the measure of absenteeism. The WES survey only collected paid sick leave but not unpaid sick leave and therefore we could not generate a variable for absenteeism due to illness, which was to a greater extent, unavoidable and unexpected. Following the definition by Dionne and Dostie,[124] we only took into account the number of days of paid sick leave, other paid leave and unpaid leave, but did not include paid vacations, paid paternity/maternity leave, or absence due to strikes or lock-outs. In this manner, we assumed that the impact of other paid leave/unpaid leave on wage/output was the same as the impact of sick leave on wage/output.

Furthermore, we used an imperfect proxy measure for the capital stock, which may have introduced potential bias into our estimates. We re-estimated the model by excluding the capital stock and the attendance rate parameters remained virtually identical. Therefore, we believe that our parameter estimates were quite robust to our measure of capital stock.

In this study, we used first differences to remove workplace fixed effects. However, some transitory shocks could not be removed and thus might lead to biased estimates. For example, a chemical spill accident may instigate sick leaves and a reduction in output. Employee work attendance decisions also depend on the slope of the wage-absence tradeoff, which causes simultaneity problems.[127] An instrumental variable (IV) approach[122,134,135] can be used to consistently estimate parameters. The challenge of this method is to find variables that can serve as valid instruments, i.e., variables that have an effect on the endogenous variable (attendance rate) but do not directly affect productivity or wage. The lagged value of attendance rate can be potentially used as instruments for the change in attendance rate. However, we found that the lagged value of attendance rate was weak (F-statistic < 10). We could not find other valid IVs and therefore, the IV method was not applied. Instead, we conducted additional analyses to test the robustness of our results. The qualitative nature of the evidence from the alternative specifications and relaxing assumptions was consistent, indicating that the full-sample estimates were relatively robust. The stability of the parameter estimates across different analyses that were conducted provided strong evidence that the comparison between the parameter estimates of marginal productivity and those of wage was meaningful.

In conclusion, this study provides some evidence to suggest that although team workers are more productive and earn higher wage, the higher wage paid to team workers considerably under-represents their higher marginal productivity relative to non-team workers. In small firms, higher employee absenteeism results in lower productivity and wage, and the marginal productivity loss with respect to team worker absenteeism is higher than the wage loss. There is not a wage-productivity gap with respect to absenteeism in large firms.

Chapter 7: Wage, marginal productivity and presenteeism

7.1 Introduction

Absenteeism is when employees do not arrive at work due to illness. Presenteeism, the flip side of absenteeism, occurs when employees attend work, however due to illness, are not functioning at full capacity.[139] In 2004, the New York Times Magazine considered health-related presenteeism to be one of the most noteworthy ideas.[140] In economic terms, presenteeism refers to the reduced intensity and/or quality of labour input due to illness while working.[58] As a result, both quantity of output (working more slowly, taking more breaks, or repeating tasks) and quality of output (mistakes) will be affected.[139] It is therefore imperative to be able to identify the distinction between absenteeism and presenteeism. Many studies have been performed to measure productivity loss arising from illness-related presenteeism and showed that presenteeism is potentially more costly than absenteeism.[141] For instance, Bank One found that the cost of presenteeism amounted to $311.8 million per year, accounting for 63% of the total health-related costs including direct medical costs and other indirect costs as a result of absenteeism, short-term and long-term disability.[139]

Despite much attention given to presenteeism, current research still suffers from limitations. First, many questionnaires have been developed to measure presenteeism but yielded rather different estimates of resulted productivity loss.[46,48,51,52] These questionnaires inquire workers about their difficulties at work,[43] job performance,[142] work limitations[49] or directly ask for productivity work time loss.[35,143] According to a recent study employing several different questionnaires, the number of lost hours resulting from presenteeism among people with arthritis ranged from 1.6 hours to 14.2 hours within two weeks.[52] With the availability of numerous questionnaires generating different estimates, people have become perplexed about what they are actually measuring and how comparable their results are to one another.

Second, there is a lack of objective measure of productivity loss resulting from presenteeism. Unlike absenteeism, presenteeism is not always noticeable. For certain jobs, we can link self-reported presenteeism and objective measures of productivity, for example, the amount of time spent on each call and the amount of time between calls for call center workers.[45] However, most often, the objective measure of productivity and thus the productivity loss resulting from presenteeism is not available.

Third, when estimating productivity loss resulting from presenteeism, time loss is first estimated followed by costs based on employees' wage. Wage is assumed to be equal to marginal productivity at the firm level.[23,24] However, for many reasons, wage may not equal marginal productivity. One instance is inequities such as race or gender discrimination that exist in imperfect labour markets, whereby an identifiable group routinely receives lower wage. More commonly, risk-averse workers might willingly accept a wage that is lower than their marginal productivity in exchange for job security, e.g. allowances for sick days.[26] A difference between wage and marginal productivity of workers also exists if a job involves team production, if the output is time-sensitive, or if perfect substitutes for workers are not readily available.[26,29]

This Chapter aims to link employees' self-reported presenteeism to an objective measure of output and wage at the firm level, then test the null hypothesis that wage losses due to presenteeism are equal to marginal productivity losses. Several studies in the literature link self-reported presenteeism and actual productivity loss. One study found that self-reported work limitations using the Work Limitations Questionnaire were significantly associated with employee work productivity as measured by the number of phone calls answered per payroll hour.[45] However, no studies have linked self-reported presenteeism to an objective monetary measure of productivity or tested the equality of wage and marginal productivity with respect to presenteeism.

An emerging method to examine the relationship between wage and marginal productivity is by using population-based datasets that link employees' input to their employers' output. For example, Hellerstein and Neumark[119] used Israeli population data on labour markets to test whether the wage gap between men and women exceeds any gap in marginal productivity. Hellerstein et al.[120] used US population data to estimate wage and marginal productivity for worker groups with different age, sex, and race characteristics, while Hægeland and Klette[121] analyzed the difference in wage and productivity across Norwegian workers by sex, education and work experience. Van Ours and Stoeldraijer[122] identified 13 studies on age related wage-productivity gap using employer-employee linked data. The databases used in these studies contain data on a firm's output, capital, materials, other expenditures, payroll, and industry, as well as workers' age, sex, education, and occupation. The availability of this data allows researchers to test the equality between wage and marginal productivity for groups of workers with different characteristics.

The setup of this Chapter is as follows: in section 7.2 we describe our employer-employee linked data, define main variables, and present the setup of our analysis methods. In section 7.3, we present our findings and parameter estimates. Section 7.4 summarizes our findings and the impact and implications that present.

7.2 Methods

7.2.1 Data

The Workplace and Employee Survey (WES) conducted by Statistics Canada in 1999-2005 is a survey of Canadian employers and employees.[77] The WES is one of only a few linked employer-employee databases worldwide and the only one in Canada. The WES has been used to estimate age-based wage and productivity differentials[128] and to compare wages and marginal productivity for workers with different levels of education and technology use.[129,130] The sampling frame for the WES included all Canadian workplaces in the Statistics Canada Business Registry that had paid employees in March of the survey year. Employers in Yukon, Nunavut, the Northwest Territories and those operating in crop production and animal production, fishing, hunting and trapping, private households, religious organizations and public administration were excluded from the survey. The sampling frame for employees comprised all employees working or on paid leave in March from the targeted workplaces. Workplaces were first randomly selected from the Business Registry, and then employees were sampled from an employee list provided by the selected workplace. A maximum of 24 employees were sampled from each of the selected workplaces. In workplaces with fewer than 4 employees, all employees were selected. The WES was administered at a single workplace in at least two consecutive years. The workplace and employee samples were refreshed in odd years (1999, 2001, 2003, and 2005) to reflect attrition, firm births, and employee turnover.

For this study, we first restricted the sample to workplaces with more than one interviewed employee. Then we focused on for-profit firms with a positive output value. During the second survey years (even years), over 11% of surveyed employees had a different employer or had left their employer and did not have a new employer, which affected almost 30% of surveyed workplaces. Since employee attrition from the WES during the second survey year is high and the attrition is likely non-random,[131] data from even-numbered years were not used. Therefore, our analysis is based on the pooled data during odd years only, i.e., 1999, 2001, 2003, and 2005. However, because the question related to our measure of presenteeism has changed since 2001 (details below), we further restricted our sample to the data in 2001, 2003 and 2005.

7.2.2 Variable definition

7.2.2.1 **Outcome variables**

Output is defined as value added, where value added is measured as annual gross operating revenues minus expenses on materials.[129,130] Expenses on materials are equal to the annual gross operating expenditures minus total gross payroll and expenditures on non-wage benefits and training. Wage is defined as annual payroll, as reported by workplaces in the WES survey.

7.2.2.2 **Independent variables of interest**

Reduction at work: Reduction at work was used as our proxy measure for self-reported presenteeism. In 1999, this was assessed by asking employees, “Are you limited in the kind of activity that you can do because of a long-term physical condition, mental condition or health problem?" followed by, "If yes, are you limited at work?".[144] Response options were limited to either yes or no. However in 2001, the work limitation question used in 1999 was replaced with a new question that asked, "Does a physical condition or mental condition or health problem reduce the amount or the kind of activity you can do at work or at school?".[144] This question refers to conditions or health problems that have lasted or are expected to last six months or more. Four choices were available: 1) yes, often, 2) yes, sometimes, 3) no, 4) not applicable. In order to maintain consistency in our concept, we decided to exclude data from 1999. Employees were classified into one of the four categories based on their responses to the question about reduction at work: 1) workers with frequent reduction, 2) workers with occasional reduction, 3) workers without reduction, 4) workers who were not applicable. It is not clear who answered "not applicable". It is possible that these employees were currently on leave and not at work or school. They are not our worker group of interest, however are included as a category to ensure our reference group remains workers without reduction as opposed to a mixed group of workers without reduction and unidentified workers. The proportion of workers at a given reduction level at work is calculated by dividing the number of workers with a given reduction level by the number of employees surveyed in the workplace.

Team Work: WES data contains information on employees' participation "in a self-directed work group (semi-autonomous work group or mini-enterprise group) that has a high level of responsibility for a particular product or service area".[144] Workers are divided into two categories based on their participation frequency ('frequently' or 'always' versus 'occasionally' or 'never' for participation in any team work). Each worker represented in the WES data therefore belongs in one of two work groups: 1) participating in a team ('frequently' or 'always') or 2) not in a team ('occasionally' or 'never').

7.2.2.3 **Covariates**

Labour and capital are important factors in the production function. However, the WES does not measure a firm's capital and therefore, we used the imputation approach of Turcotte and Rennison (2004)[128–130] to approximate this value. The capital stock of a firm is approximated using the average capital stock during the last five years in the industry the firm belongs in. The industry capital stock corresponds to the geometric (infinite) end-year net stock of non-residential capital reported in Table 031-0002 of CANSIM from Statistics Canada.[132] The firm's capital stock is then calculated by dividing the industry capital stock by the number of firms in each industry represented by the WES. A total of 837 unique industries indicated by the North American Industry Classification System (NAICS) codes in 6 digits were identified in the WES data (1999-2005). However, the net stock information was only available for 247 industries indicated by different levels of NAICS codes varying from 2 to 6 digits. Hence, 247 unique capital stock estimates were imputed into the WES data.

In addition, we controlled for variables of other workforce characteristics: age, sex, education, occupation, race, immigrant, an indicator for membership in union or collective bargaining agreement and difficulty in hearing, seeing or doing similar activities, as well as variables of workplace characteristics: an indicator for international market, an indicator for foreign country ownership, region, industry and calendar year dummies. More details on the definition of the variables we used in the study can be found in Appendix B.

7.2.3 Statistical analyses

7.2.3.1 **Production function**

We have extended the Cobb-Douglas production function to capture productivity effects related to reduction at work and team work at the firm level.[119,120,133] Detailed steps for extending the Cobb-Douglas production function have been documented in Appendix C.

For each workplace, consider a Cobb-Douglas production function

$$\ln Q_j = \alpha \ln L_j^A + \beta \ln K_j + \eta F_j + \mu_j \tag{16}$$

where Q is output, measured as value added by firm j, L^A is an aggregate function of productive labour of each type of worker, K is the capital stock, F_j is a matrix of various firm characteristics, α and β are the elasticity of output with respect to labour and capital, respectively, η is a vector of parameters for firm characteristics and μ_j is the error term. We use the log of value added as the dependent variable to address the endogeneity of materials in the production function.[120,129,130] Worker types refer to workers with different characteristics such as age, sex, education, occupation, team participation etc. If the total number of characteristics is I and workers are divided into V_i categories by each characteristic i, then the total number of worker types is $D_I = \prod_{i=1}^{I} V_i$.

With the assumption of perfect substitution among all types of workers and different marginal productivity for each worker type, the aggregate function of productive labour can be written as

$$L^A = \sum_{d=0}^{D_I-1} \lambda_d L_d \tag{17}$$

where D is the total number of worker types, L_d is the number of workers of type d in a firm, and λ_d is the marginal productivity for workers of type d. Without loss of generality, we use $d = 0$ for the reference group in our all models.

In this study, our independent variables (worker characteristics) of interest are presenteeism and team work participation. There is also a need to control for other worker characteristics including age, sex, education, occupation, race, immigrant and membership in union or collective bargaining agreement. Our sample of workers from each workplace is not large enough to allow fine distinctions based on all these worker characteristics. Instead, we are only interested in dividing workers by reduction at work (presenteeism) and team work participation. Workers are divided into four categories by reduction at work: 1) frequent reduction (R_h); 2) occasional reduction (R_s); 3) no reduction (R_0); 4) not applicable (R_x); and two categories by team work participation: 1) participating in a team (G) and 2) not in a team (N). The production function therefore needs to be simplified to address such distinctions.

To simplify the equation, we need to apply the two restrictions made by Hellerstein et al..[119,120] First, we assume that the proportion of one type of worker is constant across other characteristic groups, referred to as the *equiproportionate restriction*.[119,120] For example, older workers are equally represented in team workers and non-team workers. Second, we assume the relative marginal productivity of two types of workers within one characteristic group is equal to those within another characteristic group, referred to as the *equal relative productivity restriction*.[119,120]

For example, the relative marginal productivity of team workers versus non-team workers among older workers is the same as those among younger workers.

Having applied these restrictions, the "restricted model" for the production function (equation 8 from Appendix C) then becomes

$$\ln Q_j = \beta_0 + \beta \ln K_j + \alpha \ln L_j + \alpha \sum_{i=1}^{I} \ln\left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{ivj}\right) + \eta F_j + \mu_j$$

$$= \beta_0 + \beta \ln K_j + \alpha \ln L_j \tag{18}$$

$$+ \alpha \ln\left(1 + \left(\gamma_{R_h} - 1\right) P_{R_h j} + \left(\gamma_{R_s} - 1\right) P_{R_s j} \ + \left(\gamma_{R_x} - 1\right) P_{R_x j}\right)$$

$$+ \alpha \ln\left(1 + (\gamma_G - 1) P_{Gj}\right) + \alpha E_j + \eta F_j + \mu_j$$

where

$$E_j = \sum_{i=1}^{I-2} \ln\left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{ivj}\right) \tag{19}$$

$\gamma_{iv} = \frac{\lambda_{iv}}{\lambda_{i0}}$ is the relative marginal productivity of worker type *iv* to the reference worker type *i0* for each characteristic *i*. For example, γ_{R_h} is the relative productivity of workers with frequent reduction at work to workers without any reduction; γ_G is the relative productivity of team workers to non-team workers. $P_{ivj} = \frac{L_{ivj}}{L_j}$ is the proportion of worker type *iv* among all workers in the firm *j*. *i* represents the number of worker characteristics, *v* stands for the number of worker categories divided according to the worker characteristic *i*, and β_0 is a constant term.

If we relax the two restrictions for reduction at work and team work participation, the relatively "complete model" for the production function is

$$\begin{aligned}\ln Q_j = {} & \beta_0 + \beta \ln K_j + \alpha \ln L_j \\ & + \alpha \ln\big(1 + (\gamma_{R_hN} - 1)P_{R_hNj} + (\gamma_{R_sN} - 1)P_{R_sNj} \\ & + (\gamma_{R_xN} - 1)P_{R_xNj} + (\gamma_{R_hG} - 1)P_{R_hGj} + (\gamma_{R_sG} - 1)P_{R_sGj} \\ & + (\gamma_{R_0G} - 1)P_{R_0Gj} + (\gamma_{R_xG} - 1)P_{R_xGj}\big) + \alpha E_j + \eta F_j + \mu_j\end{aligned} \tag{20}$$

7.2.3.2 **Wage equation**

Applying the same approach as in the case of marginal productivity, the relative wage among workers with different reduction levels at work can also be estimated at the firm level. The "restricted model" for wage equation (equation 14 from Appendix C) is

$$\begin{aligned}\ln w_j & = \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j + \sum_{i=1}^{I} \ln\left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1)P_{ivj}\right) + \eta_w F_j + \mu_{w,j} \\ & = \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j \\ & \quad + \ln\big(1 + (\phi_{R_h} - 1)P_{R_hj} + (\phi_{R_s} - 1)P_{R_sj} + (\phi_{R_x} - 1)P_{R_xj}\big) \\ & \quad + \ln\big(1 + (\phi_G - 1)P_{Gj}\big) + E_{wj} + \eta_w F_j + \mu_{w,j}\end{aligned} \tag{21}$$

where

$$E_{wj} = \sum_{i=1}^{I-2} \ln\left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1)P_{ivj}\right) \tag{22}$$

i represents the number of characteristics, *v* stands for the number worker categories divided according to the worker characteristic *i*, and $\phi_{iv} = \frac{w_{iv}}{w_{i0}}$ is the relative wage of worker type *iv* to the reference worker type *i0* for each characteristic i. For example, $\phi_{R_h}$is the relative wage of workers with frequent reduction at work to workers without any reduction; $\phi_G$is the relative wage of team workers to non-team workers. β_{w0} is a constant term, α_w and β_w are the elasticity of wage with respect to labour and capital, respectively, η_w is a vector of parameters for firm characteristics, and $\mu_{w,j}$ is the error term.

The relatively "complete model" for wage is

$$\begin{aligned}\ln w_j = \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j + \ln\big(1 + (\phi_{R_hN} - 1)P_{R_hNj} + (\phi_{R_sN} - 1)P_{R_sNj} \\ + (\phi_{R_xN} - 1)P_{R_xNj} + (\phi_{R_hG} - 1)P_{R_hGj} + (\phi_{R_sG} - 1)P_{R_sGj} \\ + (\phi_{R_0G} - 1)P_{R_0Gj} + (\phi_{R_xG} - 1)P_{R_xGj}\big) + E_{wj} + \eta_w F_j + \mu_{w,j}\end{aligned} \tag{23}$$

7.2.3.3 **Estimation of the equations**

Our analysis starts with the restricted models and then the complete models in which the restrictions for reduction at work and team work participation are relaxed. The production function and wage equation were simultaneously estimated. The equality of marginal productivity and wage was tested by comparing the relative marginal productivity and relative wage among different reduction levels and team work participation, e.g, $(\lambda_{R_h} - 1)$ and $(\phi_{R_h} - 1)$; $(\lambda_{R_hG} - 1)$ and $(\phi_{R_hG} - 1)$.

Different methods were used to estimate the equations. First, we present pooled cross-section estimates (2001, 2003, and 2005 data) using nonlinear least squares (NLS).[119,120] The estimated results can be interpreted as follows: workers with reduction at work will be estimated to be less productive than workers with no reduction if a firm with a higher proportion of workers with reduction in its labour force produces less on average than a comparable firm with a lower proportion of this worker type. With NLS estimates, we are unable to determine whether the estimated lower productivity of workers with reduction at work is a result of the sorting of such workers into lower-productivity workplaces (with the productivities of workers with reduction and those without being roughly the same), or due to the lower productivity of workers with reduction relative to workers without reduction within workplaces.

Furthermore, the least squares estimates are likely to be biased. A potential source of bias is unobserved workplace-level heterogeneity in wages and output that may be correlated with the quantities of labour inputs. For example, some firms consistently invest in assistance programs that help workers with work reduction due to health conditions adapt their work. Our second method addresses such unobserved heterogeneity by estimating the equations in first differences to remove workplace-level fixed effects.[122,134,135] The coefficient on work reduction in this specification estimates the rate at which output declines within a firm when the proportion of the firm's workers with work reduction increases.

The WES employer weight was used to compute the average or frequency of workplace characteristics.[136] Since our analysis linked employer and employee characteristics, we used the WES linked weight to compute the average employee characteristics at the firm level including proportion of workers with reduction at work, proportion of team participation and proportions of other workforce characteristics that were calculated based on employee data. Similarly, the linked weight was used to estimate the equations. In addition, standard errors were estimated following Statistics Canada's recommended procedure,[136] using 100 sets of provided bootstrap sample weights. All data analyses were conducted using SAS.

7.2.3.4 **Additional analyses**

Further analyses were conducted to test the robustness of effects. First, we repeated our analyses among the sub-samples: small firms with less than 20 employees and large firms (the remainder). Second, we estimated results using the translog production function,[119,120] which are shown in Appendix E. Third, in order to examine the impacts of the equiproportionate restriction on the parameter estimates, we dropped the restriction among presenteeism, team participation and other worker characteristics including age, sex, occupation and education, respectively.

7.3 Results

For the pooled time series-cross section NLS estimates we obtained 13,755 observations with 6,842 unique workplaces. For the first differences estimates, there were 6,490 observations with 4,001 unique workplaces. There were 5,738 and 8,017 observations for small firms and large firms, respectively. Table 7.1 illustrates the transition from the gross workplace sample to our final sample in details.

Table 7.1. Transition from the gross sample to the final sample

	Observations	Workplaces
Gross sample	43832	9372
At least one employee without attrition*	36579	8875
Value added >0	31786	7931
For profit	30416	7812
Odd years excluding 1999	**13755**	**6842**
First differences	**6490**	**4001**
Small firms	**5738**	**3198**
Large firms	**8017**	**3966**

*In even survey years, employees who had a different employer or left his employer and did not have a new employer were considered as attrition

Table 7.2 provides weighted descriptive statistics for variables used in our analysis at the workplace level. The average number of employees per firm was 16 and most firms (84%) fell in the category of 1-19 employees. The mean age of employees was 41 years old and more than half were female (54.2%). On average, the proportion of workers whose work was often or sometime reduced was 2.7% and 3.9%, respectively and 93.1% of workers did not have any conditions or health problems that reduce the amount or the kind of activity they can do at work. The fraction of workers involved in team work was 7.4%. Thus, the proportion of workers who participated in a team and whose work was reduced was very low, 0.2% often and 0.3% sometimes.

Table 7.2. Descriptive statistics at workplace level

Variables	Weighted mean	Standard deviation
Value added (,000)	1325.306	43.499
Log value added	12.534	0.027
Total wage (,000)	554.094	12.917
Log wage	11.933	0.026
Employment	15.672	0.304
Capital stock (,000)	1376.150	77.187
Proportion of workers by reduction level at work		
Often	0.027	0.003
Sometime	0.039	0.004
No	0.931	0.004
Not applicable (N/A)	0.003	0.002
Proportion of workers participating in a team	0.074	0.003
Proportion of workers by reduction and team		
Often, team	0.002	0.001
Sometime, team	0.003	0.000
No, team	0.068	0.003
N/A, team	0.0001	0.0001
Often, no team	0.024	0.003
Sometime, no team	0.036	0.003
No, no team	0.862	0.005
N/A, no team	0.003	0.002
Other workforce characteristics		
Age	40.603	0.202
Proportion of workers by age		
Age <35	0.350	0.007
35 ≤ Age < 55	0.522	0.008
55≤ Age	0.128	0.006
Proportion of female workers	0.542	0.009
Proportion of workers by level of education		
< High school	0.132	0.006
High school graduate only	0.205	0.008
Under university bachelor (completed/some college or university)	0.535	0.008
University bachelor	0.094	0.004
> University bachelor	0.035	0.003
Proportion of workers by occupation		
Managers/professionals	0.278	0.006
Technical/trades/marking/sales/clerical/administrative	0.462	0.007
Production workers	0.196	0.006
Others	0.064	0.004
Proportion of ethnic minorities	0.198	0.008
Proportion of immigrants	0.180	0.007
Proportion of employees with bargaining agreement	0.046	0.003
Proportion of employees with difficulty	0.088	0.005

Variables	Weighted mean	Standard deviation
Workplace characteristics	**%**	
Establishment size		
1-19 employees	83.7	
20-99 employees	14.4	
100-499 employees	1.7	
500 employees or more	0.2	
Number of employees surveyed		
1	12.8	
2	17.4	
3	22.2	
4	10.4	
>=5	37.2	
International market	5.3	
Foreign country owned	3.4	
Industry		
Forestry, mining, oil, and gas extraction	1.4	
Labour intensive tertiary manufacturing	3.3	
Primary product manufacturing	1.3	
Secondary product manufacturing	2.0	
Capital intensive tertiary manufacturing	2.5	
Construction	8.2	
Transportation, warehousing, wholesale	11.8	
Communication and other utilities	1.4	
Retail trade and consumer services	32.9	
Finance and insurance	5.5	
Real estate, rental and leasing operations	4.2	
Business services	13.7	
Education and health services	9.9	
Information and cultural industries	1.7	
Region		
Atlantic	8.2	
Quebec	20.7	
Ontario	37.3	
Alberta	12.1	
British Columbia	15.0	
Manitoba	3.0	
Saskatchewan	3.8	
Year		
2001	32.4	
2003	32.4	
2005	35.2	

Table 7.3 presents parameter estimates using NLS and first differences methods using restricted models. Additional controls reduced the first differences parameters for reduction at work in the production function. With the additional controls, both NLS estimates and first differences estimates showed the wage differentials between workers with reduction and workers without reduction were statistically insignificant, and hence indistinguishable from zero. Using NLS, workers with frequent reduction at work were estimated to be 5% less productive than workers without reduction. On the other hand, first differences estimates showed that workers with frequent reduction at work were 34% more productive and the difference between relative productivity and relative wage was large (0.38). However, neither the estimated marginal productivity differentials, nor the wage-productivity differences were significant. Surprisingly, for workers with occasional reduction at work, estimates using both methods showed that they were more productive than workers without reduction. Using first differences, the estimated wage and marginal productivity differentials were marginally significantly distinguishable with a difference of 0.55. This implies that, on average, the wages paid to workers with occasional reduction under-represented their higher marginal productivity relative to workers without reduction. Team workers were about 20% more productive and earned 8% or 5% more than non-team workers depending on the estimation methods. Introducing workplace fixed effects had little impact on parameter estimates for reduction at work in the wage equation but a large impact on the estimates in the production function. The difference between the first differences estimates and the NLS estimates indicated that the estimated wage or productivity differentials between workplaces were different from those within workplaces.

Table 7.3. Parameter estimates using restricted models

	NLS		First differences	
	Production	**Wage**	**Production**	**Wage**
Baseline controls†				
Log (total no. of employees)	0.93 (0.02)***	1.05 (0.02)***	0.50 (0.09)***	0.65 (0.04)***
Log (capital)	0.05 (0.01)***	0.05 (0.01)***	-0.01 (0.03)	0.01 (0.01)
Reduction=often	**-0.10 (0.16)**	**-0.09 (0.12)**	**0.75 (1.09)**	**0.01 (0.08)**
Reduction=sometime	**0.22 (0.14)**	**0.03 (0.11)**	**0.88 (0.45)****	**-0.04 (0.06)**
Reduction=no	0	0	0	0
Reduction=n/a	-0.83 (0.07)***	-0.17 (0.08)**	-0.96 (0.03)***	-0.27 (0.17)
Team	**0.57 (0.18)*****	**0.41 (0.09)*****	**0.20 (0.24)**	**0.05 (0.04)**
Difference for often	**-0.01 (0.13)**		**0.74 (1.10)**	
Difference for sometime	**0.19 (0.11)***		**0.92 (0.44)****	
Difference for n/a	-0.66 (0.09)***		-0.69 (0.18)***	
Difference for team	**0.16 (0.12)**		**0.15 (0.22)**	
All controls‡				
Log (total no. of employees)	0.94 (0.02)***	1.09 (0.01)***	0.48 (0.08)***	0.66 (0.04)***
Log (capital)	-0.01 (0.02)	-0.04 (0.01)***	0.00 (0.03)	0.01 (0.01)
Reduction=often	**-0.05 (0.19)**	**0.01 (0.14)**	**0.34 (0.80)**	**-0.03 (0.08)**
Reduction=sometime	**0.22 (0.13)***	**0.05 (0.08)**	**0.49 (0.31)**	**-0.06 (0.07)**
Reduction=no	0	0	0	0
Reduction=n/a	-0.80 (0.08)***	0.00 (0.09)	-0.96 (0.03)***	-0.24 (0.19)
Team	**0.19 (0.12)***	**0.08 (0.06)**	**0.20 (0.23)**	**0.05 (0.04)**
Difference for often	**-0.06 (0.15)**		**0.38 (0.79)**	
Difference for sometime	**0.16 (0.10)**		**0.55 (0.30)***	
Difference for n/a	-0.80 (0.14)***		-0.72 (0.20)***	
Difference for team	**0.11 (0.09)**		**0.15 (0.22)**	

†Model adjusted for employment, capital stock, and years; ‡Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, international market, foreign owned, region, industry and year; First differences estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, and year; Standard error in the bracket; ***p≤0.01; **0.01<p≤0.05; *0.05<p≤0.1

In the complete models, the labour force was divided into eight different worker types by the reduction level at work and team participation and the non-team workers without reduction were the reference group. Additional controls changed parameter estimates materially (Table 7.4). For team workers with frequent reduction at work, the difference between the relative marginal productivity and wage was quite large especially using first differences method. Workers with frequent reduction at work were 84% less productive but they earned 5% more, indicating a statistically significant difference between the two estimated differentials (-0.89). This implies that if an employee works in a team, his or her frequent reduction at work leads to significant output loss but not wage loss. Non-team workers with occasional reduction at work were much more productive than those without reduction but their wage was slightly higher or lower depending on the estimation methods. The estimated relative marginal productivity and wage was marginally significantly different (0.19 or 0.63).

Table 7.4. Parameter estimates using complete models

	NLS		First differences	
	Production	**Wage**	**Production**	**Wage**
Baseline controls[†]				
Log (total no. of employees)	0.93 (0.02)***	1.05 (0.01)***	0.49 (0.09)***	0.65 (0.04)***
Log (capital)	0.05 (0.01)***	0.05 (0.01)***	-0.01 (0.03)	0.01 (0.01)
Reduction=often, team	**-0.16 (0.26)**	**0.05 (0.34)**	**-0.59 (0.30)****	**0.09 (0.12)**
Reduction=sometime, team	**0.08 (0.46)**	**0.23 (0.25)**	**0.18 (0.58)**	**0.03 (0.16)**
Reduction=no, team	**0.65 (0.19)*****	**0.44 (0.10)*****	**0.36 (0.30)**	**0.05 (0.05)**
Reduction=n/a, team	9.21 (3.48)***	1.75 (3.02)	1.26 (0.80)	0.13 (0.20)
Reduction=often, no team	**-0.05 (0.17)**	**-0.07 (0.13)**	**1.00 (1.30)**	**0.01 (0.09)**
Reduction=sometime, no team	**0.25 (0.15)***	**0.04 (0.11)**	**1.00 (0.51)****	**-0.04 (0.06)**
Reduction=n/a, no team	-0.83 (0.07)***	-0.17 (0.07)**	-0.96 (0.03)***	-0.27 (0.17)
Reduction=no, no team	0	0	0	0
Difference for often, team	**-0.21 (0.42)**		**-0.68 (0.24)*****	
Difference for sometime, team	**-0.15 (0.27)**		**0.15 (0.49)**	
Difference for no, team	**0.22 (0.13)***		**0.31 (0.29)**	
Difference for n/a, team	7.46 (4.51)*		1.13 (0.63)*	
Difference for often, no team	**0.02 (0.14)**		**1.00 (1.30)**	
Difference for sometime, no team	**0.21 (0.12)***		**1.04 (0.50)****	
Difference for n/a, no team	-0.66 (0.09)***		-0.69 (0.18)***	
All controls[‡]				
Log (total no. of employees)	0.94 (0.02)***	1.09 (0.01)***	0.47 (0.08)***	0.66 (0.04)***
Log (capital)	-0.01 (0.02)	-0.04 (0.01)***	0.00 (0.03)	0.01 (0.01)
Reduction=often, team	**-0.22 (0.27)**	**0.12 (0.13)**	**-0.84 (0.13)*****	**0.05 (0.13)**
Reduction=sometime, team	**-0.36 (0.29)**	**-0.19 (0.18)**	**-0.30 (0.48)**	**0.00 (0.17)**
Reduction=no, team	**0.26 (0.13)****	**0.10 (0.06)***	**0.37 (0.29)**	**0.05 (0.05)**
Reduction=n/a, team	8.13 (4.05)**	1.37 (2.98)	1.28 (0.85)	0.23 (0.20)
Reduction=often, no team	**-0.01 (0.20)**	**0.01 (0.15)**	**0.54 (0.95)**	**-0.04 (0.08)**
Reduction=sometime, no team	**0.26 (0.14)***	**0.07 (0.08)**	**0.57 (0.34)***	**-0.06 (0.07)**
Reduction=n/a, no team	-0.81 (0.08)***	0.00 (0.08)	-0.96 (0.03)***	-0.24 (0.20)
Reduction=no, no team	0	0	0	0

	NLS		First differences	
	Production	**Wage**	**Production**	**Wage**
Difference for often, team	**-0.34 (0.30)**		**-0.89 (0.12)*** **	
Difference for sometime, team	**-0.17 (0.18)**		**-0.30 (0.38)**	
Difference for no, team	**0.16 (0.10)**		**0.32 (0.28)**	
Difference for n/a, team	6.77 (4.04)*		1.05 (0.71)	
Difference for often, no team	**-0.02 (0.16)**		**0.58 (0.94)**	
Difference for sometime, no team	**0.19 (0.11)***		**0.63 (0.33)***	
Difference for n/a, no team	-0.81 (0.13)***		-0.72 (0.21)***	

†Model adjusted for employment, capital stock, and years; ‡Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, international market, foreign owned, region, industry and year; First differences estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, and year; Standard error in the bracket; ***$p \leq 0.01$; **$0.01 < p \leq 0.05$; *$0.05 < p \leq 0.1$

Table 7.5 presents estimates from the sub-samples of small and large firms using restricted models with all controls. Table 7.5 shows that the relative productivity and wage estimates varied by firm size. In small firms, the results were similar to what we found when pooling small and large firms together. Using the first differences estimation method, the relative productivity of employees with occasional reduction versus those without reduction at work was marginally higher than their relative wage. However, in large firms, employees with frequent or occasional reduction were significantly less productive and lower paid than those without reduction. Their productivity differentials were significantly higher than their wage differentials. This suggests that reduction at work leads to significant productivity loss in large firms and the productivity loss is higher than the wage loss.

Table 7.6 presents the results after considering the interaction between presenteeism and team participation. The first differences estimation shows that in small firms, team workers with frequent reduction were 73% less productive but earn 27% more than non-team workers without reduction, with a significant wage-productivity gap. Non-team workers with occasional reduction were more productive and their difference between the relative productivity and wage was significant. Similar results were shown for team workers with frequent reduction in large firms. They were 95% less productive and the difference between the relative wage and productivity was significant. Differently, in large firms, non-team workers with frequent or occasional reduction were both significantly less productive and less paid than those without reduction. The productivity differentials between non-team workers with occasional reduction and those without reduction were significantly higher than their wage differentials.

Table 7.5. Parameter estimates using restricted models with all controls among small firms and large firms

	NLS		First differences[#]	
	Production	**Wage**	**Production**	**Wage**
Small firms[‡]				
Log (total no. of employees)	0.86 (0.03)***	1.08 (0.02)***	0.40 (0.10)***	0.64 (0.05)***
Log (capital)	-0.01 (0.02)	-0.04 (0.02)***	-0.01 (0.04)	0.01 (0.02)
Reduction=often	**-0.02 (0.23)**	**0.05 (0.16)**	**0.66 (1.19)**	**-0.02 (0.08)**
Reduction=sometime	**0.25 (0.15)***	**0.08 (0.09)**	**0.76 (0.49)**	**-0.06 (0.08)**
Reduction=no	0	0	0	0
Reduction=n/a	-0.85 (0.06)***	0.02 (0.09)	-0.98 (0.02)***	-0.23 (0.21)
Team	**0.20 (0.18)**	**0.03 (0.06)**	**0.20 (0.43)**	**0.11 (0.08)**
Difference for often	**-0.07 (0.18)**		**0.68 (1.18)**	
Difference for sometime	**0.17 (0.12)**		**0.81 (0.48)***	
Difference for n/a	-0.87 (0.13)***		-0.75 (0.22)***	
Difference for team	**0.17 (0.14)**		**0.09 (0.40)**	
Large firms[‡]				
Log (total no. of employees)	1.10 (0.02)***	1.03 (0.01)***	0.68 (0.08)***	0.67 (0.05)***
Log (capital)	-0.01 (0.02)	-0.01 (0.01)	-0.03 (0.03)	-0.01 (0.01)
Reduction=often	**-0.38 (0.15)*****	**-0.44 (0.14)*****	**-0.74 (0.20)*****	**-0.26 (0.12)****
Reduction=sometime	**-0.02 (0.17)**	**-0.13 (0.11)**	**-0.44 (0.15)*****	**-0.12 (0.06)****
Reduction=no	0	0	0	0
Reduction=n/a	-0.43 (0.25)*	-0.19 (0.36)	0.18 (1.03)	0.11 (0.37)
Team	**0.12 (0.08)**	**0.07 (0.07)**	**-0.08 (0.08)**	**-0.02 (0.03)**
Difference for often	**0.06 (0.12)**		**-0.47 (0.18)*****	
Difference for sometime	**0.11 (0.13)**		**-0.33 (0.15)****	
Difference for n/a	-0.23 (0.22)		0.07 (0.68)	
Difference for team	**0.04 (0.07)**		**-0.06 (0.07)**	

[‡]Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, international market, foreign owned, region, industry and year; First differences estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, and year; Standard error in the bracket; ***$p \leq 0.01$; **$0.01 < p \leq 0.05$; *$0.05 < p \leq 0.1$; [#]The estimates were based on 2352 observations for small firms and 3812 for large firms

Table 7.6. Parameter estimates using complete models with all controls among small firms and large firms

	NLS		First differences[#]	
	Production	**Wage**	**Production**	**Wage**
Small firms[‡]				
Log (total no. of employees)	0.86 (0.03)***	1.08 (0.02)***	0.40 (0.10)***	0.64 (0.05)***
Log (capital)	-0.01 (0.02)	-0.04 (0.02)***	-0.01 (0.04)	0.01 (0.02)
Reduction=often, team	**-0.17 (0.34)**	**0.13 (0.15)**	**-0.73 (0.32)****	**0.27 (0.10)*****
Reduction=sometime, team	**-0.60 (0.42)**	**-0.38 (0.28)**	**-0.73 (0.75)**	**-0.07 (0.30)**
Reduction=no, team	**0.29 (0.20)**	**0.05 (0.07)**	**0.43 (0.61)**	**0.10 (0.08)**
Reduction=n/a, team	75.48 (27.37)***	2.44 (0.62)***		
Reduction=often, no team	**0.01 (0.25)**	**0.05 (0.16)**	**0.76 (1.30)**	**-0.03 (0.09)**
Reduction=sometime, no team	**0.29 (0.16)***	**0.10 (0.09)**	**0.84 (0.52)**	**-0.05 (0.08)**
Reduction=n/a, no team	-0.85 (0.06)***	0.03 (0.09)	-0.98 (0.02)***	-0.23 (0.21)
Reduction=no, no team	0	0	0	0
Difference for often, team	**-0.31 (0.37)**		**-0.99 (0.27)*****	
Difference for sometime, team	**-0.22 (0.24)**		**-0.65 (0.58)**	
Difference for no, team	**0.24 (0.17)**		**0.33 (0.58)**	
Difference for n/a, team	73.04 (27.52)***			
Difference for often, no team	**-0.03 (0.19)**		**0.79 (1.29)**	
Difference for sometime, no team	**0.19 (0.13)**		**0.89 (0.51)***	
Difference for n/a, no team	-0.87 (0.13)***		-0.75 (0.22)***	
Large firms[‡]				
Log (total no. of employees)	1.10 (0.02)***	1.03 (0.01)***	0.68 (0.08)***	0.66 (0.05)***
Log (capital)	-0.01 (0.02)	-0.01 (0.01)	-0.03 (0.03)	-0.01 (0.01)
Reduction=often, team	**-0.26 (0.30)**	**0.04 (0.30)**	**-0.95 (0.15)*****	**0.02 (0.20)**
Reduction=sometime, team	**0.05 (0.28)**	**0.16 (0.20)**	**0.08 (0.29)**	**0.03 (0.11)**
Reduction=no, team	**0.11 (0.08)**	**0.05 (0.07)**	**-0.09 (0.08)**	**-0.03 (0.03)**
Reduction=n/a, team	0.31 (1.89)	0.10 (2.96)	0.36 (0.48)	0.00 (0.19)
Reduction=often, no team	**-0.39 (0.16)****	**-0.55 (0.15)*****	**-0.67 (0.30)****	**-0.33 (0.14)****
Reduction=sometime, no team	**-0.02 (0.20)**	**-0.22 (0.11)***	**-0.60 (0.16)*****	**-0.17 (0.06)*****
Reduction=n/a, no team	-0.44 (0.23)*	-0.21 (0.27)	0.12 (1.16)	0.11 (0.42)
Reduction=no, no team	0	0	0	0

	NLS		First differences[#]	
	Production	**Wage**	**Production**	**Wage**
Difference for often, team	**-0.31 (0.24)**		**-0.97 (0.28)*** **	
Difference for sometime, team	**-0.10 (0.25)**		**0.05 (0.28)**	
Difference for no, team	**0.07 (0.07)**		**-0.06 (0.07)**	
Difference for n/a, team	0.21 (1.27)		0.37 (0.34)	
Difference for often, no team	**0.16 (0.14)**		**-0.34 (0.26)**	
Difference for sometime, no team	**0.20 (0.15)**		**-0.43 (0.15)*** **	
Difference for n/a, no team	-0.23 (0.17)		0.01 (0.76)	

[‡]Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, international market, foreign owned, region, industry and year; First differences estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, and year; Standard error in the bracket; [***]p≤0.01; [**]0.01<p≤0.05; [*]0.05<p≤0.1; [#]The estimates were based on 2352 observations for small firms and 3812 for large firms

The first differences estimates were different from the NLS estimates in both small firms and large firms, which indicates that within-workplace estimates were different from between-workplace estimates. The between workplace estimates showed no wage-productivity gap related to presenteeism in both small firms and large firms.

In Appendix E, we present the parameter estimates for all covariates included in the models for Table 7.3 to Table 7.6. We also included the results from additional analyses using the translog production function. The results from the translog production function were similar. Furthermore, the equiproportionate restriction had little impact on our parameter estimates.

7.4 Discussion

Following similar methodologies to Hellerstein et al.[119,120] and Crepon et al.[134,135], we linked the employee self-reported reduction at work, a proxy for presenteeism, to the actual output (value added) and wage at the firm level and then tested the equality of the marginal productivity and wage losses due to presenteesim using linked employee-employer data. This study was the first to perform such analyses. We found that for team workers, those with frequent reduction were significantly less productive than non-team workers without reduction and the marginal productivity differential was significantly distinct from (higher) the wage differential. The findings were consistent among both small and large firms. They support the literature which states that the productivity loss resulting from employee presenteeism could exceed the wage if they are involved in team work.[18]

Another finding from our full sample was that for non-team workers, those with occasional reduction were marginally significantly more productive than those without reduction and their relative productivity was marginally higher than their relative wage. We confirmed this mainly from small firms. This suggests that in small firms, the occasional work reduction of non-team workers does not lead to output loss compared with those without reduction at the workplace. Their wages underrepresent their marginal productivity. On the contrary, in large firms, non-team workers with frequent or occasional reduction were significantly less productive and lower paid than those without reduction and the productivity differentials were higher than the wage differentials between those with occasional reduction and those without reduction. This suggests that in large firms, non-team worker presenteeism leads to a significantly higher productivity loss than wage loss.

Our study was limited by the proxy measure of presenteeism. The question asks employees whether a physical condition or mental condition or health problem reduces the amount or the kind of activity they can do at work or at school. As we mentioned in the introduction, presenteeism refers to reduced quantity and quality of labour input. Illness may result in working in slower paces, taking more breaks, repeating tasks, reducing the amount of work, reducing the kind of work, or making mistakes.[139] In this study, the measure of reduction at work only captures partial information on health-related presenteeism reported by employees. The impact of other aspects on productivity is unknown.

The higher productivity of non-team workers with occasional reduction in small firms seems counter intuitive, which needs further investigation. This might be partially due to the limitation of the presenteeism measure. One possible future exploration is to examine whether there is misclassification between “sometime” and “no” reduction when employees responding to the presenteeism question. How do they distinguish “often”, “sometime” and “no”? How much reduction in work activity is considered as occasional or frequent reduction? How important are the work tasks in which they are limited by their health problems?

Furthermore, we used an imperfect proxy measure for the capital stock, which might have introduced potential bias in our estimates. We re-estimated the model by excluding the capital stock and the parameters remained virtually identical. Therefore, we believe that our parameter estimates were quite robust to our measure of capital stock.

In this study, we used first differences to remove workplace fixed effects. However, some transitory shocks could not be removed and thus might lead to biased estimates. For example, the simultaneity bias remains when external shocks affect not only the productivity of the workplace but also the workforce adjustment. An external productivity shock due to technology or demand leads the workplace to reduce its workforce size instantaneously, e.g., firing those non-team workers with lower work capacity at work. Thus, the decrease in the share of non-team workers with reduction at work, i.e., the increasing share of team-workers with reduction at work occurs at the same time as the productivity shock. The part of the negative productivity shock could be erroneously attributed to a lower productivity of workers with frequent reduction at work in the fixed effect estimation. An instrumental variable (IV) approach[122,134,135] can be used to consistently estimate the parameters. The challenge of the method is to find variables that can serve as valid instruments, i.e., variables that have an effect on the endogenous variable (reduction at work) but do not directly affect productivity or wage. The lagged value of reduction at work can be potentially used as instruments for the change in reduction at work. However, we found that the lagged value of reduction at work was weak. We could not find other valid IV and therefore, the IV method was not applied. Instead, we conducted additional analyses to test the robustness of our results. The qualitative nature of the evidence from the alternative specifications and relaxing the equiproportionate restriction was consistent, indicating that the full-sample estimates were relatively robust. The stability of the parameter estimates across different analyses we conducted provided strong evidence that the comparison between the parameter estimates of marginal productivity and those of wage was meaningful.

In conclusion, the wage-productivity gap with respect to health-related reduction at work is especially large among team workers. This study provides some evidence to suggest that for team workers, health-related frequent reduction at work results in lower productivity and the resulted productivity loss is more than the wage differentials in both large and small firms. In large firms, non-team workers' reduction also leads to significant productivity loss and the resulted productivity loss exceeds the wage loss for those with occasional reduction. On the other hand, in small firms, non-team workers' occasional reduction at work may not lead to productivity loss but they are paid less than their productivity.

Chapter 8: Conclusion

Productivity loss due to health problems represents a large share of economic burden of illness. It has been considered in cost-of-illness studies and economic evaluations to help policy makers to allocate limited resources and make decisions on the implementations of a new health care or preventive intervention. However, there is still a fierce debate over whether to include productivity loss in economic evaluations for many reasons including double counting, equity concern, perspective choice, and limitations in methodological guidance on measurement and valuation of productivity loss. In order to address the issues, health economists have made recommendations on how to report productivity loss in economic evaluations. This thesis attempted to address the methodological limitations in measuring and valuing productivity loss due to poor health.

The research chapters of this thesis were designed to be used for publication elsewhere. As such, each chapter included specific conclusions and implications. The objective of this final chapter is to synthesize the overall findings, emphasize the significance and contributions, and discuss the challenges and limitations that point to future research.

8.1 Summary

Research question 1: What are the current limitations and issues on measurement and valuation of productivity loss and how to address them?

In Chapter 2, a review was conducted to identify the following limitations and issues on measurement and valuation of productivity loss due to poor health and the corresponding recommendations were made.

1) The concepts of productivity and productivity loss due to poor health were not clearly defined. The economic concept of productivity was then introduced as a measure of output per unit of input. Labour as an input was distinguished from its impact on the final output of the firm and productivity loss was defined as the output loss corresponding to the reduced labour input.
2) Current valuation methods of productivity loss use wage to represent the value of productivity loss. However, in many scenarios, wage does not represent the output value resulting from labour input loss. This needs to be tested in real life. Also, a wage multiplier that adjusts wage to represent the value of productivity loss was suggested to be developed for practical uses.
3) Presenteeism and unpaid work productivity loss were often ignored in measuring the labour input loss. They should be included as the components of labour input loss alongside absenteeism and loss from employment status changes. Chapter 2 also shed some light on the trade-offs between input loss components: absenteeism and presenteeism and the trade-offs among paid work, unpaid work and leisure.
4) Recommendations were made to address the issues with regard to measurement of productivity loss such as objective versus self-reported measures, generic versus disease

specific measures, recall periods, quantity and quality aspects of labour input, and measures from different perspectives. A self-reported questionnaire was suggested to measure productivity loss due to general health by considering both quantity and quality aspects of labour input. The literature evidence suggested a 3-month recall period for absenteeism and a 7-day recall period for presenteeism. Different questionnaires can be developed for different purposes to measure productivity loss from different perspectives.

Research question 2: Is a new questionnaire needed to measure and value productivity loss? If so, what should it capture? Is the questionnaire demonstrated valid and reliable to measure and value productivity loss and applicable to measure the treatment impact on productivity in an empirical study?

No existing questionnaires captured all time input loss components (absenteeism, presenteeism, employment status changes, and unpaid work productivity loss) as well as information on job and workplace characteristics, necessary for valuing output impact of the time input loss. Based on recommendations made in Chapter 2, a new questionnaire, the Valuation of Lost Productivity (VOLP), was then developed to meet the need. Chapter 4 provides evidence on the validity and reliability of the VOLP's time input loss estimates including absenteeism, presetneeism and unpaid work loss in people with rheumatoid arthritis (RA). The VOLP was also applied in an empirical study to measure and value the productivity loss of patients with RA over 52 weeks of etanercept and methotrexate treatment. The results in Chapter 5 suggest that productivity loss significantly dropped for those who remained on treatment at week 52. Over the one-year treatment, early responders at week 13 suffered significantly less productivity loss than non-responders. Thus, the reduction in productivity loss over 52 weeks was related to treatment response.

Research question 3: Is wage a good proxy to represent the value of productivity loss? If not, how to adjust wage to represent the value of productivity loss?

In Chapters 6 and 7, the equality between wage and marginal productivity was tested using the Workplace and Employ Survey (WES), a linked employer-employee database in Canada. Some evidence suggests the wage underestimates the productivity of team workers. In small firms, high absenteeism results in lower productivity and wage, and for team workers the reduced wage under-represents the reduced productivity (Chapter 6). In addition, compared with non-team workers without reduction at work, team workers with frequent reduction are much less productive and the productivity differentials between them are significantly greater than their wage differentials (Chapter 7). In large firms, non-team workers' reduction also leads to significant productivity loss and the resulted productivity loss exceeds the wage loss for those with occasional reduction. On the other hand, in small firms, non-team workers' occasional reduction at work may not lead to productivity loss at the workplace but they are paid less than their productivity. The wage-productivity gap exists for team workers and both absenteeism and presenteeism and therefore wage multipliers are needed to adjust wage to represent the value of productivity loss. Chapter 3 demonstrates that it is feasible to derive wage multipliers based on the self-reported workplace characteristics, i.e., team work and availability of substitutes and their substitutability using an assumed algorithm.

8.2 Strengths and contributions

The novelty of this research has been discussed in each of the study chapters (2-7). Some strengths and unique contributions are summarized as follows.

8.2.1 The development of a composite questionnaire that can be used to measure and value productivity loss

The VOLP is the first questionnaire that was developed based on the economic theory behind measuring and valuing productivity losses from a societal perspective. The VOLP development followed the guidelines on how to measure productivity that were summarized in Chapter 2. First, in order to estimate the costs, it has been recommended to measure the loss in terms of time amount first and then multiply it by the value of the time.[58] Correspondingly, the VOLP measures the time input loss due to poor health including employment status changes, absenteeism, presenteeism and unpaid work loss.

Second, instead of a disease specific questionnaire, the VOLP is a generic questionnaire assessing the labour input loss due to health (any physical, mental, or emotional problems or symptoms). It aims to capture not only the loss due to the disease itself but also the impact of its co-morbidities and the side-effects and/or toxicities of treatments when treatment effects on productivity are concerned.

Third, the recall period of the VOLP was determined by the literature recommendations, i.e., 3 months for absenteeism and 7 days for both presenteeism and unpaid work loss. Fourth, presenteeism is measured by comparing the number of hours actually used to complete all the work in the past 7 days and the number of hours that would be used to do the same work if not experiencing any health problems. In this manner, the work quantity is compared between the situations with and without health problems while the work quality is controlled (the same work).

Last, but most importantly, the VOLP enables the valuation of the output loss corresponding to the input loss. For the valuation purpose, it collects information on job and workplace characteristics such as job and industry type, team dynamics, substitutability, compensation and availability of substitutes.

8.2.2 Wage and marginal productivity

Although there are many reasons that wage may not be equal to marginal productivity, there is still lack of empirical evidence on their equality with regard to team participation, absenteeism and presenteeism. This is the first study to date that has tested the equality between wage and marginal productivity and measured the multiplicative effect of abenteeism and presenteeism for team workers. A methodology has been well established by labour economists to examine whether the wage differentials associated with age and sex are comparable to the marginal productivity differentials.[119,120] Applying this methodology, this study compares the wage differentials associated with team participation, absenteeism and presenteeism with the marginal productivity differentials using a unique database, i.e., the WES. Some evidence of team participation, absenteeism and presnteeteeism related wage-productivity gaps has been found. These study findings support the literature which states that the productivity loss resulting from worker absence and presenteeism could exceed the wage if they are involved in team work.[26,29]

They also provide the justification for generating the multipliers to adjust wage to represent marginal productivity.

8.2.3 Wage multipliers

Due to the discrepancy between wage and marginal productivity, multipliers relating wage rates to marginal productivity need to be derived to value productivity loss. Pauly et al.[28,29] attempted to estimate the multipliers for different job types. The multipliers were calculated as the ratio between the cost of absenteeism and presenteesim to the firm and the worker's wage, which is often greater than one. Managers instead of employees were interviewed to obtain estimates of the impact of absenteeism and presenteeism on output for three different job characteristics, team production, availability of perfect substitutes and time sensitivity. To use the multipliers estimated by Pauly et al., a study has to match each participant's job type to that considered by Pauly et al.. The underlying assumption is that their study samples are representative and thus the multipliers are generalizable. However, with the limited number of job and firm types studied by Pauly et al., only certain jobs were covered. Furthermore, given the data was from the US, the multipliers may not be applicable to other countries. Therefore, an alternative source for deriving multipliers is required.

Based on the job and workplace characteristics collected by the VOLP, an additive algorithm was proposed to derive wage multipliers. The factors considered in the algorithm include work compensation, team work status, team size, impact on team function, availability of substitutes and their substitutability. In practice, the VOLP should be administered to obtain the multiplier for each study participant. The advantage is that the VOLP has the ability to value productivity loss using internal responses without requiring external data or job type matching. Furthermore, the VOLP collects detailed information about job type and workplace characteristics from study participants. Hence, the VOLP also enables the use of the multipliers for different job and workplace characteristics developed from external data.

8.2.4 Addressing the zero inflated productivity loss data

Analysis methods are applied to address the non-normal distribution of productivity loss data. Productivity loss due to poor health is usually first expressed as time input loss i.e., the number of lost days or hours of work and then valued as costs. Time input loss is non-negative count data. Studies have shown that the proportion of people without any loss is very high, i.e., zero inflated data.[32,52,81] However, regressions or statistical methods implying a normal distribution are commonly used to analyze productivity loss.[44,88,145] Some studies even avoided estimating the mean loss by using logistic models where productivity loss was treated as binary or categorical variables.[89,90,146] These analysis methods may be problematic for data with excessive zeros. A statistical technique has been developed to address the zero inflated data but rarely applied in productivity loss analysis. Lavigne et al.[147] applied a Tobit regression to model work productivity loss. Kleinman et al.[148] utilized a two-part model to estimate annual lost days due to sick leave, disability and workers' compensation indemnity. In the first part, a logistic regression was used to predict the likelihood of absence and in the second part, a generalized linear model with a gamma distribution and log link was used to estimate average lost days for those with work absence. Also, a zero-inflated Poisson was used to estimate the number of missed workdays in the study of Van Vollenhoven et al..[115] In the study shown in Chapter 5, I applied a zero-inflated negative binomial model to analyze the time input loss and a two-part model (a logistic regression for the probability of no costs and a generalized linear model with gamma distribution and log link for nonzero costs) to analyze the costs.

8.2.5 Interdisciplinarity

Overall, this thesis is a combination of different academic disciplines including measurement, labour economics, economic evaluations and population health. The development of the VOLP involved a process of content development, item reduction, pre-testing in a focus group and final assessment. Psychometric approach, classical test theory, was used to test the validity and reliability of time input loss measured by the VOLP. According to labour economic theory, a production function and a wage equation were used to simultaneously measure the impact of absenteeism and presenteeism on value added and wage at firm level. The equality of wage and marginal productivity was tested. The findings support the application of the VOLP in the economic evaluation studies of a new health technology and cost-of-illness studies estimating the economic burden of illness in a specific population.

8.3 Limitations and future research directions

8.3.1 Objective versus subjective measures

One limitation of the study is the lack of an objective measure of productivity loss, which is generally considered as the gold standard.[42] Therefore, the relationship between the VOLP measure of productivity loss and the actual productivity loss (criterion validity) was not demonstrated. It is, however, quite difficult to obtain an objective measure of work productivity. The objective measure changes with occupations as well as workplaces and some jobs' output is not even quantifiable.[41,42] Even if objective productivity measures are available, it would be costly to obtain the measures if study subjects have different jobs and work at different organizations. Therefore, objectively measuring productivity is not feasible for this study. A further study comparing the VOLP measures with objective measures can be conducted only if it is possible to recruit a sample of workers (e.g., call centers) whose actual productivity can be observed and quantified. For example, the number of phone calls answered per payroll hour and the number of merchandise units processed per hour are considered as the objective measures of work productivity for employees in the customer service department and return department.[45]

8.3.2 Presenteeism measures

There are different methods to measure the time loss attributable to presenteeism. They include directly estimating time loss and measuring the percent of loss while working using a 0-10 scale or a multidimensional scale. Many studies have shown that different methods provide widely different time loss esitmates.[35,46,48,51,52] Directly asking for time loss provides the lowest estimate, while the 0-10 scale gives the highest estimate.[52] The VOLP asks for time loss directly and thus provides the most conservative estimate. However, it is still too early to conclude whether it is a better presenteeism estimate. Further studies are needed to identify what these different methods are actually capturing: labour input loss (work quantity and quality), quality of life (QOL) and/or psychosocial impacts (job satisfaction, stress, etc.). In order to achieve this objective, all aspects of work potentially affected by poor health should first be listed through a literature review and expert and focus group discussions. An exploratory factor analysis can be performed to determine the underlying factor structure of the list of aspects and compare the factors on which different presenteeism measures load. A confirmatory factor analysis can then be conducted to verify the factor structure and test whether the underlying latent constructs exists.

8.3.3 Compensation mechanisms

In Chapter 3, using the VOLP questionnaire I measured the job and workplace characteristics of employed people with RA. Most employed patients' work would be taken over or partially taken over if they were absent from work or present at work but sick, indicating good compensation mechanisms in most workplaces. However, these questions could not indicate whether the compensation was done during normal working hours or extra working hours, and whether the employees or their colleagues had to sacrifice their leisure time or take more effort to make up the lost work. Therefore, the lost work could not be corrected for compensation mechanisms as done by Jacob-Tacken et al.[39] and Severens et al.[40] who assumed that no loss would occur if missed work was compensated by the absent worker later during normal working hours or by his/her colleagues during normal working hours. Although the lost work can be compensated, the compensation mechanisms are not costless. The productivity loss reduced by compensation should be calculated as the net value of the gains of reduced productivity loss and the costs of compensation.[38] The costs of compensation mechanisms were ignored by Jacob-Tacken et al. and Severens et al. Further investigations should focus on how to measure the net reductions in productivity loss as a result of compensation.

8.3.4 Algorithm for multipliers

Multipliers based on employees' self-reported responses have potential limitations. It is possible that the personality or cognitive characteristics of employees (e.g., self-enhancing biases) would influence the validity of the measures on team function and substitutability. Furthermore, time sensitivity was not considered because it is difficult for employees themselves to estimate the magnitude of the corresponding impact. Also, I assumed the output from a team was the sum of each member's wage and the wage for each team member was the same. Thus, if one employee was absent and no substitute was available, the loss was the employee's wage plus the other team members' wages. Nonetheless, the additive assumption of output may be questionable. Future studies should focus on investigating the validity and accuracy of the VOLP multipliers.

8.3.5 Workplace and Employee Survey

Although the WES is a unique database that can be used to compare wage and marginal productivity, the small number of employees being surveyed for each workplace prevented us from fine distinctions of the labour force based on more worker characteristics. Thus, I was able to examine the absenteeism- and presenteeism-related wage-productivity gap by team work status, but probably not by team work status, occupations, age and sex for example. In addition, a variable for absenteeism due to illness could not be generated from the WES because it did not ask for the number of unpaid sick leave days. In Chapter 6, I defined absenteeism as did Dionne and Dostie,[124] only taking into account the number of days of paid sick leave, other paid leave and unpaid leave. The measure of presenteeism was not ideal either. The WES question asked employees whether a physical condition or mental condition or health problem reduced the amount or the kind of activity they could do at work or at school. Illness may result in working at a slower pace, taking more breaks, repeating tasks, reducing the amount of work, reducing the kind of work, or making mistakes.[139] Hence, the measure of reduction at work only captured partial information on health-related presenteeism reported by employees. Furthermore, the capital of each workplace was not measured in the WES and thus I had to use an imperfect proxy measure. However, the estimates from the models including the proxy measure were virtually identical to those from the models excluding the measure, which suggests that the parameter estimates are robust to the measure of capital.

8.3.6 Distinctions between work and non-work activities

In this thesis, I suggested distinguishing paid work, unpaid work and leisure as well as considering their trade-offs when measuring and valuing productivity loss due to poor health. However, we are now at a time when more workers are in salaried positions (rather than hourly positions) where distinctions between work and non-work activities may blur. For example, those in knowledge industries including universities work a lot of the time “off the books” when they not only answer emails but also invest in their human capital by keeping up with developments in their fields. For many jobs, “off the book” work time may be spent in coffee shop networking with others in their fields. This brings difficulties to the measurement of absenteeism and presenteeism effects. To partially address this challenge, the VOLP measures the average number of actual work days/hours per week instead of that on the contract. Also, in measuring presenteeism, the VOLP compares the number of actual work hours in the past week with the number of hours that would be used to complete the same work if not experiencing any health problems. In this way, the VOLP attempts to capture the “off the book” work time.

In addition, the employment changes from hourly positions to salaried positions can differentially affect persons with severe chronic diseases since they may have to marshal more time for activities of daily living, leisure or recovery. This may affect their actual productivity and their march through seniority ranks. Also, persons with severe chronic diseases may be less able to engage in work outside normal hours and locations, which may limit them to jobs with a clear distinction between work and non-work. Measuring these effects is a challenge and worth further exploring in the future.

8.4 Potential applications of the research findings

The validation of the VOLP among people with RA will be of particular interest to the rheumatology community. Most importantly, the VOLP has been applied in a clinical trial designed to measure the impact of the drug, Etanercept, on productivity of RA patients. Although this questionnaire has been validated among people with RA, it can be further applied in different populations and in observational studies or clinical trials. The study results will be an invaluable resource for applied researchers who require estimates of the value of productivity loss due to illness. This is in turn will inform the consumers of such applied research findings, namely policy-makers and health insurers, and help to better understand the burden of illnesses in terms of the indirect costs (productivity losses) and evaluate the true gain to society from implementing health care interventions that improve productivity. Furthermore, the multipliers created will be of long-lasting use in improving cost-effectiveness estimates of health interventions.

Given that health economists have made specific recommendations on how to report productivity loss in economic evaluations in order to minimize theoretical concerns (shown in the introduction), it remains legitimate to pursue increased accuracy in estimating productivity losses. While the debate continues, there is strong support by many proponents of the societal perspective for the inclusion of productivity losses in economic evaluations, such that accurate estimates based on appropriate methodology are being demanded and are needed now.

An emerging argument in favor of estimating lost productivity associated with illness arises from recent evidence that unemployment has its own negative impact on health.[6] This means illnesses that negatively affect productivity may have greater potential to become chronic, as a cycle develops between illness and unemployment. By including productivity losses in economic evaluations, decision-makers have opportunities to identify illnesses that lead to chronic unemployment and resulting poverty. Cost-effectiveness analyses that highlight lost productivity can therefore increase investment in the most cost-effective technologies that allow individuals affected by illness to continue working and stay well. This research will make a significant contribution to the demand for meaningful cost-effectiveness analyses by developing a method that can be used in the long-term to accurately estimate productivity losses.

8.5 Conclusion

The findings of this thesis suggest the VOLP is a valid and reliable questionnaire that can be used to measure and value productivity loss due to poor health from a societal perspective. It also provides a new practical approach to evaluate the treatment effect on productivity. Some evidence suggests a gap exists between wage and marginal productivity with regard to absenteeism and presenteeism especially among team workers. Multipliers that adjust wage to represent the value of productivity loss are required and can be developed for practical use. This has important implications for providing an accurate estimate of productivity loss due to poor health.

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Appendices

Appendix A **Valuation of Lost Productivity questionnaire (Canadian English version)**

A.1 Valuation of Lost Productivity questionnaire (VOLP) - Baseline

The following questions ask about your employment status and the effect of YOUR HEALTH on your ability to work and perform regular activities.
By YOUR HEALTH we mean any physical, mental, or emotional problems or symptoms.

1. What is the highest level of education you have completed?

1 ❑ None 2 ❑ Primary school 3 ❑ Secondary education 4 ❑ Post-secondary education

Employment status

2. Are you currently working either as an employee or in self-employment?

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 4 BELOW)**

3. Which of the following describes your current work situation *(tick one only)*?

1 ❑ Working full time as an employee

2 ❑ Working part time as an employee

3 ❑ Self-employed

(NOW PLEASE SKIP TO QUESTION 7)

4. If you are not currently working as an employee or in self-employment, which unemployment status is most applicable to you *(tick one only)*?

1 ❑ On official work disability

2 ❑ Unemployed but looking for work

3 ❑ Unemployed but not looking for work

4 ❑ Retired

5 ❑ Housewife / househusband

6 ❑ Other *(please specify)*____

5. Is your current unemployment status mainly due to YOUR HEALTH *(please think of any physical, mental, or emotional problems or symptoms)?*

1 ❑ YES 2 ❑ NO

6. Do you feel well enough to work if a job is available?

1 ❑ YES, I am able to work full time

2 ❑ YES, but I am only able to work part time

3 ❑ NO, I am unable to work at all

(NOW PLEASE SKIP TO QUESTION 25)

Job characteristics

If you have more than one job, please report only on your main job — the job at which you spend the majority of work hours.

7. Please state your job title. *For example, primary school teacher, chartered accountant, cashier:*
____

8. **In the past 3 months**, which of the following best describes your work habits *(tick one only)*?

1 ❑ Usually sit during the day and do not walk around very much

2 ❑ Stand or walk quite a lot during the day but do not often have to carry or lift things

3 ❑ Usually lift or carry light loads, or often have to climb stairs or hills

4 ❑ Do heavy work or carry very heavy loads

9. On average, how many days do you work per week at this job?
______ days per week

10. On average, how many hours do you work per week at this job?
______ hours per week

11. What is your average annual gross income (before taxes) from paid work or self employment *(if you have more than one job, please report only on your main job)?*

1 ❑ Less than $10,000

2 ❑ $10,000 – $19,999

3 ❑ $20,000 – $29,999

4 ❑ $30,000 – $39,999

5 ❑ $40,000 – $49,999

6 ❑ $50,000 – $64,999

7 ❑ $65,000 – $79,999

8 ❑ $80,000 – $99,999

9 ❑ $100,000 or more

0 ❑ I do not know or I prefer not to answer

12. What kind of business, industry or service is your working organisation? *Please give details. For example: construction, primary school, hospital, police, farm, shoe shop, food wholesale, factory:*

____

____

Absenteeism (absence from work)

The next questions ask about your absence because of YOUR HEALTH in the past 3 months.
By YOUR HEALTH we mean any physical, mental, or emotional problems or symptoms.
If you have more than one job, please report only on your main job — the job at which you spend the majority of work hours.

13. In the past 3 months, how many work days **in total** have you been absent from work because of YOUR HEALTH (any physical, mental, or emotional problems or symptoms)?
*Please include **work days** you missed due to your health, and/or **partial work days** where you went in late or left early due to your health (e.g. doctor appointments); DO NOT include any work days you missed to participate in this study*
________work days **(IF 0, SKIP TO QUESTION 20)**

14. In the past 3 months, considering the total number of absent days you reported in **QUESTION 13** above, how many separate periods of absence *(any period of time that you did not go to work for one or more consecutive days)* have you had?
________periods

15. In the past 3 months, how many work days were you absent during your **most recent period** of absence due to YOUR HEALTH?
________work days

16. During your **most recent period** of absence due to YOUR HEALTH in the past 3 months, was your work *(tick one only):*

1 ❑ Taken over by others

2 ❑ Partly taken over by others and partly postponed until I returned

3 ❑ Postponed until I returned

0 ❑ Do not know

17. Who mainly took over your work during your **most recent period** of absence due to YOUR HEALTH in the past 3 months *(tick one only)?*

1 ❑ Co-workers

2 ❑ Supervisors

3 ❑ Temporary worker(s)/additional staff hired from outside agencies to do my work

4 ❑ No one

0 ❑ Do not know

18. In the past 3 months, have you completed the same amount of work **as if you had not been absent**?

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 20)**

19. In order to complete the same amount of work, did you:

1 ❑ Work overtime for payment

2 ❑ Work overtime without payment *(i.e., completed the work in my own time)*

3 ❑ Take no or fewer breaks

4 ❑ Other *(please specify)*____

Work performance

The next questions ask about the effect of YOUR HEALTH on your work performance in the past 7 days, not including today.
By YOUR HEALTH we mean any physical, mental, or emotional problems or symptoms.
If you have more than one job, report only on your main job — the job at which you spend the majority of work hours.

20. In the past 7 days, have you gone to work?

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 25)**

21. In the past 7 days, have you worked harder than your co-workers because of YOUR HEALTH *(please think of any physical, mental, or emotional problems or symptoms)?*

1 ❑ YES 2 ❑ NO

22. Think of all the work you have completed **during the past 7 days**. Would you complete the same work in **less time** if you did NOT experience any health problems *(i.e., any physical, mental, or emotional problems or symptoms)?*

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 24 BELOW)**

23. If yes, please indicate the time you took to complete all your work in the past 7 days and the time you would take to complete the same work if you did NOT experience any health problems:

a) Time taken to complete all of my work during the past 7 days ______hours

b) Time I would take to complete the same work if I did NOT experience any health problems (*should be less than a)*) ______hours

24. In the past 7 days, to what extent was your performance at work affected by YOUR HEALTH **while you were working** *(please think of any physical, mental, or emotional problems or symptoms)*?

My health had no effect on my work **0** | | | | | | | | | | | | | | | | | | | | | **10** **I could not do any work at all due to my health**

1 2 3 4 5 6 7 8 9

Please indicate the effect on the line by marking with a cross 'X'

Unpaid work

The next questions ask about unpaid work in the past 7 days, not including today.
A distinction has been made between work in the household; shopping; odd jobs and chores; activities for or with the children; and voluntary activities.
You will be asked how many hours in the past 7 days you spent on each activity. If you did not perform a particular activity, please simply write '0' hours.

25. During the past 7 days, how many hours have you spent on:

	Number of hours in the past 7 days
Housework *(e.g. preparing meals, cleaning the house, washing clothes)*	______hours
Shopping *(e.g. shopping for the daily groceries, other types of shopping, going to the bank or post office)*	______ hours
Odd jobs and chores *(e.g. house repairs, gardening, fixing the car)*	______ hours
Doing things for or with your own children *(e.g. caring for them, taking them to school, helping with homework)*	______ hours
Voluntary activities	______ hours
Total time spent on these unpaid work activities	______ hours

26. During the past 7 days, have you had help with any of your household tasks (cleaning the house, shopping, taking care of the children) due to YOUR HEALTH *(please think of any physical, mental, or emotional problems or symptoms;* ***tick all that apply****)?*

	Number of hours in the past 7 days
❑ No, I have performed my household tasks myself	
❑ Family members (e.g. partner, children) have taken over my household tasks	______ hours
❑ Others (e.g. neighbours or volunteers) have taken over my household tasks	______ hours
❑ I have had a home-help	______ hours
❑ I have had another type of paid help	______ hours

IF YOU ARE **NOT WORKING AS AN EMPLOYEE AND ARE NOT SELF-EMPLOYED**, THIS IS THE END OF THE QUESTIONNAIRE.

IF YOU ARE **WORKING FULL TIME OR PART TIME AS AN EMPLOYEE OR ARE SELF-EMPLOYED**, PLEASE CONTINUE.

Working environment

If you are working full time or part time as an employee or are self-employed, please continue answering the following questions about your working environment.
By YOUR HEALTH we mean any physical, mental, or emotional problems or symptoms.
If you have more than one job, report only on your main job – the job at which you spend the majority of work hours.

27. Imagine if you are at work but YOUR HEALTH affects your ability to complete your work, will your work be *(please think of any physical, mental, or emotional problems or symptoms) (tick one only):*

1 ❑ Taken over by others

2 ❑ Partly taken over by others and partly postponed until later (i.e., I will do it later)

3 ❑ Postponed until later (i.e., I will do it later)

0 ❑ Do not know

28. If you are at work but YOUR HEALTH affects your ability to complete your work, who mainly takes over the work you cannot complete *(tick one only)?*

1 ❑ Co-workers

2 ❑ Supervisors

3 ❑ Temporary worker(s)/additional staff hired from outside agencies to do my work

4 ❑ No-one

0 ❑ Do not know

29. Imagine if you are at work but YOUR HEALTH affects your ability to complete your work, will you complete the same amount of work in 3 months as if YOUR HEALTH did not affect your ability to work?

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 31 BELOW)**

30. In order to complete the same amount of work in 3 months, will you have to:

1 ❑ Work overtime for payment

2 ❑ Work overtime without payment (i.e., complete the work in my own time)

3 ❑ Take no or fewer breaks

4 ❑ Other *(please specify)*____

31. How often do you need to work with your co-workers as a team *(by team, we mean 'a group of people who work/act together for a common purpose (e.g. projects and tasks)') (tick one only)?*

1 ❑ None of the time **(IF NONE OF THE TIME, SKIP TO QUESTION 34)**

2 ❑ A little of the time

3 ❑ Some of the time

4 ❑ Most of the time

5 ❑ All the time

32. For the time you are working with a team, how many co-workers do you usually work with as a team *(if you are working with more than one team,* ***please focus on the team you spend the most time with****. Please DO NOT include yourself)?*
Please write down a specific number such as '4' or a range such as '8–12' ___________________

33. For the time you are working with a team, how important are you to the function of your team *(if you are working with more than one team,* ***please focus on the team you spend the most time with****) (tick one only)?*

1 ❑ My team can **function as usual** when I am absent, or when I am present but less productive
(*e.g. this might be appropriate for a person who works in a team picking crops in a field. Each person in the team picks crops all by himself or herself*)

2 ❑ My team's function can **be affected a little bit** when I am absent, or when I am present but less productive

3 ❑ My team's function can **be somewhat affected** when I am absent, or when I am present but less productive

4 ❑ My team's function can **be affected quite a lot** when I am absent, or when I am present but less productive

5 ❑ My team **cannot function** when I am absent, or when I am present for work but less productive *(e.g. this might be appropriate for the conductor of an orchestra where the orchestra can't play without the conductor and the conductor is useless without the orchestra*)

34. Can any of your co-workers do your work *(tick one only)*?

1 ❑ There are co-workers who can complete my work in **the same amount of time** as me

2 ❑ My co-workers can complete my work in **a little bit more time** than me

3 ❑ My co-workers can complete my work in **somewhat more time** than me

4 ❑ My co-workers can complete my work in **a lot more time** than me

5 ❑ None of my co-workers can do my work

35. Does your working organisation hire temporary (i.e., temp) workers from external agencies who do the same or similar work as you do?

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO OPTIONAL QUESTION 37)**

36. Can any of the temp workers hired from external agencies do your work *(tick one only)?*

1 ❑ Temp workers can complete my work in **the same amount of time** as me

2 ❑ Temp workers can complete my work in **a little bit more time** than me

3 ❑ Temp workers can complete my work in **somewhat more time** than me

4 ❑ Temp workers can complete my work in **a lot more time** than me

5 ❑ It is impossible to find any temp workers who can do my work

The following are optional questions on the impact of your health on your work.

37. The following questions ask about the way YOUR HEALTH has interfered with your work in the past 7 days *(please think of any physical, mental, or emotional problems or symptoms) (tick one only).*

In the past 7 days, because of MY HEALTH,	**Never 1**	**Rarely 2**	**Sometimes 3**	**Often 4**	**Always 5**
I have had to work more slowly	❑	❑	❑	❑	❑
I have had to take more frequent or longer breaks	❑	❑	❑	❑	❑
I have been less able to concentrate on my work	❑	❑	❑	❑	❑
I have been able to finish work on time	❑	❑	❑	❑	❑
I have been more likely to make mistakes at work	❑	❑	❑	❑	❑
I have been limited in the amount of work I could do	❑	❑	❑	❑	❑
I have been limited in the kind of work I could do	❑	❑	❑	❑	❑
I have found I could not do anything at work	❑	❑	❑	❑	❑
I have felt stressed at work	❑	❑	❑	❑	❑
I have avoided certain tasks that I would otherwise do	❑	❑	❑	❑	❑

In the past 7 days, because of MY HEALTH,	**Never 1**	**Rarely 2**	**Sometimes 3**	**Often 4**	**Always 5**
I have needed more help from co-workers	❑	❑	❑	❑	❑
I have had to use my own time or work overtime to complete my work	❑	❑	❑	❑	❑
I have had to work much harder than co-workers	❑	❑	❑	❑	❑
I have felt exhausted after work	❑	❑	❑	❑	❑
I have felt fatigued at work	❑	❑	❑	❑	❑
I have avoided interaction with co-workers, clients, vendors or supervisors	❑	❑	❑	❑	❑
I have been less likely to help co-workers to get work done	❑	❑	❑	❑	❑
I have been less satisfied with my job	❑	❑	❑	❑	❑
I have been less satisfied with my co-workers and supervisors	❑	❑	❑	❑	❑
I have felt I was more likely to lose my job	❑	❑	❑	❑	❑
I have felt I had less control over my work	❑	❑	❑	❑	❑
I have had less opportunity to upgrade my skills	❑	❑	❑	❑	❑
I have had less time to learn new skills	❑	❑	❑	❑	❑
I have felt hopeless to complete certain work tasks	❑	❑	❑	❑	❑

THANK YOU
END OF QUESTIONNAIRE

A.2 Valuation of Lost Productivity questionnaire (VOLP) - Follow up

The following questions ask about your employment status and the effect of YOUR HEALTH on your ability to work and perform regular activities.
By YOUR HEALTH we mean any physical, mental, or emotional problems or symptoms.

Employment status

1. Which of the following best describes your current employment status *(tick one only)?*

1 ❑ Working full time as an employee **(SKIP TO QUESTION 3 BELOW)**

2 ❑ Working part time as an employee **(SKIP TO QUESTION 3 BELOW)**

3 ❑ Self-employed **(SKIP TO QUESTION 3 BELOW)**

4 ❑ On official work disability

5 ❑ Unemployed but looking for work

6 ❑ Unemployed but not looking for work

7 ❑ Retired

8 ❑ Housewife / househusband

9 ❑ Other *(please specify)*____

2. Do you feel well enough to work if a job is available?

1 ❑ YES, I am able to work full time

2 ❑ YES, but I am only able to work part time

3 ❑ NO, I am unable to work at all

(NOW PLEASE SKIP TO QUESTION 16)

Absenteeism (absence from work)

The next questions ask about your absence because of YOUR HEALTH in the past 3 months.
By YOUR HEALTH we mean any physical, mental, or emotional problems or symptoms.
If you have more than one job, please report only on your main job — the job at which you spend the majority of work hours.

3. In the past 3 months, how many work days **in total** have you been absent from work because of YOUR HEALTH (any physical, mental, or emotional problems or symptoms)?
*Please include **work days** you missed due to your health, and/or **partial work days** where you went in late or left early due to your health (e.g. doctor appointments); DO NOT include any work days you missed to participate in this study*
________ work days **(IF 0, SKIP TO QUESTION 10)**

4. In the past 3 months, considering the total number of absent days you reported in **QUESTION 3** above, how many separate periods of absence *(any period of time that you did not go to work for one or more consecutive days)* have you had?
________ periods

5. In the past 3 months, how many work days were you absent during your **most recent period** of absence due to YOUR HEALTH?
________ work days

6. During your **most recent period** of absence due to YOUR HEALTH in the past 3 months, was your work *(tick one only):*

1 ❑ Taken over by others

2 ❑ Partly taken over by others and partly postponed until I returned

3 ❑ Postponed until I returned

0 ❑ Do not know

7. Who mainly took over your work during your **most recent period** of absence due to YOUR HEALTH in the past 3 months *(tick one only)?*

1 ❑ Co-workers

2 ❑ Supervisors

3 ❑ Temporary worker(s)/additional staff hired from outside agencies to do my work

4 ❑ No one

0 ❑ Do not know

8. In the past 3 months, have you completed the same amount of work **as if you had not been absent**?

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 10)**

9. In order to complete the same amount of work, did you:

1 ❑ Work overtime for payment

2 ❑ Work overtime without payment *(i.e., completed the work in my own time)*

3 ❑ Take no or fewer breaks

4 ❑ Other *(please specify)* ____

Work performance

The next questions ask about the effect of YOUR HEALTH on your work performance in the past 7 days, not including today.
By YOUR HEALTH we mean any physical, mental, or emotional problems or symptoms.
If you have more than one job, report only on your main job — the job at which you spend the majority of work hours.

10. In the past 7 days, have you gone to work?

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 15)**

11. In the past 7 days, have you worked harder than your co-workers because of YOUR HEALTH *(please think of any physical, mental, or emotional problems or symptoms)?*

1 ❑ YES 2 ❑ NO

12. Think of all the work you have completed **during the past 7 days**. Would you complete the same work in **less time** if you did NOT experience any health problems *(i.e., any physical, mental, or emotional problems or symptoms)?*

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 14 BELOW)**

13. If yes, please indicate the time you took to complete all your work in the past 7 days and the time you would take to complete the same work if you did NOT experience any health problems:

a) Time taken to complete all of my work during the past 7 days ______hours

b) Time I would take to complete the same work if I did NOT experience any health problems (*should be less than a)*) ______hours

14. In the past 7 days, to what extent was your performance at work affected by YOUR HEALTH **while you were working** (please think of any physical, mental, or emotional problems or symptoms)?

My health had no effect on my work **0** |–|–|–|–|–|–|–|–|–|–|–|–|–|–|–|–|–|–|–|–| **10** **I could not do any work at all due to my health**

1 2 3 4 5 6 7 8 9

Please indicate the effect on the line by marking with a cross 'X'

Work ability

15. Do you think the change in YOUR HEALTH **in the past 3 months** was sufficient to improve your ability to perform your work *(please think of any physical, mental, or emotional problems or symptoms)?*

1 ❑ YES 2 ❑ NO

Unpaid work

The next questions ask about unpaid work in the past 7 days, not including today.
A distinction has been made between work in the household; shopping; odd jobs and chores; activities for or with the children; and voluntary activities.
You will be asked how many hours in the past 7 days you spent on each activity. If you did not perform a particular activity, please simply write '0' hours.

16. During the past 7 days, how many hours have you spent on:

	Number of hours in the past 7 days
Housework *(e.g. preparing meals, cleaning the house, washing clothes)*	______hours
Shopping *(e.g. shopping for the daily groceries, other types of shopping, going to the bank or post office)*	______ hours
Odd jobs and chores *(e.g. house repairs, gardening, fixing the car)*	______ hours
Doing things for or with your own children *(e.g. caring for them, taking them to school, helping with homework)*	______ hours
Voluntary activities	______ hours
Total time spent on these unpaid work activities	______ hours

17. During the past 7 days, have you had help with any of your household tasks (cleaning the house, shopping, taking care of the children) due to YOUR HEALTH *(please think of any physical, mental, or emotional problems or symptoms;* ***tick all that apply****)?*

	Number of hours in the past 7 days
❑ No, I have performed my household tasks myself	
❑ Family members (e.g. partner, children) have taken over my household tasks	______ hours
❑ Others (e.g. neighbours or volunteers) have taken over my household tasks	______ hours
❑ I have had a home-help	______ hours
❑ I have had another type of paid help	______ hours

18. Do you think the change in YOUR HEALTH **in the past 3 months** was sufficient to improve your ability to perform your unpaid work *(please think of any physical, mental, or emotional problems or symptoms)?*

1 ❑ YES 2 ❑ NO

Employment status change

19. **In the past 3 months**, has your employment status changed in any of the following ways (*tick the most applicable one)?*

1 ❑ NO, my employment status has not changed **(IF NO, END OF THE QUESTIONNAIRE)**

2 ❑ YES, I have stopped working as an employee or self-employment; when did you stop?

(mm/yy) _____

3 ❑ YES, I have started working as an employee or self-employment from unemployment or work disability; when did you start? (mm/yy) ___________

4 ❑ YES, I have changed my job/working organisation

5 ❑ YES, I have changed the number of hours I routinely work per week

20. Was the change of your employment status mainly due to YOUR RHEUMATOID ARTHRITIS or OTHER HEALTH PROBLEMS *(tick one only)?*

1 ❑ YES, it is mainly due to my rheumatoid arthritis

2 ❑ YES, it is mainly due to my other health problems

3 ❑ NO

IF YOU HAVE **STOPPED WORKING AS AN EMPLOYEE OR SELF-EMPLOYMENT**, THIS IS THE END OF THE QUESTIONAIRE.

IF YOUR **EMPLOYMENT STATUS HAS CHANGED IN OTHER WAYS**, PLEASE CONTINUE.

Job characteristics and working environment

Please answer the following questions about your job characteristics and working environment if in the past 3 months you:

- **started working as an employee or self-employment, or**
- **changed your job or working organisation, or**
- **changed number of hours your routinely work**

By YOUR HEALTH we mean any physical, mental, or emotional problems or symptoms.
If you have more than one job, please report only on your main job — the job at which you spend the majority of work hours.

21. Please state your job title. *For example, primary school teacher, chartered accountant, cashier:*
____

22. **In the past 3 months**, which of the following best describes your work habits *(tick one only)?*

1 ❑ Usually sit during the day and do not walk around very much

2 ❑ Stand or walk quite a lot during the day but do not often have to carry or lift things

3 ❑ Usually lift or carry light loads, or often have to climb stairs or hills

4 ❑ Do heavy work or carry very heavy loads

23. On average, how many days do you work per week at this job?
______ days per week

24. On average, how many hours do you work per week at this job?
______ hours per week

25. What is your average annual gross income (before taxes) from paid work or self employment *(if you have more than one job, please report only on your main job)?*

1 ❑ Less than $10,000

2 ❑ $10,000 – $19,999

3 ❑ $20,000 – $29,999

4 ❑ $30,000 – $39,999

5 ❑ $40,000 – $49,999

6 ❑ $50,000 – $64,999

7 ❑ $65,000 – $79,999

8 ❑ $80,000 – $99,999

9 ❑ $100,000 or more

0 ❑ I do not know or I prefer not to answer

26. What kind of business, industry or service is your working organisation? *Please give details. For example: construction, primary school, hospital, police, farm, shoe store, food wholesale, factory:*

____

____

27. Imagine if you are at work but YOUR HEALTH affects your ability to complete your work, will your work be *(please think of any physical, mental, or emotional problems or symptoms) (tick one only):*

1 ❑ Taken over by others

2 ❑ Partly taken over by others and partly postponed until later (i.e., I will do it later)

3 ❑ Postponed until later (i.e., I will do it later)

0 ❑ Do not know

28. If you are at work but YOUR HEALTH affects your ability to complete your work, who mainly takes over the work you cannot complete *(tick one only)*?

1 ❑ Co-workers

2 ❑ Supervisors

3 ❑ Temporary worker(s)/additional staff hired from outside agencies to do my work

4 ❑ No-one

0 ❑ Do not know

29. Imagine if you are at work but YOUR HEALTH affects your ability to complete your work, will you complete the same amount of work in 3 months as if YOUR HEALTH did not affect your ability to work?

1 ❑ YES 2 ❑ NO **(IF NO, SKIP TO QUESTION 31 BELOW)**

30. In order to complete the same amount of work in 3 months, will you have to:

1 ❑ Work overtime for payment

2 ❑ Work overtime without payment (i.e., complete the work in my own time)

3 ❑ Take no or fewer breaks

4 ☐ Other *(please specify)* ____

31. How often do you need to work with your co-workers as a team *(by team, we mean 'a group of people who work/act together for a common purpose (e.g. projects and tasks)') (tick one only)?*

1 ☐ None of the time **(IF NONE OF THE TIME, SKIP TO QUESTION 34)**

2 ☐ A little of the time

3 ☐ Some of the time

4 ☐ Most of the time

5 ☐ All the time

32. For the time you are working with a team, how many co-workers do you usually work with as a team *(if you are working with more than one team, **please focus on the team you spend the most time with**. Please DO NOT include yourself)?*
Please write down a specific number such as '4' or a range such as '8–12' ____________________

33. For the time you are working with a team, how important are you to the function of your team *(if you are working with more than one team, **please focus on the team you spend the most time with**) (tick one only)?*

1 ☐ My team can **function as usual** when I am absent, or when I am present but less productive (*e.g. this might be appropriate for a person who works in a team picking crops in a field. Each person in the team picks crops all by himself or herself*)

2 ☐ My team's function can **be affected a little bit** when I am absent, or when I am present but less productive

3 ☐ My team's function can **be somewhat affected** when I am absent, or when I am present but less productive

4 ☐ My team's function can **be affected quite a lot** when I am absent, or when I am present but less productive

5 ☐ My team **cannot function** when I am absent, or when I am present for work but less productive *(e.g. this might be appropriate for the conductor of an orchestra where the orchestra can't play without the conductor and the conductor is useless without the orchestra*)

34. Can any of your co-workers do your work *(tick one only)?*

1 ☐ There are co-workers who can complete my work in **the same amount of time** as me

2 ☐ My co-workers can complete my work in **a little bit more time** than me

3 ❑ My co-workers can complete my work in **somewhat more time** than me

4 ❑ My co-workers can complete my work in **a lot more time** than me

5 ❑ None of my co-workers can do my work

35. Does your working organisation hire temporary (i.e., temp) workers from external agencies who do the same or similar work as you do?

1 ❑ YES 2 ❑ NO **(IF NO, END OF THE QUESTIONNAIRE)**

36. Can any of the temp workers hired from external agencies do your work *(tick one only)?*

1 ❑ Temp workers can complete my work in **the same amount of time** as me

2 ❑ Temp workers can complete my work in **a little bit more time** than me

3 ❑ Temp workers can complete my work in **somewhat more time** than me

4 ❑ Temp workers can complete my work in **a lot more time** than me

5 ❑ It is impossible to find any temp workers who can do my work

THANK YOU
END OF QUESTIONNAIRE

Appendix B **Definition of variables in Chapters 6 and 7**

B.1 Outcome variables

Value added: Annual gross operating revenues minus expenses on materials.

Expenses on material (proxy): Gross operating expenditures minus total gross payroll and expenses on non-wage benefits and on training.

Wage: Total gross payroll for all employees.

B.2 Independent variables of interest

Absence rate: The total number of days of leave taken by employees, including paid sick leave, other paid leave (e.g., education leave, disability leave, bereavement, marriage, jury duty, union business) and unpaid leave, divided by the total number of 'usual workdays' in the past twelve months/since the employee started his/her current job. The total number of usual workdays is equal to the number of days per week employees usually work multiplied by the number of weeks per year they usually work.

Attendance rate: 1 minus absence rate.

Proportion of workers in team work (proxy): Number of employees involved in team work divided by the number of employees surveyed in the workplace. The question asking about team work participation is "how frequently are you part of a self-directed work group (semi-autonomous work group or mini-enterprise group) that has a high level of responsibility for a particular product or service area? In such systems, part of your pay is normally related to group performance. Self-directed work groups: 1) Are responsible for production of a fixed product or service, and have a high degree of autonomy in how they organize themselves to produce that product or service. 2) Act almost as ‘businesses within businesses’. 3) Often have incentives related to productivity, timeliness and quality. 4) While most have a designated leader, other members also contribute to the organization of the group’s activities.” Workers are divided into two groups based on their participation frequency (‘frequently’ or ‘always’ (team work) versus ‘occasionally’ or ‘never’ (no team work) for participation in any team work).

Proportion of workers by reduction levels at work (proxy): Number of workers with a given reduction level divided by the number of employees surveyed in the workplace. In WES, surveyed employees were asked, “Does a physical condition or mental condition or health problem reduce the amount or the kind of activity you can do at work or at school?” The reduction levels were defined by the four different responses: 1) yes, often; 2) yes, sometimes; 3) no; 4) not applicable.

B.3 Covariates

Employment: Number of people employed at each workplace.

Capital stock (proxy): The capital stock for a firm is approximated by using the average capital stock of the particular industry that the firm belongs to during the five years prior to the corresponding year. The industry capital stock corresponds to the geometric (infinite) end-year net stock of non-residential capital reported in Table 031-0002 of CANSIM from Statistics Canada (chained 2002 dollars). The firm capital stock is calculated by dividing the industry capital stock by the number of firms in each industry in the WES. The number of firms in each industry in the WES is calculated by adding the WES weight for each firm by industry.

Proportion of workers by age (proxy): Number of employees in an age group divided by the number of employees surveyed in the workplace. Three age groups were defined as 1) less than 35, 2) between 35 and 55, and 3) over 55.

Proportion of female workers (proxy): Number of female employees divided by the number of employees surveyed in the workplace.

Proportion of workers by level of education (proxy): Number of workers with a given education level divided by the number of employees surveyed in the workplace. We distinguish among the following levels of education: less than high school, high school graduate only, under university graduate (completed/some college or university below bachelor), University bachelor, and higher than a bachelor's degree.

Proportion of workers by occupation: Number of workers in the given occupation group divided by the number of people employed in the workplace. Occupation types include 1) managers and professionals; 2) technical/trades, marketing/sales, and clerical/administrative; and 3) production workers with no trade/certification, operation and maintenance; 4) others.

Proportion of employees with non-white ethnic minorities (proxy): Number of employees from any ethnic, cultural and racial group other than Canadian, British, American, French, and other European groups divided by the number of employees surveyed in the workplace.

Proportion of employees who were immigrants (proxy): Number of employees born outside of Canada divided by the number of employees surveyed in the workplace.

Proportion of employees with bargaining agreement (proxy): Number of non-management employees with membership in a union or collective bargaining agreement divided by the number of employees in the workplace.

Proportion of employees with any difficulty (proxy): Number of employees who have any difficulty hearing, seeing, communicating, walking, climbing stairs, bending, learning or doing any similar activities divided by the number of employees surveyed in the workplace.

International market: Market with the highest market sales in percentage of total sales among "local", "rest of Canada", "USA or rest of the World". Workplaces with an international market are those for which the most important market for sales is "USA or the rest of World".

Foreign country owned: Workplaces where more than 50 percent of the assets of this workplace are held by foreign interest assets.

Industry: There are 14 industry categories: 1) Forestry, mining, oil, and gas extraction, 2) Labour intensive tertiary manufacturing, 3) Primary product manufacturing, 4) Secondary product manufacturing , 5) Capital intensive tertiary manufacturing, 6) Construction, 7) Transportation, warehousing, wholesale, 8) Communication and other utilities, 9) Retail trade and consumer services, 10) Finance and insurance, 11) Real estate, rental and leasing operations, 12) Business services, 13) Education and health services, 14) Information and cultural industries.

Region: There are seven categories: 1) Atlantic, 2) Quebec, 3) Ontario, 4) Alberta, 5) British Columbia, 6) Manitoba and 7) Saskatchewan.

Appendix C **Equations**

C.1 Production function

For each workplace, consider a Cobb-Douglas production function

$$\ln Q_j = \alpha \ln L_j^A + \beta \ln K_j + \eta F_j + \mu_j \quad (1)$$

where Q is output, measured as value added by firm j, L^A is an aggregate function of productive labour of each type of workers (defined below), K is the capital stock, F_j is a matrix of various firm characteristics, α, β are the elasticity of output with respect to labour and capital, respectively, η is a vector of parameters for firm characteristics and μ_j is the error term. The value added is measured as gross revenues minus expense on materials.[129,130] Expenses on materials are equal to gross operating expenditure less payroll and expenses on non-wage benefits and training. We use the log of value added as the dependent variable to address the endogeneity issue by avoiding estimation of a coefficient on materials.[120,129,130] Worker types refer to workers with different characteristics such as age, sex, education, occupation, team participation etc. If the total number of characteristics is I and workers are divided into V_i categories by each characteristic i, then the total number of worker types will be $D_I = \prod_{i=1}^{I} V_i$.

If we assume perfect substitution among all types of workers and different marginal productivity for each worker type,[119,120] we can write the aggregate function of productive labour as

$$L^A = \sum_{d=0}^{D_I - 1} \lambda_d L_d \quad (2)$$

where D is the total number of worker types, L_d is the number of workers of type d in a firm, and λ_d is the marginal productivity for workers of type d. Without loss of generality, we use $d = 0$

for the reference group in our all models. For example, if we distinguish types of workers according to two characteristics (I=2): team work participation and age, workers are divided into 2 categories by team work participation ($V_1 = 2$): 1) participating in a team (G) and 2) not in a team (N), and 3 age categories ($V_2 = 3$): 1) less than 35 years (R); 2) between 35 and 55 (C); and 3) over 55 (O). Therefore, a firm's workforce can be fully described by $D_2 = V_1 \times V_2 = 2 \times 3 = 6$ combinations of these characteristics (NR, NC, NO, GR, GC, GO).

In this example, if we take production workers who do not participate in a team as our reference category (NO), the productive labour is

$$L^A = \sum_{d=0}^{D_2-1} \lambda_d L_d$$
$$= \lambda_{NO} L \left(\frac{L_{NO}}{L} + \frac{\lambda_{NR}}{\lambda_{NO}} \cdot \frac{L_{NR}}{L} + \frac{\lambda_{NC}}{\lambda_{NO}} \cdot \frac{L_{NC}}{L} + \frac{\lambda_{GR}}{\lambda_{NO}} \cdot \frac{L_{GR}}{L} + \frac{\lambda_{GC}}{\lambda_{NO}} \cdot \frac{L_{GC}}{L} + \frac{\lambda_{GO}}{\lambda_{NO}} \cdot \frac{L_{GO}}{L} \right) \tag{3}$$

The equation can be simplified if we make the two restrictions that Hellerstein et al.[120] made on the form of L^A. Restriction I is the equiproportionate restriction regarding the distribution of workers, i.e., the proportion of one type worker defined by one characteristic is constant across all other characteristic groups. Restriction II is the equal relative productivity restriction, i.e., the relative marginal productivity of two types of workers within one characteristic group is equal to those within another characteristic group.

Using the example above, restrictions I and II imply

$$\frac{L_{GO}}{L_O} = \frac{L_{GR}}{L_R} = \frac{L_{GC}}{L_C} = \frac{L_G}{L} = P_G;$$

$$\frac{L_{NO}}{L_O} = \frac{L_{NR}}{L_R} = \frac{L_{NC}}{L_C} = \frac{L_N}{L} = P_N;$$

$$\frac{L_{GR}}{L_G} = \frac{L_{NR}}{L_N} = \frac{L_R}{L} = P_R;$$

$$\frac{L_{GC}}{L_G} = \frac{L_{NC}}{L_N} = \frac{L_C}{L} = P_C;$$

$$\frac{L_{GO}}{L_G} = \frac{L_{NO}}{L_N} = \frac{L_O}{L} = P_O;$$

and

$$\frac{\lambda_{GR}}{\lambda_{NR}} = \frac{\lambda_{GC}}{\lambda_{NC}} = \frac{\lambda_{GO}}{\lambda_{NO}} = \frac{\lambda_G}{\lambda_N} = \gamma_G;$$

$$\frac{\lambda_{GR}}{\lambda_{GO}} = \frac{\lambda_{NR}}{\lambda_{NO}} = \frac{\lambda_R}{\lambda_O} = \gamma_R;$$

$$\frac{\lambda_{GC}}{\lambda_{GO}} = \frac{\lambda_{NC}}{\lambda_{NO}} = \frac{\lambda_C}{\lambda_O} = \gamma_{C.}$$

Under the two restrictions, the productive labour function (3) can be simplified as follows,

$$\begin{aligned} L^A &= \lambda_{NO} L \left(\tfrac{L_{NO}}{L} + \tfrac{\lambda_{NR}}{\lambda_{NO}} \cdot \tfrac{L_{NR}}{L} + \tfrac{\lambda_{NC}}{\lambda_{NO}} \cdot \tfrac{L_{NC}}{L} + \tfrac{\lambda_{GR}}{\lambda_{NO}} \cdot \tfrac{L_{GR}}{L} + \tfrac{\lambda_{GC}}{\lambda_{NO}} \cdot \tfrac{L_{GC}}{L} + \tfrac{\lambda_{GO}}{\lambda_{NO}} \cdot \tfrac{L_{GO}}{L}\right) \\ &= \lambda_0 L(P_N P_O + \gamma_R P_N P_R + \gamma_C P_N P_C + \gamma_G \gamma_R P_G P_R + \gamma_G \gamma_C P_G P_C + \gamma_G P_G P_O) \\ &= \lambda_0 L\big(P_N(P_O + \gamma_R P_R + \gamma_C P_C) + \gamma_G P_G (P_O + \gamma_R P_R + \gamma_C P_C)\big) \qquad (4) \\ &= \lambda_0 L(P_N + \gamma_G P_G)(P_O + \gamma_R P_R + \gamma_C P_C) \\ &= \lambda_0 L\, (1 + (\gamma_G - 1)P_G)(1 + (\gamma_R - 1)P_R + (\gamma_C - 1)P_C) \end{aligned}$$

where $\lambda_0 = \lambda_{NO}$.

Similarly, if we distinguish types of workers according to three characteristics: team work participation (G or N), age (R, C, or O), and sex (women (W), or men (M)). Therefore, a firm's workforce can be fully described by D_3=2×3×2=12 combinations of these characteristics (NRM, NCM, NOM, NRW, NCW, NOW, GRM, GCM, GOM, GRW, GCW, GOW). If we take male production workers who do not participate in a team as our reference category (NOM), the productive labour is

$$
\begin{aligned}
L^A &= \sum_{d=0}^{D_2-1} \lambda_{dM} L_{dM} + \sum_{d=0}^{D_2-1} \lambda_{dW} L_{dW} \\
&= \lambda_{NOM} L_M \left(\frac{L_{NOM}}{L_M} + \frac{\lambda_{NRM}}{\lambda_{NOM}} \cdot \frac{L_{NRM}}{L_M} + \frac{\lambda_{NCM}}{\lambda_{NOM}} \cdot \frac{L_{NCM}}{L_M} + \frac{\lambda_{GRM}}{\lambda_{NOM}} \cdot \frac{L_{GRM}}{L_M} \right. \\
&\quad \left. + \frac{\lambda_{GCM}}{\lambda_{NOM}} \cdot \frac{L_{GCM}}{L_M} + \frac{\lambda_{GOM}}{\lambda_{NOM}} \cdot \frac{L_{GOM}}{L_M} \right) \\
&\quad + \lambda_{NOW} L_W \left(\frac{L_{NOW}}{L_W} + \frac{\lambda_{NRW}}{\lambda_{NOW}} \cdot \frac{L_{NRW}}{L_W} + \frac{\lambda_{NCW}}{\lambda_{NOW}} \cdot \frac{L_{NCW}}{L_W} + \frac{\lambda_{GRW}}{\lambda_{NOW}} \cdot \frac{L_{GRW}}{L_W} \right. \\
&\quad \left. + \frac{\lambda_{GCW}}{\lambda_{NOW}} \cdot \frac{L_{GCW}}{L_W} + \frac{\lambda_{GOW}}{\lambda_{NOW}} \cdot \frac{L_{GOW}}{L_W} \right)
\end{aligned}
\tag{5}
$$

In this example, restriction I means

$$\frac{L_{GOM}}{L_{OM}} = \frac{L_{GOW}}{L_{OW}} = \frac{L_{GRM}}{L_{RM}} = \frac{L_{GRW}}{L_{RW}} = \frac{L_{GCM}}{L_{CM}} = \frac{L_{GCW}}{L_{CW}} = \frac{L_{GO}}{L_O} = \frac{L_{GR}}{L_R} = \frac{L_{GC}}{L_C} = \frac{L_{GM}}{L_M} = \frac{L_{GW}}{L_W} = \frac{L_G}{L} = P_G;$$

$$\frac{L_{NOM}}{L_{OM}} = \frac{L_{NOW}}{L_{OW}} = \frac{L_{NRM}}{L_{RM}} = \frac{L_{NRW}}{L_{RW}} = \frac{L_{NCM}}{L_{CM}} = \frac{L_{NCW}}{L_{CW}} = \frac{L_{NO}}{L_O} = \frac{L_{NR}}{L_R} = \frac{L_{NC}}{L_C} = \frac{L_{NM}}{L_M} = \frac{L_{NW}}{L_W} = \frac{L_N}{L} = P_N;$$

$$\frac{L_{GRM}}{L_{GM}} = \frac{L_{GRW}}{L_{GW}} = \frac{L_{NRM}}{L_{NM}} = \frac{L_{NRW}}{L_{NW}} = \frac{L_{GR}}{L_G} = \frac{L_{NR}}{L_N} = \frac{L_{RM}}{L_M} = \frac{L_{RW}}{L_W} = \frac{L_R}{L} = P_R;$$

$$\frac{L_{GCM}}{L_{GM}} = \frac{L_{GCW}}{L_{GW}} = \frac{L_{NCM}}{L_{NM}} = \frac{L_{NCW}}{L_{NW}} = \frac{L_{GC}}{L_G} = \frac{L_{NC}}{L_N} = \frac{L_{CM}}{L_M} = \frac{L_{CW}}{L_W} = \frac{L_C}{L} = P_C;$$

$$\frac{L_{GOM}}{L_{GM}} = \frac{L_{GOW}}{L_{GW}} = \frac{L_{NOM}}{L_{NM}} = \frac{L_{NOW}}{L_{NW}} = \frac{L_{GO}}{L_G} = \frac{L_{NO}}{L_N} = \frac{L_{OM}}{L_M} = \frac{L_{OW}}{L_W} = \frac{L_O}{L} = P_O;$$

$$\frac{L_{GOW}}{L_{GO}} = \frac{L_{NOW}}{L_{NO}} = \frac{L_{GRW}}{L_{GR}} = \frac{L_{NRW}}{L_{NR}} = \frac{L_{GCW}}{L_{GC}} = \frac{L_{NCW}}{L_{NC}} = \frac{L_{GW}}{L_G} = \frac{L_{NW}}{L_N} = \frac{L_{OW}}{L_O} = \frac{L_{RW}}{L_R} = \frac{L_{CW}}{L_C} = \frac{L_W}{L} = P_W;$$

$$\frac{L_{GOM}}{L_{GO}}=\frac{L_{NOM}}{L_{NO}}=\frac{L_{GRM}}{L_{GR}}=\frac{L_{NRM}}{L_{NR}}=\frac{L_{GCM}}{L_{GC}}=\frac{L_{NCM}}{L_{NC}}=\frac{L_{GM}}{L_{G}}=\frac{L_{NM}}{L_{N}}=\frac{L_{OM}}{L_{O}}=\frac{L_{RM}}{L_{R}}=\frac{L_{CM}}{L_{C}}=\frac{L_{M}}{L}=P_M;$$

while restriction II means

$$\frac{\lambda_{GRM}}{\lambda_{NRM}}=\frac{\lambda_{GRW}}{\lambda_{NRW}}=\frac{\lambda_{GCM}}{\lambda_{NCM}}=\frac{\lambda_{GCW}}{\lambda_{NCW}}=\frac{\lambda_{GOM}}{\lambda_{NOM}}=\frac{\lambda_{GOW}}{\lambda_{NOW}}=\frac{\lambda_{GR}}{\lambda_{NR}}=\frac{\lambda_{GC}}{\lambda_{NC}}=\frac{\lambda_{GO}}{\lambda_{NO}}=\frac{\lambda_{GM}}{\lambda_{NM}}=\frac{\lambda_{GW}}{\lambda_{NW}}$$

$$=\frac{\lambda_{G}}{\lambda_{N}}=\gamma_G;$$

$$\frac{\lambda_{GRM}}{\lambda_{GOM}}=\frac{\lambda_{GRW}}{\lambda_{GOW}}=\frac{\lambda_{NRM}}{\lambda_{NOM}}=\frac{\lambda_{NRW}}{\lambda_{NOW}}=\frac{\lambda_{GR}}{\lambda_{GO}}=\frac{\lambda_{NR}}{\lambda_{NO}}=\frac{\lambda_{RM}}{\lambda_{OM}}=\frac{\lambda_{RW}}{\lambda_{OW}}=\frac{\lambda_{R}}{\lambda_{O}}=\gamma_R;$$

$$\frac{\lambda_{GCM}}{\lambda_{GOM}}=\frac{\lambda_{GCW}}{\lambda_{GOW}}=\frac{\lambda_{NCM}}{\lambda_{NOM}}=\frac{\lambda_{NCW}}{\lambda_{NOW}}=\frac{\lambda_{GC}}{\lambda_{GO}}=\frac{\lambda_{NC}}{\lambda_{NO}}=\frac{\lambda_{CM}}{\lambda_{OM}}=\frac{\lambda_{CW}}{\lambda_{OW}}=\frac{\lambda_{C}}{\lambda_{O}}=\gamma_C;$$

$$\frac{\lambda_{GRW}}{\lambda_{GRM}}=\frac{\lambda_{NRW}}{\lambda_{NRM}}=\frac{\lambda_{GCW}}{\lambda_{GCM}}=\frac{\lambda_{NCW}}{\lambda_{NCM}}=\frac{\lambda_{GOW}}{\lambda_{GOM}}=\frac{\lambda_{NOW}}{\lambda_{NOM}}=\frac{\lambda_{GW}}{\lambda_{GM}}=\frac{\lambda_{NW}}{\lambda_{NM}}=\frac{\lambda_{RW}}{\lambda_{RM}}=\frac{\lambda_{CW}}{\lambda_{CM}}=\frac{\lambda_{OW}}{\lambda_{OM}}$$

$$=\frac{\lambda_{W}}{\lambda_{M}}=\gamma_W.$$

According to the two restrictions and equation (4), the productive labour function (5) can be simplified as follows,

$$\begin{aligned}
L^A &= \lambda_{NOM}L_M(P_NP_O+\gamma_RP_NP_R+\gamma_CP_NP_C+\gamma_G\gamma_RP_GP_R+\gamma_G\gamma_CP_GP_C+\gamma_GP_GP_O)\\
&\quad+\lambda_{NOW}L_W(P_NP_O+\gamma_RP_NP_R+\gamma_CP_NP_C+\gamma_G\gamma_RP_GP_R+\gamma_G\gamma_CP_GP_C+\gamma_GP_GP_O)\\
&=\lambda_{NOM}L\left(\frac{L_M}{L}+\frac{\lambda_{NOW}}{\lambda_{NOM}}\right)(1+(\gamma_G-1)P_G)(1+(\gamma_R-1)P_R+(\gamma_C-1)P_C)\\
&=\lambda_0L(1+(\gamma_W-1)P_W)(1+(\gamma_G-1)P_G)(1+(\gamma_R-1)P_R+(\gamma_C-1)P_C)
\end{aligned}\tag{6}$$

where $\lambda_0=\lambda_{NOM}$.

Thus, in general, if we distinguish worker types according to I characteristics including team participation, age, sex, occupation, and education, the "restricted model" after making the two restrictions will be

$$L^A = \lambda_{0,I} L \prod_{i=1}^{I} \left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{iv}\right) \tag{7}$$

and

$$\ln Q_j = \beta_0 + \beta \ln K_j + \alpha \ln L_j + \alpha \sum_{i=1}^{I} \ln \left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{ivj}\right) + \eta F_j + \mu_j \tag{8}$$

where $\lambda_{0,I}$ is the marginal productivity for the reference group when work force is divided by *I* characteristics, $\gamma_{iv} = \frac{\lambda_{iv}}{\lambda_{i0}}$ is the relative marginal productivity of one worker type *iv* to the worker type *i0* for each characteristic *i*, $P_{iv} = \frac{L_{iv}}{L}$ is the proportion of the worker type *iv* among all workers, β_0 is a constant term that incorporates $\alpha \ln \lambda_{0,I}$.

This general form of the function can be proved by mathematical induction. The base case has been proved using the previous two examples when *I*=2 and *I*=3. In the inductive step, we will show that if the general form holds for *I*=*n*, then the general form also holds when *I*=*n* + 1. That is, when *I*=*n*, $D_n = \prod_{i=1}^{n} V_i$ and the "restricted" productive labour function is

$$\begin{aligned} L^A &= \sum_{d=0}^{D_n - 1} \lambda_d L_d \\ &= \lambda_{0,n} L \prod_{i=1}^{n} \left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{iv}\right) \end{aligned} \tag{9}$$

When I=n + 1, the $D_{n+1} = D_n V_{n+1}$ and the productive labour function can be written as

$$L^A = \sum_{d=0}^{D_{n+1}-1} \lambda_d L_d = \sum_{z=0}^{V_{n+1}-1} \sum_{d=0}^{D_n-1} \lambda_{dz} L_{dz} \tag{10}$$

After the two restrictions, the function can be simplified as

$$\begin{aligned} L^A &= \sum_{z=0}^{V_{n+1}-1} \sum_{d=0}^{D_n-1} \lambda_{dz} L_{dz} \\ &= \sum_{z=0}^{V_{n+1}-1} \lambda_{0,n,z} L_z \prod_{i=1}^{n} \left(1 + \sum_{v=1}^{V_i-1} (\gamma_{iv} - 1) P_{iv} \right) \\ &= \lambda_{0,n+1} L \left(1 + \sum_{z=1}^{V_{n+1}-1} (\gamma_z - 1) P_z \right) \prod_{i=1}^{n} \left(1 + \sum_{v=1}^{V_i-1} (\gamma_{iv} - 1) P_{iv} \right) \\ &= \lambda_{0,n+1} L \prod_{i=1}^{n+1} \left(1 + \sum_{v=1}^{V_i-1} (\gamma_{iv} - 1) P_{iv} \right) \end{aligned} \tag{11}$$

Thus, if the general form holds for I=n, then the general form also holds when I=n + 1.

C.2 Wage equation (labour cost equation)

First we write the aggregate wage as the sum of wage for each worker type.

$$w = \sum_{d=0}^{D_I-1} w_d L_d \tag{12}$$

where w_d is the wage for the worker type d.

Applying the same approach as in the case of marginal productivity, the "restricted model" for wage equation will be

$$w = w_{0,I} L \prod_{i=1}^{I} \left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1) P_{iv} \right) \tag{13}$$

and

$$\ln w_j = \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j + \sum_{i=1}^{I} \ln \left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1) P_{ivj} \right) + \eta_w F_j + \mu_{w,j} \tag{14}$$

where $w_{0,I}$ is the wage for the reference group when work force is divided by *I* characteristics, *i* stands for the number of characteristics, and *v* stands for the number worker categories divided according to the worker characteristic i, $\phi_{iv} = \frac{w_{iv}}{w_{i0}}$ is the relative wage of one worker type *iv* to the worker type *i0* for each characteristic i, β_{w0} is a constant term that incorporates $\ln w_{0,I}$, α_w, β_w are the elasticity of wage with respect to labour and capital, respectively, η_w is a vector of parameters for firm characteristics, $\mu_{w,j}$ is the error term.

C.3 Incorporating absence rate

C.3.1 Specification I: production function

We can incorporate absence rate into the aggregate function of productive labour in the following form:

$$L^A = \sum_{d=0}^{D_I - 1} \lambda_d (1 - a)^{\theta_d} L_d \,; 0 \leq a \leq 1 \; and \; \theta_d > 0; \tag{15}$$

where *a* is the absence rate in a firm based on the assumption that the absence rate is the same across different worker types, $\lambda_d (1 - a)^{\theta_d}$is the marginal productivity for workers of type *d*, λ_d

is the marginal productivity for worker type *d* when absence rate = 0, and θ_d is the parameter of (1-absence rate), i.e., the attendance impact on the marginal productivity for workers of type *d*. This is a convenient form for estimation because it reduces to the standard model $L^A = \sum_{d=0}^{D_I-1} \lambda_d L_d$ if *a* = 0 (no absence) and $L^A = 0$ if *a* = 1 (no attendance). Using this form, it can also be shown that the condition, $\frac{\partial L^A}{\partial a} < 0$, will hold.

If we assume that the attendance impacts on the marginal productivity for different worker type *d* are the same ($\theta_d = \theta$), then the productive labour function can be rewritten as

$$L^A = (1-a)^\theta \sum_{d=0}^{D_I-1} \lambda_d L_d \tag{16}$$

where θ is the parameter of attendance rate for any worker type.

After making the equiproportionate restriction and equal relative productivity restriction, the "restricted model", according to the equation (7), will be

$$\begin{aligned} L^A &= (1-a)^\theta \sum_{d=0}^{D_I-1} \lambda_d L_d \\ &= (1-a)^\theta \lambda_{0,I} L \prod_{i=1}^{I} \left(1 + \sum_{v=1}^{V_i-1} (\gamma_{iv} - 1) P_{iv} \right) \\ &= (1-a)^\theta \lambda_{0,I} L (1 + (\gamma_G - 1) P_G) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i-1} (\gamma_{iv} - 1) P_{iv} \right) \end{aligned} \tag{17}$$

and

$$
\begin{aligned}
\ln Q_j &= \beta_0 + \beta \ln K_j + \alpha \ln L_j + \alpha\theta \ln\left(1 - a_j\right) \\
&\quad + \alpha \sum_{i=1}^{I} \ln\left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{ivj}\right) + \eta F_j + \mu_j \\
&= \beta_0 + \beta \ln K_j + \alpha \ln L_j + \alpha\theta \ln\left(1 - a_j\right) + \alpha \ln\left(1 + (\gamma_G - 1) P_{Gj}\right) \\
&\quad + \alpha E_j + \eta F_j + \mu_j
\end{aligned}
\tag{18}
$$

where

$$
E_j = \sum_{i=1}^{I-1} \ln\left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{ivj}\right) \tag{19}
$$

γ_G is the relative marginal productivity of team workers to non-team workers, P_{Gj} is the proportion of team workers among all workers at firm *j*, *i* = 1, 2, …, *I*-1, indicates characteristics other than team work participation.

If we assume that the attendance impact on the marginal productivity for team workers (G) is different from that for non-team workers (N), then the productive labour function (15) can be rewritten as

$$
L^A = (1 - a)^{\theta_G} \sum_{d=0}^{\frac{D_I}{2} - 1} \lambda_{Gd} L_{Gd} + (1 - a)^{\theta_N} \sum_{d=0}^{\frac{D_I}{2} - 1} \lambda_{Nd} L_{Nd} \tag{20}
$$

where θ_G is the parameter of attendance rate for team workers, θ_N is the parameter of attendance rate for non-team workers, λ_{Gd} is the marginal productivity for the worker type *d* in team workers, λ_{Nd} is the marginal productivity for the worker type *d* in non-team workers.

With the same restrictions as above, the relatively "complete model" will be

$$L^A = (1-a)^{\theta_G}\lambda_{G,0,I-1}L_G\prod_{i=1}^{I-1}\left(1+\sum_{v=1}^{V_i-1}(\gamma_{iv}-1)P_{iv}\right)$$

$$+ (1-a)^{\theta_N}\lambda_{N,0,I-1}L_N\prod_{i=1}^{I-1}\left(1+\sum_{v=1}^{V_i-1}(\gamma_{iv}-1)P_{iv}\right) \tag{21}$$

$$= \lambda_{0,I}(1-a)^{\theta_N}L\big(1+\big(\gamma_G(1-a)^{\theta_G-\theta_N}-1\big)P_G\big)\prod_{i=1}^{I-1}\left(1+\sum_{v=1}^{V_i-1}(\gamma_{iv}-1)P_{iv}\right)$$

and

$$\ln Q_j = \beta_0 + \beta\ln K_j$$

$$+ \alpha\ln L_j + \alpha\theta_N\ln\big(1-a_j\big) + \alpha\ln\Big(1+\Big(\gamma_G\big(1-a_j\big)^{\theta_G-\theta_N}-1\Big)P_{Gj}\Big) \tag{22}$$

$$+ \alpha E_j + \eta F_j + \mu_j$$

C.3.2 Specification I: wage equation

Correspondingly, we rewrite the aggregate wage as the sum of wage for each worker type incorporating into absence rate:

$$w = \sum_{d=0}^{D_I-1} w_d(1-a)^{\zeta_d}L_d \tag{23}$$

where $w_d(1-a)^{\zeta_d}$ is the wage for the worker type *d*, w_d is the wage for the worker type *d* when absence=0, and ζ_d is the parameter of attendance rate, i.e., the attendance impact on wage for the worker type *d*.

If we assume that the attendance impacts on wage for different worker type *d* are the same ($\zeta_d = \zeta$) and make the two restrictions, then the “restricted model” will be

$$w = (1-a)^{\zeta} \sum_{d=0}^{D_I - 1} w_d L_d$$

$$= w_{0,I}(1-a)^{\zeta} L \prod_{i=1}^{I} \left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1) P_{iv}\right) \tag{24}$$

$$= w_{0,I}(1-a)^{\zeta} L (1 + (\phi_G - 1) P_G) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1) P_{iv}\right)$$

and

$$\ln w_j = \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j + \zeta \ln\big(1 - a_j\big) + \ln\big(1 + (\phi_G - 1) P_{Gj}\big) \tag{25}$$

$$+ E_{wj} + \eta_{\mathrm{w}} F_j + \mu_{w,j}$$

where

$$E_{wj} = \sum_{i=1}^{I-1} \ln\left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1) P_{ivj}\right) \tag{26}$$

and ϕ_G is the relative wage of team workers to non-team workers.

If we assume the attendance impact on wage differs by team participation and make the two restrictions, the relatively "complete model" will be

$$w = (1-a)^{\zeta_G} \sum_{d=0}^{\frac{D_I}{2} - 1} w_{Gd} L_{Gd} + (1-a)^{\zeta_N} \sum_{d=0}^{\frac{D_I}{2} - 1} w_{Nd} L_{Nd}$$

$$= w_{0,I}(1-a)^{\zeta_N} L\big(1 + \big(\phi_G (1-a)^{\zeta_G - \zeta_N} - 1\big) P_G\big) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1) P_{iv}\right) \tag{27}$$

and

$$\ln w_j = \beta_{w0} + \beta_w \ln K_j$$
$$+ \alpha_w \ln L_j + \zeta_N \ln(1 - a_j) + \ln\left(1 + \left(\phi_G(1 - a_j)^{\zeta_G - \zeta_N} - 1\right) P_{Gj}\right) \tag{28}$$
$$+ E_{wj} + \eta_w F_j + \mu_{w,j}$$

where ζ_G is the parameter of attendance rate for team workers, and ζ_N is the parameter of attendance rate for team workers.

C.3.3 Specification II: production function

We incorporate absence rate into the aggregate function of productive labour in another form:

$$L^A = \sum_{d=0}^{D_I - 1} \lambda_d e^{\theta_d a} L_d \,; 0 \leq a \leq 1 \; and \; \theta_d < 0; \tag{29}$$

where $\lambda_d e^{\theta_d a}$ is the marginal productivity for workers of type d, λ_d is the marginal productivity for worker type *d* when absence rate = 0, and θ_d is the parameter of absence rate, i.e., the absence impact on the marginal productivity for workers of type *d*. This is another convenient form for estimation because it reduces to the standard model $L^A = \sum_{d=0}^{D_I-1} \lambda_d L_d$ if $a = 0$ (no absence) and $L^A = \sum_{d=0}^{D_I-1} \lambda_d e^{\theta_d} L_d < \sum_{d=0}^{D_I-1} \lambda_d L_d$ if $a = 1$ (no attendance). Using this form, it can also be shown that the condition, $\frac{\partial L^A}{\partial a} < 0$, will hold.

If we assume the absence impacts on marginal productivity for different worker type are the same and then make the equiproportionate restriction and equal relative productivity restriction, the “restricted model” will be

$$L^A = e^{\theta a} \sum_{d=0}^{D_I - 1} \lambda_d L_d$$
$$= e^{\theta a} \lambda_{0,I} L(1 + (\gamma_G - 1)P_G) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{iv} \right) \tag{30}$$

and

$$\ln Q_j = \beta_0 + \beta \ln K_j + \alpha \ln L_j + \alpha\theta a_j + \alpha \ln\big(1 + (\gamma_G - 1)P_{Gj}\big)$$
$$+ \alpha E_j + \eta F_j + \mu_j \tag{31}$$

If we assume that the absence impact on the marginal productivity for team workers (G) is different from that for non-team workers (N) and make the restrictions, then the relatively "complete model" will be

$$L^A = e^{\theta_G a} \sum_{d=0}^{\frac{D_I}{2} - 1} \lambda_{Gd} L_{Gd} + e^{\theta_N a} \sum_{d=0}^{\frac{D_I}{2} - 1} \lambda_{Nd} L_{Nd}$$
$$= \lambda_{0,I} e^{\theta_N a} L\big(1 + \big(\gamma_G e^{(\theta_G - \theta_N)a} - 1\big) P_G\big) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i - 1} (\gamma_{iv} - 1) P_{iv} \right) \tag{32}$$

and

$$\ln Q_j = \beta_0 + \beta \ln K_j + \alpha \ln L_j + \alpha\theta_N a_j + \alpha \ln\big(1 + \big(\gamma_G e^{(\theta_G - \theta_N)a_j} - 1\big) P_{Gj}\big)$$
$$+ \alpha E_j + \eta F_j + \mu_j \tag{33}$$

where θ_G is the parameter of absence rate for team workers, θ_N is the parameter of absence rate for non-team workers.

C.3.4 Specification II: wage equation

Correspondingly, the aggregate wage is

$$w = \sum_{d=0}^{D_I - 1} w_d e^{\zeta_d a} L_d \tag{34}$$

where $w_d e^{\zeta_d a}$ is the wage for the worker type *d*, w_d is the wage for the worker type *d* when absence=0, and ζ_d is the parameter of absence rate, i.e., the absence impact on wage for the worker type *d*.

If we assume that the absence impacts on wage for different worker type *d* are the same ($\zeta_d = \zeta$) and make the two restrictions, then the "restricted model" will be

$$\begin{aligned} w &= e^{\zeta a} \sum_{d=0}^{D_I - 1} w_d L_d \\ &= w_{0,I} e^{\zeta a} L (1 + (\phi_G - 1) P_G) \prod_{i=1}^{I-1} \left(1 + \sum_{v=1}^{V_i - 1} (\phi_{iv} - 1) P_{iv} \right) \end{aligned} \tag{35}$$

and

$$\begin{aligned} \ln w_j &= \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j + \zeta a_j + \ln\big(1 + (\phi_G - 1) P_{Gj}\big) \\ &\quad + E_{wj} + \eta_w F_j + \mu_{w,j} \end{aligned} \tag{36}$$

If we assume the absence impact on wage differs by team participation and make the two restrictions, the relatively "complete model" will be

$$w = e^{\zeta_G a}\sum_{d=0}^{\frac{D_I}{2}-1} w_{Gd}L_{Gd} + e^{\zeta_N a}\sum_{d=0}^{\frac{D_I}{2}-1} w_{Nd}L_{Nd}$$

$$= w_{0,I}e^{\zeta_N a}L\left(1 + \left(\phi_G e^{(\zeta_G-\zeta_N)a_j} - 1\right)P_G\right)\prod_{i=1}^{I-1}\left(1 + \sum_{v=1}^{V_i-1}(\phi_{iv} - 1)P_{iv}\right) \tag{37}$$

and

$$\ln w_j = \beta_{w0} + \beta_w \ln K_j + \alpha_w \ln L_j + \zeta_N a_j + \ln\left(1 + \left(\phi_G e^{(\zeta_G-\zeta_N)a_j} - 1\right)P_{Gj}\right)$$
$$+ E_{wj} + \gamma_{\mathrm{w}}F_j + \mu_{w,j} \tag{38}$$

where ζ_G is the parameter of absence rate for team workers, and ζ_N is the parameter of absence rate for team workers.

Appendix D **Additional results for Chapter 6**

D.1 Specification I

D.1.1 Full sample: Cobb-Douglas production function

Table D.1. Parameter estimates using restricted models for all workplaces

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.34 (0.12)***	9.41 (0.07)***	10.97 (0.21)***	10.46 (0.13)***				
Log (employment)	0.94 (0.02)***	1.04 (0.01)***	0.95 (0.02)***	1.08 (0.01)***	0.60 (0.08)***	0.69 (0.04)***	0.61 (0.08)***	0.70 (0.04)***
Log (stock)	0.04 (0.01)***	0.05 (0.01)***	0.00 (0.01)	-0.03 (0.01)***	-0.03 (0.03)	0.00 (0.01)	-0.03 (0.03)	-0.01 (0.01)
Attendance rate	0.42 (0.12)***	0.41 (0.07)***	0.46 (0.13)***	0.47 (0.07)***	0.42 (0.40)	0.05 (0.11)	0.44 (0.38)	0.05 (0.11)
Team	0.66 (0.19)***	0.40 (0.08)***	0.26 (0.11)**	0.08 (0.05)	0.08 (0.14)	-0.01 (0.04)	0.08 (0.15)	-0.01 (0.04)
35 ≤ Age < 55			0.28 (0.08)***	0.26 (0.04)***			0.01 (0.09)	0.05 (0.03)*
55≤ Age			-0.01 (0.17)	0.18 (0.06)***			-0.06 (0.23)	0.00 (0.04)
Female			-0.24 (0.06)***	-0.25 (0.02)***			0.08 (0.18)	-0.02 (0.04)
> a bachelor's degree			0.26 (0.12)**	0.32 (0.08)***			-0.20 (0.12)*	0.05 (0.06)
Managers/professionals			0.61 (0.15)***	0.80 (0.11)***			0.20 (0.24)	0.09 (0.07)
Technical/sales/clerical			0.69 (0.13)***	0.42 (0.07)***			0.08 (0.14)	0.02 (0.04)
Others			-0.14 (0.09)	-0.05 (0.06)			-0.01 (0.23)	0.08 (0.06)
Minorities			0.00 (0.08)	-0.05 (0.04)			0.05 (0.16)	-0.02 (0.03)
Immigrants			-0.03 (0.08)	-0.06 (0.04)			0.17 (0.24)	0.00 (0.04)
Bargaining agreement			0.32 (0.14)**	0.16 (0.05)***			0.08 (0.34)	-0.02 (0.06)
International market			0.37 (0.08)***	0.12 (0.03)***				
Foreign owned			0.57 (0.09)***	0.22 (0.04)***				
Labour tertiary manufacturing			-0.44 (0.07)***	-0.32 (0.04)***				
Primary product			-0.28 (0.07)***	-0.17 (0.04)***				

	NLS				First differences			
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
manufacturing								
Secondary product manufacturing			-0.24 (0.07)***	-0.12 (0.04)***				
Capital tertiary manufacturing			-0.27 (0.09)***	-0.15 (0.04)***				
Construction			-0.42 (0.12)***	-0.18 (0.05)***				
Transportation			-0.13 (0.07)*	-0.14 (0.04)***				
Communication			-0.42 (0.07)***	-0.24 (0.04)***				
Retail trade			-0.73 (0.09)***	-0.79 (0.05)***				
Finance			-0.02 (0.09)	-0.12 (0.05)***				
Real estate			-0.43 (0.11)***	-0.45 (0.05)***				
Business services			-0.34 (0.09)***	-0.32 (0.05)***				
Education			-0.24 (0.10)**	-0.46 (0.06)***				
Information			-0.58 (0.11)***	-0.31 (0.05)***				
Atlantic			-0.14 (0.10)	-0.15 (0.04)***				
Quebec			-0.13 (0.06)**	-0.19 (0.03)***				
Alberta			-0.07 (0.06)	-0.06 (0.03)**				
British Columbia			-0.13 (0.06)**	-0.03 (0.03)				
Manitoba			-0.04 (0.09)	-0.17 (0.05)***				
Saskatchewan			-0.27 (0.09)***	-0.22 (0.04)***				
Year01	-0.11 (0.06)*	-0.03 (0.03)	-0.13 (0.05)**	-0.07 (0.03)**				
Year03	-0.20 (0.07)***	-0.08 (0.04)**	-0.19 (0.07)***	-0.07 (0.03)**	0.02 (0.04)	0.04 (0.02)**	0.02 (0.04)	0.04 (0.02)**
Year05	-0.12 (0.06)**	-0.05 (0.03)*	-0.10 (0.06)*	-0.04 (0.03)	0.07 (0.03)**	0.05 (0.02)***	0.07 (0.03)**	0.05 (0.02)***
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference in attendance rate parameters	0.01 (0.10)		-0.01 (0.10)		0.37 (0.36)		0.38 (0.34)	
Difference in attendance rate parameters with team								
Difference in team	0.26 (0.14)*		0.18 (0.09)**		0.09 (0.13)		0.09 (0.14)	

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
parameters								

†Model adjusted for employment, capital stock, and years; ‡ Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, international market, foreign owned, region, industry and year; First differences estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, and year; Standard error in the bracket; $^{***}p \leq 0.01$; $^{**}0.01 < p \leq 0.05$; $^{*}0.05 < p \leq 0.1$

Table D.2. Parameter estimates using complete models for all workplaces

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.34 (0.12)***	9.41 (0.07)***	10.97 (0.21)***	10.46 (0.13)***				
Log (employment)	0.94 (0.02)***	1.04 (0.01)***	0.95 (0.02)***	1.08 (0.01)***	0.60 (0.08)***	0.69 (0.04)***	0.61 (0.08)***	0.70 (0.04)***
Log (stock)	0.04 (0.01)***	0.05 (0.01)***	0.00 (0.01)	-0.03 (0.01)***	-0.03 (0.03)	0.00 (0.01)	-0.03 (0.03)	-0.01 (0.01)
Attendance rate with no team	0.37 (0.12)***	0.38 (0.07)***	0.43 (0.13)***	0.45 (0.07)***	0.27 (0.39)	0.01 (0.11)	0.29 (0.37)	0.01 (0.11)
Attendance rate with team	2.78 (1.44)*	1.83 (0.84)**	2.38 (1.40)*	1.43 (0.75)*	2.72 (2.08)	0.71 (0.62)	2.73 (1.92)	0.71 (0.64)
Team	0.75 (0.17)***	0.45 (0.08)***	0.32 (0.12)**	0.10 (0.05)**	0.13 (0.17)	0.00 (0.04)	0.14 (0.18)	0.00 (0.04)
35 ≤ Age < 55			0.28 (0.08)***	0.26 (0.04)***			0.01 (0.09)	0.05 (0.03)*
55≤ Age			-0.01 (0.17)	0.18 (0.06)***			-0.06 (0.23)	0.00 (0.04)
Female			-0.24 (0.06)***	-0.25 (0.02)***			0.08 (0.17)	-0.02 (0.04)
> a bachelor’s degree			0.26 (0.12)**	0.32 (0.08)***			-0.20 (0.12)*	0.05 (0.06)
Managers/professionals			0.61 (0.15)***	0.80 (0.11)***			0.21 (0.24)	0.10 (0.07)
Technical/sales/clerical			0.69 (0.13)***	0.42 (0.07)***			0.08 (0.15)	0.02 (0.04)
Others			-0.14 (0.09)	-0.05 (0.06)			-0.02 (0.23)	0.08 (0.06)
Minorities			0.00 (0.08)	-0.05 (0.04)			0.05 (0.15)	-0.02 (0.03)
Immigrants			-0.03 (0.08)	-0.06 (0.04)			0.16 (0.24)	0.00 (0.04)
Bargaining agreement			0.33 (0.14)**	0.16 (0.05)***			0.08 (0.34)	-0.02 (0.06)
International market			0.37 (0.08)***	0.12 (0.03)***				
Foreign owned			0.57 (0.09)***	0.22 (0.04)***				
Labour tertiary manufacturing			-0.45 (0.07)***	-0.32 (0.04)***				
Primary product manufacturing			-0.29 (0.07)***	-0.17 (0.04)***				
Secondary product manufacturing			-0.24 (0.07)***	-0.13 (0.04)***				
Capital tertiary manufacturing			-0.28 (0.09)***	-0.15 (0.04)***				
Construction			-0.43 (0.12)***	-0.18 (0.05)***				
Transportation			-0.14 (0.07)*	-0.14 (0.04)***				
Communication			-0.43 (0.07)***	-0.25 (0.04)***				
Retail trade			-0.74 (0.09)***	-0.80 (0.05)***				

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Finance			-0.02 (0.09)	-0.12 (0.05)***				
Real estate			-0.43 (0.11)***	-0.45 (0.05)***				
Business services			-0.35 (0.09)***	-0.32 (0.05)***				
Education			-0.24 (0.10)**	-0.46 (0.06)***				
Information			-0.58 (0.11)***	-0.31 (0.05)***				
Atlantic			-0.14 (0.10)	-0.15 (0.04)***				
Quebec			-0.14 (0.06)**	-0.19 (0.03)***				
Alberta			-0.07 (0.06)	-0.06 (0.03)**				
British Columbia			-0.12 (0.06)**	-0.03 (0.03)				
Manitoba			-0.04 (0.09)	-0.17 (0.05)***				
Saskatchewan			-0.27 (0.09)***	-0.22 (0.04)***				
Year01	-0.11 (0.06)*	-0.03 (0.03)	-0.13 (0.05)**	-0.07 (0.03)**				
Year03	-0.20 (0.07)***	-0.08 (0.04)**	-0.19 (0.07)***	-0.06 (0.03)**	0.02 (0.04)	0.04 (0.02)**	0.02 (0.04)	0.04 (0.02)**
Year05	-0.11 (0.06)**	-0.05 (0.03)*	-0.10 (0.06)*	-0.04 (0.03)	0.07 (0.03)**	0.05 (0.02)***	0.07 (0.03)**	0.06 (0.02)***
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference in attendance rate parameters with no team	-0.01 (0.10)		-0.02 (0.10)		0.27 (0.35)		0.28 (0.33)	
Difference in attendance rate parameters with team	0.95 (0.95)		0.95 (1.00)		2.02 (1.85)		2.02 (1.70)	
Difference in team parameters	0.30 (0.12)**		0.21 (0.10)**		0.13 (0.16)		0.14 (0.17)	

D.1.2 Full sample: Translog production function

Table D.3. Parameter estimates using restricted models

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	13.13 (0.53)***	9.41 (0.07)***	13.52 (0.82)***	10.46 (0.13)***				
Log (employment)	0.74 (0.07)***	1.04 (0.01)***	0.79 (0.08)***	1.08 (0.01)***	0.87 (0.28)***	0.69 (0.04)***	0.90 (0.29)***	0.70 (0.04)***
Log (stock)	-0.38 (0.09)***	0.05 (0.01)***	-0.38 (0.12)***	-0.03 (0.01)***	-0.24 (0.24)	0.00 (0.01)	-0.24 (0.24)	-0.01 (0.01)
Attendance rate	0.61 (0.18)***	0.42 (0.07)***	0.60 (0.18)***	0.47 (0.07)***	0.45 (0.44)	0.05 (0.11)	0.47 (0.42)	0.05 (0.11)
Team	0.73 (0.23)***	0.40 (0.08)***	0.25 (0.14)*	0.08 (0.05)	0.03 (0.09)	-0.01 (0.04)	0.03 (0.09)	-0.01 (0.04)
35 ≤ Age < 55			0.33 (0.11)***	0.26 (0.04)***			0.01 (0.06)	0.05 (0.03)*
55≤ Age			-0.04 (0.22)	0.18 (0.06)***			-0.03 (0.15)	0.00 (0.04)
Female			-0.30 (0.07)***	-0.25 (0.02)***			0.04 (0.11)	-0.02 (0.04)
> a bachelor's degree			0.29 (0.15)*	0.32 (0.08)***			-0.16 (0.09)*	0.05 (0.06)
Managers/professionals			0.81 (0.24)***	0.80 (0.11)***			0.14 (0.16)	0.09 (0.07)
Technical/sales/clerical			0.87 (0.21)***	0.42 (0.07)***			0.06 (0.09)	0.02 (0.04)
Others			-0.16 (0.11)	-0.05 (0.06)			-0.01 (0.15)	0.08 (0.06)
Minorities			0.00 (0.09)	-0.05 (0.04)			0.04 (0.10)	-0.02 (0.03)
Immigrants			-0.04 (0.10)	-0.06 (0.04)			0.11 (0.16)	0.00 (0.04)
Bargaining agreement			0.28 (0.17)*	0.16 (0.05)***			0.06 (0.22)	-0.02 (0.06)
International market			0.34 (0.08)***	0.12 (0.03)***				
Foreign owned			0.54 (0.09)***	0.22 (0.04)***				
Labour tertiary manufacturing			-0.39 (0.07)***	-0.32 (0.04)***				
Primary product manufacturing			-0.30 (0.07)***	-0.17 (0.04)***				
Secondary product manufacturing			-0.19 (0.07)***	-0.12 (0.04)***				
Capital tertiary manufacturing			-0.22 (0.09)**	-0.15 (0.04)***				
Construction			-0.35 (0.12)***	-0.18 (0.05)***				
Transportation			-0.05 (0.07)	-0.14 (0.04)***				

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Communication			-0.42 (0.07)***	-0.24 (0.04)***				
Retail trade			-0.68 (0.08)***	-0.79 (0.05)***				
Finance			0.05 (0.09)	-0.12 (0.05)***				
Real estate			-0.40 (0.11)***	-0.45 (0.05)***				
Business services			-0.33 (0.09)***	-0.32 (0.05)***				
Education			-0.31 (0.11)***	-0.46 (0.06)***				
Information			-0.57 (0.11)***	-0.31 (0.05)***				
Atlantic			-0.14 (0.10)	-0.15 (0.04)***				
Quebec			-0.13 (0.06)**	-0.19 (0.03)***				
Alberta			-0.07 (0.06)	-0.06 (0.03)**				
British Columbia			-0.12 (0.05)**	-0.03 (0.03)				
Manitoba			-0.05 (0.09)	-0.17 (0.05)***				
Saskatchewan			-0.27 (0.09)***	-0.22 (0.04)***				
Year01	-0.10 (0.06)*	-0.03 (0.03)	-0.13 (0.06)**	-0.07 (0.03)**				
Year03	-0.19 (0.07)***	-0.08 (0.04)**	-0.18 (0.07)***	-0.07 (0.03)**	0.02 (0.04)	0.04 (0.02)**	0.02 (0.04)	0.04 (0.02)**
Year05	-0.10 (0.06)*	-0.05 (0.03)*	-0.09 (0.06)	-0.04 (0.03)	0.07 (0.03)**	0.05 (0.02)***	0.08 (0.03)**	0.05 (0.02)***
LnL*LnL	0.04 (0.01)***		0.04 (0.01)***		0.05 (0.04)		0.05 (0.03)	
LnK*LnK	0.02 (0.00)***		0.01 (0.00)***		0.01 (0.01)		0.01 (0.01)	
LnL*LnK	0.00 (0.01)		0.00 (0.01)		-0.04 (0.02)**		-0.04 (0.02)**	
Difference in attendance rate parameters	0.19 (0.16)		0.13 (0.15)		0.40 (0.40)		0.42 (0.38)	
Difference in attendance rate parameters with team								
Difference in team parameters	0.33 (0.19)*		0.18 (0.11)		0.04 (0.08)		0.04 (0.08)	

Table D.4. Parameter estimates using complete models

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	13.13 (0.53)***	9.41 (0.07)***	13.52 (0.82)***	10.46 (0.13)***				
Log (employment)	0.75 (0.07)***	1.04 (0.01)***	0.79 (0.08)***	1.08 (0.01)***	0.86 (0.28)***	0.69 (0.04)***	0.89 (0.29)***	0.70 (0.04)***
Log (stock)	-0.38 (0.09)***	0.05 (0.01)***	-0.38 (0.12)***	-0.03 (0.01)***	-0.24 (0.24)	0.00 (0.01)	-0.24 (0.24)	-0.01 (0.01)
Attendance rate with no team	0.52 (0.18)***	0.39 (0.08)***	0.55 (0.18)***	0.45 (0.07)***	0.31 (0.41)	0.01 (0.11)	0.32 (0.39)	0.01 (0.11)
Attendance rate with team	2.67 (1.27)**	1.81 (0.83)**	2.19 (1.24)*	1.41 (0.75)*	1.84 (1.80)	0.69 (0.62)	1.93 (1.77)	0.69 (0.62)
Team	0.56 (0.14)***	0.45 (0.08)***	0.23 (0.11)**	0.10 (0.05)**	0.07 (0.13)	0.00 (0.04)	0.07 (0.13)	0.00 (0.04)
35 ≤ Age < 55			0.33 (0.11)***	0.26 (0.04)***			0.01 (0.06)	0.05 (0.03)*
55≤ Age			-0.04 (0.21)	0.18 (0.06)***			-0.03 (0.15)	0.00 (0.04)
Female			-0.30 (0.07)***	-0.25 (0.02)***			0.04 (0.11)	-0.02 (0.04)
> a bachelor’s degree			0.28 (0.15)*	0.32 (0.08)***			-0.16 (0.09)*	0.05 (0.06)
Managers/professionals			0.80 (0.23)***	0.80 (0.11)***			0.14 (0.16)	0.10 (0.07)
Technical/sales/clerical			0.86 (0.20)***	0.42 (0.07)***			0.06 (0.09)	0.02 (0.04)
Others			-0.16 (0.11)	-0.05 (0.06)			-0.01 (0.15)	0.08 (0.06)
Minorities			0.00 (0.09)	-0.05 (0.04)			0.04 (0.10)	-0.02 (0.03)
Immigrants			-0.04 (0.09)	-0.06 (0.04)			0.11 (0.16)	0.00 (0.04)
Bargaining agreement			0.29 (0.17)*	0.16 (0.05)***			0.06 (0.23)	-0.02 (0.06)
International market			0.34 (0.08)***	0.12 (0.03)***				
Foreign owned			0.54 (0.09)***	0.22 (0.04)***				
Labour tertiary manufacturing			-0.39 (0.07)***	-0.32 (0.04)***				
Primary product manufacturing			-0.30 (0.07)***	-0.17 (0.04)***				
Secondary product manufacturing			-0.19 (0.07)***	-0.13 (0.04)***				
Capital tertiary manufacturing			-0.22 (0.09)**	-0.15 (0.04)***				
Construction			-0.35 (0.12)***	-0.18 (0.05)***				
Transportation			-0.06 (0.07)	-0.14 (0.04)***				
Communication			-0.42 (0.07)***	-0.24 (0.04)***				
Retail trade			-0.68 (0.08)***	-0.80 (0.05)***				

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Finance			0.05 (0.09)	-0.12 (0.05)***				
Real estate			-0.40 (0.11)***	-0.45 (0.05)***				
Business services			-0.33 (0.09)***	-0.32 (0.05)***				
Education			-0.32 (0.11)***	-0.46 (0.06)***				
Information			-0.57 (0.11)***	-0.31 (0.05)***				
Atlantic			-0.14 (0.10)	-0.15 (0.04)***				
Quebec			-0.13 (0.06)**	-0.19 (0.03)***				
Alberta			-0.07 (0.06)	-0.06 (0.03)**				
British Columbia			-0.12 (0.05)**	-0.03 (0.03)				
Manitoba			-0.05 (0.09)	-0.17 (0.05)***				
Saskatchewan			-0.27 (0.09)***	-0.22 (0.04)***				
Year01	-0.10 (0.06)*	-0.03 (0.03)	-0.13 (0.06)**	-0.07 (0.03)**				
Year03	-0.19 (0.07)***	-0.08 (0.04)**	-0.18 (0.07)***	-0.06 (0.03)**	0.02 (0.04)	0.04 (0.02)**	0.02 (0.04)	0.04 (0.02)**
Year05	-0.10 (0.06)*	-0.05 (0.03)*	-0.08 (0.06)	-0.04 (0.03)	0.08 (0.03)**	0.05 (0.02)***	0.08 (0.03)**	0.06 (0.02)***
LnL*LnL	0.04 (0.01)***		0.04 (0.01)***		0.05 (0.04)		0.05 (0.03)	
LnK*LnK	0.02 (0.00)***		0.01 (0.00)***		0.01 (0.01)		0.01 (0.01)	
LnL*LnK	0.00 (0.01)		0.00 (0.01)		-0.04 (0.02)**		-0.04 (0.02)**	
Difference in attendance rate parameters with no team	0.14 (0.15)		0.10 (0.16)		0.30 (0.38)		0.31 (0.36)	
Difference in attendance rate parameters with team	0.86 (0.80)		0.78 (0.86)		1.15 (1.57)		1.25 (1.55)	
Difference in team parameters	0.12 (0.10)		0.13 (0.08)		0.06 (0.12)		0.07 (0.12)	

D.1.3 Sub-samples: Cobb-Douglas production function

Table D.5. Parameter estimates using restricted models for small firms and large firms

	NLS (small firms)				NLS (large firms)			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.56 (0.15)***	9.51 (0.09)***	11.08 (0.27)***	10.55 (0.17)***	9.33 (0.19)***	8.91 (0.14)***	10.35 (0.25)***	10.24 (0.17)***
Log (employment)	0.87 (0.03)***	1.04 (0.02)***	0.88 (0.03)***	1.07 (0.02)***	1.07 (0.02)***	1.02 (0.02)***	1.10 (0.02)***	1.03 (0.02)***
Log (stock)	0.03 (0.01)***	0.04 (0.01)***	0.00 (0.02)	-0.03 (0.01)***	0.09 (0.01)***	0.08 (0.01)***	0.00 (0.01)	-0.01 (0.01)
Attendance rate	0.44 (0.13)***	0.38 (0.07)***	0.51 (0.14)***	0.46 (0.07)***	1.20 (0.57)**	1.19 (0.42)***	0.80 (0.51)	0.75 (0.34)**
Team	0.53 (0.23)**	0.27 (0.09)***	0.21 (0.15)	0.02 (0.05)	0.82 (0.14)***	0.70 (0.11)***	0.25 (0.09)***	0.13 (0.06)**
35 ≤ Age < 55			0.28 (0.09)***	0.24 (0.04)***			0.45 (0.11)***	0.40 (0.09)***
55≤ Age			-0.06 (0.18)	0.16 (0.06)***			0.44 (0.17)***	0.39 (0.10)***
Female			-0.25 (0.07)***	-0.24 (0.03)***			-0.27 (0.05)***	-0.33 (0.04)***
> a bachelor’s degree			0.26 (0.14)*	0.30 (0.08)***			0.15 (0.18)	0.46 (0.13)***
Managers/professionals			0.62 (0.18)***	0.75 (0.12)***			1.31 (0.26)***	1.54 (0.22)***
Technical/sales/clerical			0.68 (0.17)***	0.38 (0.08)***			0.98 (0.13)***	0.66 (0.10)***
Others			-0.15 (0.11)	-0.06 (0.07)			-0.17 (0.08)**	-0.05 (0.08)
Minorities			-0.01 (0.09)	-0.05 (0.05)			0.06 (0.09)	-0.03 (0.05)
Immigrants			-0.04 (0.09)	-0.07 (0.04)*			-0.10 (0.09)	0.08 (0.07)
Bargaining agreement			0.44 (0.29)	0.19 (0.10)**			0.07 (0.06)	0.12 (0.04)***
International market			0.47 (0.11)***	0.17 (0.03)***			-0.03 (0.05)	-0.02 (0.06)
Foreign owned			0.74 (0.13)***	0.32 (0.06)***			0.20 (0.06)***	0.03 (0.06)
Labour tertiary manufacturing			-0.51 (0.08)***	-0.35 (0.05)***			-0.16 (0.12)	-0.29 (0.05)***
Primary product manufacturing			-0.41 (0.09)***	-0.25 (0.05)***			-0.07 (0.11)	-0.10 (0.05)*
Secondary product manufacturing			-0.22 (0.09)**	-0.09 (0.05)*			-0.15 (0.11)	-0.21 (0.06)***
Capital tertiary manufacturing			-0.28 (0.10)***	-0.16 (0.05)***			-0.15 (0.11)	-0.18 (0.05)***
Construction			-0.42 (0.14)***	-0.18 (0.05)***			-0.30 (0.10)***	-0.23 (0.06)***
Transportation			-0.11 (0.09)	-0.13 (0.05)***			-0.14 (0.11)	-0.22 (0.06)***

	NLS (small firms)				NLS (large firms)			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Communication			-0.48 (0.08)***	-0.26 (0.05)***			-0.31 (0.11)***	-0.31 (0.05)***
Retail trade			-0.72 (0.10)***	-0.78 (0.06)***			-0.68 (0.10)***	-0.82 (0.06)***
Finance			-0.02 (0.11)	-0.13 (0.05)**			-0.01 (0.12)	-0.17 (0.06)***
Real estate			-0.44 (0.12)***	-0.45 (0.05)***			-0.14 (0.13)	-0.20 (0.09)**
Business services			-0.34 (0.11)***	-0.33 (0.06)***			-0.37 (0.13)***	-0.35 (0.06)***
Education			-0.20 (0.12)	-0.45 (0.07)***			-0.66 (0.12)***	-0.66 (0.07)***
Information			-0.62 (0.14)***	-0.30 (0.06)***			-0.48 (0.12)***	-0.36 (0.07)***
Atlantic			-0.17 (0.11)	-0.16 (0.05)***			0.01 (0.09)	-0.12 (0.05)**
Quebec			-0.16 (0.07)**	-0.20 (0.03)***			-0.12 (0.07)*	-0.15 (0.05)***
Alberta			-0.08 (0.07)	-0.06 (0.04)			-0.05 (0.06)	-0.08 (0.04)*
British Columbia			-0.14 (0.06)**	-0.03 (0.03)			-0.04 (0.07)	-0.01 (0.03)
Manitoba			-0.06 (0.10)	-0.17 (0.06)***			0.03 (0.11)	-0.17 (0.04)***
Saskatchewan			-0.31 (0.10)***	-0.25 (0.05)***			-0.01 (0.09)	0.00 (0.07)
Year01	-0.09 (0.06)	-0.04 (0.03)	-0.12 (0.06)*	-0.07 (0.03)**	-0.18 (0.07)**	0.05 (0.04)	-0.24 (0.06)***	-0.01 (0.03)
Year03	-0.20 (0.08)**	-0.11 (0.05)**	-0.19 (0.08)**	-0.08 (0.03)***	-0.15 (0.07)**	0.13 (0.05)***	-0.24 (0.06)***	0.05 (0.04)
Year05	-0.10 (0.06)	-0.07 (0.03)**	-0.08 (0.07)	-0.05 (0.03)*	-0.16 (0.07)**	0.09 (0.04)**	-0.25 (0.06)***	0.01 (0.04)
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference in attendance rate parameters	0.06 (0.11)		0.05 (0.12)		0.01 (0.35)		0.05 (0.32)	
Difference in attendance rate parameters with team								
Difference in team parameters	0.26 (0.18)		0.19 (0.13)		0.11 (0.10)		0.12 (0.07)*	

Table D.6. Parameter estimates using complete models for small firms and large firms

	NLS (small firms)				NLS (large firms)			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.56 (0.15)***	9.51 (0.09)***	11.09 (0.27)***	10.56 (0.17)***	9.36 (0.19)***	8.93 (0.14)***	10.36 (0.25)***	10.25 (0.17)***
Log (employment)	0.87 (0.03)***	1.04 (0.02)***	0.88 (0.03)***	1.07 (0.02)***	1.07 (0.02)***	1.01 (0.02)***	1.10 (0.02)***	1.03 (0.02)***
Log (stock)	0.03 (0.01)***	0.04 (0.01)***	0.00 (0.02)	-0.03 (0.01)***	0.09 (0.01)***	0.08 (0.01)***	0.00 (0.01)	-0.01 (0.01)
Attendance rate with no team	0.39 (0.14)***	0.36 (0.08)***	0.47 (0.14)***	0.44 (0.06)***	1.95 (0.80)**	1.66 (0.58)***	1.32 (0.70)*	1.08 (0.47)**
Attendance rate with team	6.34 (2.25)***	3.01 (1.03)***	4.97 (1.87)***	2.25 (0.95)**	-0.57 (0.76)	-0.02 (0.70)	-0.76 (0.73)	-0.33 (0.64)
Team	0.75 (0.27)***	0.35 (0.10)***	0.33 (0.18)*	0.06 (0.06)	0.71 (0.15)***	0.63 (0.12)***	0.19 (0.10)*	0.09 (0.07)
$35 \leq$ Age < 55			0.28 (0.09)***	0.24 (0.04)***			0.45 (0.11)***	0.40 (0.09)***
$55 \leq$ Age			-0.06 (0.18)	0.16 (0.06)***			0.44 (0.17)***	0.40 (0.10)***
Female			-0.25 (0.07)***	-0.24 (0.03)***			-0.27 (0.05)***	-0.33 (0.04)***
> a bachelor’s degree			0.25 (0.14)*	0.30 (0.08)***			0.16 (0.18)	0.46 (0.13)***
Managers/professionals			0.62 (0.18)***	0.75 (0.12)***			1.32 (0.26)***	1.55 (0.22)***
Technical/sales/clerical			0.67 (0.17)***	0.37 (0.08)***			0.97 (0.13)***	0.66 (0.10)***
Others			-0.15 (0.11)	-0.06 (0.07)			-0.17 (0.08)**	-0.05 (0.08)
Minorities			-0.01 (0.09)	-0.05 (0.05)			0.06 (0.09)	-0.03 (0.05)
Immigrants			-0.04 (0.09)	-0.08 (0.04)*			-0.11 (0.09)	0.08 (0.07)
Bargaining agreement			0.45 (0.29)	0.19 (0.10)**			0.06 (0.06)	0.12 (0.04)***
International market			0.47 (0.11)***	0.17 (0.03)***			-0.04 (0.05)	-0.02 (0.06)
Foreign owned			0.74 (0.13)***	0.32 (0.06)***			0.20 (0.06)***	0.03 (0.06)
Labour tertiary manufacturing			-0.52 (0.08)***	-0.35 (0.05)***			-0.15 (0.12)	-0.28 (0.05)***
Primary product manufacturing			-0.41 (0.08)***	-0.25 (0.05)***			-0.06 (0.11)	-0.09 (0.05)*
Secondary product manufacturing			-0.22 (0.09)**	-0.09 (0.05)*			-0.14 (0.11)	-0.21 (0.06)***
Capital tertiary manufacturing			-0.29 (0.10)***	-0.16 (0.05)***			-0.14 (0.11)	-0.17 (0.05)***
Construction			-0.43 (0.14)***	-0.18 (0.05)***			-0.29 (0.10)***	-0.23 (0.06)***
Transportation			-0.12 (0.09)	-0.13 (0.05)***			-0.13 (0.11)	-0.22 (0.06)***
Communication			-0.49 (0.08)***	-0.26 (0.05)***			-0.31 (0.11)***	-0.31 (0.05)***
Retail trade			-0.73 (0.10)***	-0.79 (0.06)***			-0.67 (0.10)***	-0.82 (0.06)***

	NLS (small firms)				NLS (large firms)			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Finance			-0.03 (0.11)	-0.14 (0.05)**			-0.01 (0.12)	-0.17 (0.06)***
Real estate			-0.44 (0.12)***	-0.45 (0.05)***			-0.13 (0.13)	-0.20 (0.09)**
Business services			-0.35 (0.11)***	-0.33 (0.06)***			-0.36 (0.13)***	-0.35 (0.06)***
Education			-0.21 (0.12)*	-0.46 (0.07)***			-0.65 (0.12)***	-0.66 (0.07)***
Information			-0.62 (0.14)***	-0.30 (0.06)***			-0.47 (0.12)***	-0.36 (0.07)***
Atlantic			-0.17 (0.11)	-0.16 (0.05)***			0.01 (0.09)	-0.12 (0.05)**
Quebec			-0.16 (0.07)**	-0.20 (0.03)***			-0.12 (0.07)*	-0.15 (0.05)***
Alberta			-0.08 (0.07)	-0.06 (0.04)			-0.05 (0.06)	-0.08 (0.04)*
British Columbia			-0.14 (0.06)**	-0.03 (0.03)			-0.04 (0.07)	-0.01 (0.03)
Manitoba			-0.06 (0.10)	-0.17 (0.06)***			0.03 (0.11)	-0.17 (0.04)***
Saskatchewan			-0.31 (0.10)***	-0.25 (0.05)***			-0.01 (0.09)	0.00 (0.07)
Year01	-0.09 (0.06)	-0.04 (0.03)	-0.11 (0.06)*	-0.07 (0.03)**	-0.18 (0.07)**	0.05 (0.04)	-0.24 (0.06)***	-0.01 (0.03)
Year03	-0.20 (0.08)**	-0.11 (0.05)**	-0.19 (0.08)**	-0.08 (0.03)**	-0.16 (0.07)**	0.13 (0.05)***	-0.24 (0.06)***	0.05 (0.04)
Year05	-0.10 (0.06)	-0.07 (0.03)**	-0.08 (0.07)	-0.05 (0.03)	-0.17 (0.07)**	0.09 (0.04)**	-0.26 (0.06)***	0.01 (0.04)
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference in attendance rate parameters with no team	0.04 (0.11)		0.03 (0.12)		0.29 (0.36)		0.24 (0.37)	
Difference in attendance rate parameters with team	3.33 (1.59)**		2.72 (1.49)*		-0.55 (0.70)		-0.43 (0.72)	
Difference in team parameters	0.40 (0.21)*		0.27 (0.16)*		0.08 (0.10)		0.10 (0.07)	

D.2 Specification II

D.2.1 Full sample: Cobb-Douglas production function

Table D.7. Parameter estimates using restricted models for all workplaces

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.34 (0.12)***	9.41 (0.07)***	10.98 (0.21)***	10.47 (0.13)***				
Log (employment)	0.94 (0.02)***	1.04 (0.01)***	0.95 (0.02)***	1.08 (0.01)***	0.60 (0.08)***	0.69 (0.04)***	0.61 (0.08)***	0.70 (0.04)***
Log (stock)	0.04 (0.01)***	0.05 (0.01)***	0.00 (0.01)	-0.03 (0.01)***	-0.03 (0.03)	0.00 (0.01)	-0.03 (0.03)	-0.01 (0.01)
Absence rate	-0.83 (0.33)**	-0.77 (0.20)***	-0.90 (0.35)**	-0.91 (0.18)***	-0.52 (0.56)	-0.09 (0.14)	-0.55 (0.53)	-0.09 (0.14)
Team	0.66 (0.19)***	0.40 (0.08)***	0.26 (0.11)**	0.08 (0.05)	0.08 (0.14)	-0.01 (0.04)	0.08 (0.15)	-0.01 (0.04)
35 ≤ Age < 55			0.27 (0.08)***	0.25 (0.04)***			0.01 (0.09)	0.05 (0.03)*
55≤ Age			-0.01 (0.17)	0.18 (0.06)***			-0.06 (0.23)	0.00 (0.04)
Female			-0.24 (0.06)***	-0.25 (0.02)***			0.08 (0.18)	-0.02 (0.04)
> a bachelor's degree			0.26 (0.12)**	0.32 (0.08)***			-0.20 (0.12)*	0.05 (0.06)
Managers/professionals			0.61 (0.15)***	0.80 (0.11)***			0.20 (0.24)	0.09 (0.07)
Technical/sales/clerical			0.68 (0.13)***	0.42 (0.07)***			0.08 (0.14)	0.02 (0.04)
Others			-0.13 (0.09)	-0.05 (0.06)			-0.01 (0.23)	0.08 (0.06)
Minorities			0.00 (0.08)	-0.05 (0.04)			0.05 (0.16)	-0.02 (0.03)
Immigrants			-0.03 (0.08)	-0.06 (0.04)			0.17 (0.24)	0.00 (0.04)
Bargaining agreement			0.33 (0.14)**	0.16 (0.05)***			0.08 (0.34)	-0.02 (0.06)
International market			0.37 (0.08)***	0.12 (0.03)***				
Foreign owned			0.57 (0.09)***	0.22 (0.04)***				
Labour tertiary manufacturing			-0.45 (0.07)***	-0.33 (0.04)***				
Primary product manufacturing			-0.29 (0.07)***	-0.17 (0.04)***				
Secondary product manufacturing			-0.24 (0.07)***	-0.13 (0.04)***				
Capital tertiary manufacturing			-0.28 (0.09)***	-0.15 (0.04)***				

	NLS				First differences			
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
Construction			-0.42 (0.12)***	-0.18 (0.05)***				
Transportation			-0.13 (0.07)*	-0.14 (0.04)***				
Communication			-0.43 (0.07)***	-0.25 (0.04)***				
Retail trade			-0.74 (0.09)***	-0.80 (0.05)***				
Finance			-0.02 (0.09)	-0.12 (0.05)***				
Real estate			-0.43 (0.11)***	-0.45 (0.05)***				
Business services			-0.35 (0.09)***	-0.33 (0.05)***				
Education			-0.24 (0.10)**	-0.46 (0.06)***				
Information			-0.58 (0.11)***	-0.31 (0.05)***				
Atlantic			-0.14 (0.10)	-0.15 (0.04)***				
Quebec			-0.14 (0.06)**	-0.19 (0.03)***				
Alberta			-0.07 (0.06)	-0.06 (0.03)**				
British Columbia			-0.12 (0.06)**	-0.03 (0.03)				
Manitoba			-0.04 (0.09)	-0.17 (0.05)***				
Saskatchewan			-0.27 (0.09)***	-0.22 (0.04)***				
Year01	-0.11 (0.06)*	-0.03 (0.03)	-0.14 (0.05)**	-0.07 (0.03)**				
Year03	-0.20 (0.07)***	-0.08 (0.04)**	-0.19 (0.07)***	-0.06 (0.03)**	0.02 (0.04)	0.04 (0.02)**	0.02 (0.04)	0.04 (0.02)**
Year05	-0.11 (0.06)**	-0.05 (0.03)*	-0.10 (0.06)*	-0.04 (0.03)	0.07 (0.03)**	0.05 (0.02)***	0.07 (0.03)**	0.05 (0.02)***
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference in absence rate parameters	-0.06 (0.26)		0.01 (0.27)		-0.43 (0.50)		-0.46 (0.48)	
Difference in absence rate parameters with team								
Difference in team parameters	0.26 (0.14)*		0.18 (0.09)**		0.09 (0.13)		0.09 (0.14)	

Table D.8. Parameter estimates using complete models for all workplaces

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.34 (0.12)***	9.41 (0.07)***	10.98 (0.21)***	10.47 (0.13)***				
Log (employment)	0.94 (0.02)***	1.04 (0.01)***	0.95 (0.02)***	1.08 (0.01)***	0.60 (0.08)***	0.69 (0.04)***	0.61 (0.08)***	0.70 (0.04)***
Log (stock)	0.04 (0.01)***	0.05 (0.01)***	0.00 (0.01)	-0.03 (0.01)***	-0.03 (0.03)	0.00 (0.01)	-0.03 (0.03)	-0.01 (0.01)
Absence rate with no team	-0.72 (0.36)**	-0.71 (0.23)***	-0.82 (0.38)**	-0.89 (0.19)***	-0.32 (0.55)	-0.02 (0.15)	-0.34 (0.52)	-0.03 (0.15)
Absence rate with team	-2.82 (1.61)*	-1.84 (0.94)**	-2.30 (1.52)	-1.28 (0.83)	-2.93 (2.43)	-0.81 (0.70)	-3.05 (2.10)	-0.81 (0.71)
Team	0.73 (0.18)***	0.44 (0.08)***	0.30 (0.13)**	0.09 (0.05)*	0.13 (0.17)	0.00 (0.04)	0.14 (0.18)	0.00 (0.04)
35 ≤ Age < 55			0.28 (0.08)***	0.25 (0.04)***			0.01 (0.09)	0.05 (0.03)*
55≤ Age			-0.01 (0.17)	0.18 (0.06)***			-0.06 (0.23)	0.00 (0.04)
Female			-0.24 (0.06)***	-0.25 (0.02)***			0.08 (0.17)	-0.02 (0.04)
> a bachelor’s degree			0.26 (0.12)**	0.32 (0.08)***			-0.20 (0.12)*	0.05 (0.06)
Managers/professionals			0.61 (0.15)***	0.80 (0.11)***			0.20 (0.24)	0.10 (0.07)
Technical/sales/clerical			0.68 (0.13)***	0.42 (0.07)***			0.08 (0.15)	0.02 (0.04)
Others			-0.13 (0.09)	-0.05 (0.06)			-0.02 (0.23)	0.08 (0.06)
Minorities			0.00 (0.08)	-0.05 (0.04)			0.05 (0.15)	-0.02 (0.03)
Immigrants			-0.03 (0.08)	-0.06 (0.04)			0.17 (0.24)	0.00 (0.04)
Bargaining agreement			0.33 (0.14)**	0.16 (0.05)***			0.08 (0.34)	-0.02 (0.06)
International market			0.37 (0.08)***	0.12 (0.03)***				
Foreign owned			0.57 (0.09)***	0.22 (0.04)***				
Labour tertiary manufacturing			-0.45 (0.07)***	-0.33 (0.04)***				
Primary product manufacturing			-0.29 (0.07)***	-0.18 (0.04)***				
Secondary product manufacturing			-0.24 (0.07)***	-0.13 (0.04)***				
Capital tertiary manufacturing			-0.28 (0.09)***	-0.15 (0.04)***				
Construction			-0.43 (0.12)***	-0.18 (0.05)***				
Transportation			-0.14 (0.07)*	-0.14 (0.04)***				
Communication			-0.43 (0.07)***	-0.25 (0.04)***				
Retail trade			-0.74 (0.09)***	-0.80 (0.05)***				

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Finance			-0.02 (0.09)	-0.12 (0.05)***				
Real estate			-0.43 (0.11)***	-0.45 (0.05)***				
Business services			-0.35 (0.09)***	-0.33 (0.05)***				
Education			-0.24 (0.10)**	-0.46 (0.06)***				
Information			-0.58 (0.11)***	-0.31 (0.05)***				
Atlantic			-0.14 (0.10)	-0.15 (0.04)***				
Quebec			-0.14 (0.06)**	-0.19 (0.03)***				
Alberta			-0.07 (0.06)	-0.06 (0.03)**				
British Columbia			-0.12 (0.06)**	-0.03 (0.03)				
Manitoba			-0.04 (0.09)	-0.17 (0.05)***				
Saskatchewan			-0.27 (0.09)***	-0.22 (0.04)***				
Year01	-0.11 (0.06)*	-0.03 (0.03)	-0.14 (0.05)**	-0.07 (0.03)**				
Year03	-0.20 (0.07)***	-0.08 (0.04)**	-0.19 (0.07)***	-0.06 (0.03)**	0.02 (0.04)	0.04 (0.02)**	0.02 (0.04)	0.04 (0.02)**
Year05	-0.11 (0.06)**	-0.05 (0.03)*	-0.10 (0.06)*	-0.04 (0.03)	0.07 (0.03)**	0.05 (0.02)***	0.07 (0.03)**	0.06 (0.02)***
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference in absence rate parameters with no team	0.00 (0.27)		0.07 (0.29)		-0.30 (0.51)		-0.31 (0.48)	
Difference in absence rate parameters with team	-0.98 (1.04)		-1.02 (1.08)		-2.12 (2.19)		-2.23 (1.87)	
Difference in team parameters	0.30 (0.13)**		0.21 (0.10)**		0.13 (0.16)		0.14 (0.17)	

D.2.2 Full sample: Translog production function

Table D.9. Parameter estimates using restricted models

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	13.13 (0.53)***	9.41 (0.07)***	13.53 (0.82)***	10.47 (0.13)***				
Log (employment)	0.74 (0.07)***	1.04 (0.01)***	0.79 (0.08)***	1.08 (0.01)***	0.87 (0.28)***	0.69 (0.04)***	0.90 (0.29)***	0.70 (0.04)***
Log (stock)	-0.38 (0.09)***	0.05 (0.01)***	-0.38 (0.12)***	-0.03 (0.01)***	-0.24 (0.24)	0.00 (0.01)	-0.24 (0.24)	-0.01 (0.01)
Absence rate	-1.03 (0.37)***	-0.77 (0.20)***	-1.03 (0.39)***	-0.91 (0.18)***	-0.53 (0.57)	-0.09 (0.14)	-0.57 (0.54)	-0.09 (0.14)
Team	0.73 (0.23)***	0.40 (0.08)***	0.25 (0.14)*	0.08 (0.05)	0.03 (0.09)	-0.01 (0.04)	0.03 (0.09)	-0.01 (0.04)
35 ≤ Age < 55			0.32 (0.11)***	0.25 (0.04)***			0.01 (0.06)	0.05 (0.03)*
55≤ Age			-0.04 (0.21)	0.18 (0.06)***			-0.03 (0.15)	0.00 (0.04)
Female			-0.30 (0.07)***	-0.25 (0.02)***			0.04 (0.11)	-0.02 (0.04)
> a bachelor's degree			0.29 (0.15)*	0.32 (0.08)***			-0.16 (0.09)*	0.05 (0.06)
Managers/professionals			0.81 (0.24)***	0.80 (0.11)***			0.14 (0.16)	0.09 (0.07)
Technical/sales/clerical			0.86 (0.21)***	0.42 (0.07)***			0.06 (0.09)	0.02 (0.04)
Others			-0.16 (0.11)	-0.05 (0.06)			-0.01 (0.15)	0.08 (0.06)
Minorities			0.00 (0.09)	-0.05 (0.04)			0.04 (0.10)	-0.02 (0.03)
Immigrants			-0.04 (0.10)	-0.06 (0.04)			0.11 (0.16)	0.00 (0.04)
Bargaining agreement			0.29 (0.17)*	0.16 (0.05)***			0.06 (0.22)	-0.02 (0.06)
International market			0.34 (0.08)***	0.13 (0.03)***				
Foreign owned			0.54 (0.09)***	0.22 (0.04)***				
Labour tertiary manufacturing			-0.39 (0.07)***	-0.32 (0.04)***				
Primary product manufacturing			-0.30 (0.07)***	-0.17 (0.04)***				
Secondary product manufacturing			-0.19 (0.07)***	-0.13 (0.04)***				
Capital tertiary manufacturing			-0.22 (0.09)**	-0.15 (0.04)***				
Construction			-0.35 (0.12)***	-0.18 (0.05)***				
Transportation			-0.06 (0.07)	-0.14 (0.04)***				

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Communication			-0.42 (0.07)***	-0.25 (0.04)***				
Retail trade			-0.68 (0.08)***	-0.80 (0.05)***				
Finance			0.05 (0.09)	-0.12 (0.05)***				
Real estate			-0.40 (0.11)***	-0.45 (0.05)***				
Business services			-0.34 (0.09)***	-0.33 (0.05)***				
Education			-0.31 (0.11)***	-0.46 (0.06)***				
Information			-0.57 (0.11)***	-0.31 (0.05)***				
Atlantic			-0.14 (0.10)	-0.15 (0.04)***				
Quebec			-0.13 (0.06)**	-0.19 (0.03)***				
Alberta			-0.07 (0.06)	-0.06 (0.03)**				
British Columbia			-0.12 (0.05)**	-0.03 (0.03)				
Manitoba			-0.05 (0.09)	-0.17 (0.05)***				
Saskatchewan			-0.27 (0.09)***	-0.22 (0.04)***				
Year01	-0.10 (0.06)*	-0.03 (0.03)	-0.13 (0.06)**	-0.07 (0.03)**				
Year03	-0.19 (0.07)***	-0.08 (0.04)**	-0.18 (0.07)***	-0.06 (0.03)**	0.02 (0.04)	0.04 (0.02)**	0.02 (0.04)	0.04 (0.02)**
Year05	-0.10 (0.06)*	-0.05 (0.03)*	-0.08 (0.06)	-0.04 (0.03)	0.07 (0.03)**	0.05 (0.02)***	0.08 (0.03)**	0.05 (0.02)***
LnL*LnL	0.04 (0.01)***		0.04 (0.01)***		0.05 (0.04)		0.05 (0.03)	
LnK*LnK	0.02 (0.00)***		0.01 (0.00)***		0.01 (0.01)		0.01 (0.01)	
LnL*LnK	0.00 (0.01)		0.00 (0.01)		-0.04 (0.02)**		-0.04 (0.02)**	
Difference in absence rate parameters	-0.26 (0.29)		-0.12 (0.30)		-0.45 (0.52)		-0.48 (0.50)	
Difference in absence rate parameters with team								
Difference in team parameters	0.33 (0.18)*		0.18 (0.11)		0.04 (0.08)		0.04 (0.08)	

Table D.10. Parameter estimates using complete models

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	13.13 (0.53)***	9.41 (0.07)***	13.53 (0.82)***	10.47 (0.13)***				
Log (employment)	0.75 (0.07)***	1.04 (0.01)***	0.80 (0.08)***	1.08 (0.01)***	0.86 (0.28)***	0.69 (0.04)***	0.89 (0.29)***	0.70 (0.04)***
Log (stock)	-0.38 (0.09)***	0.05 (0.01)***	-0.38 (0.12)***	-0.03 (0.01)***	-0.24 (0.24)	0.00 (0.01)	-0.24 (0.24)	-0.01 (0.01)
Absence rate with no team	-0.89 (0.41)**	-0.71 (0.23)***	-0.95 (0.43)**	-0.89 (0.19)***	-0.35 (0.56)	-0.03 (0.15)	-0.39 (0.53)	-0.03 (0.15)
Absence rate with team	-2.70 (1.40)*	-1.82 (0.92)**	-2.13 (1.36)	-1.27 (0.83)	-2.00 (1.94)	-0.79 (0.69)	-2.10 (1.92)	-0.79 (0.69)
Team	0.55 (0.15)***	0.43 (0.08)***	0.22 (0.11)**	0.09 (0.05)*	0.07 (0.13)	0.00 (0.04)	0.07 (0.13)	0.00 (0.04)
35 ≤ Age < 55			0.32 (0.10)***	0.25 (0.04)***			0.01 (0.06)	0.05 (0.03)*
55≤ Age			-0.04 (0.21)	0.18 (0.06)***			-0.03 (0.15)	0.00 (0.04)
Female			-0.30 (0.07)***	-0.25 (0.02)***			0.04 (0.11)	-0.02 (0.04)
> a bachelor’s degree			0.28 (0.15)*	0.32 (0.08)***			-0.16 (0.09)*	0.05 (0.06)
Managers/professionals			0.80 (0.23)***	0.80 (0.11)***			0.14 (0.16)	0.10 (0.07)
Technical/sales/clerical			0.86 (0.20)***	0.42 (0.07)***			0.06 (0.09)	0.02 (0.04)
Others			-0.16 (0.11)	-0.05 (0.06)			-0.01 (0.15)	0.08 (0.06)
Minorities			0.00 (0.09)	-0.05 (0.04)			0.04 (0.10)	-0.02 (0.03)
Immigrants			-0.04 (0.09)	-0.06 (0.04)			0.11 (0.16)	0.00 (0.04)
Bargaining agreement			0.29 (0.17)*	0.16 (0.05)***			0.06 (0.23)	-0.02 (0.06)
International market			0.34 (0.08)***	0.13 (0.03)***				
Foreign owned			0.54 (0.09)***	0.22 (0.04)***				
Labour tertiary manufacturing			-0.39 (0.07)***	-0.33 (0.04)***				
Primary product manufacturing			-0.31 (0.07)***	-0.18 (0.04)***				
Secondary product manufacturing			-0.19 (0.07)***	-0.13 (0.04)***				
Capital tertiary manufacturing			-0.22 (0.09)**	-0.15 (0.04)***				
Construction			-0.35 (0.12)***	-0.18 (0.05)***				
Transportation			-0.06 (0.07)	-0.14 (0.04)***				
Communication			-0.42 (0.07)***	-0.25 (0.04)***				
Retail trade			-0.68 (0.08)***	-0.80 (0.05)***				

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Finance			0.05 (0.09)	-0.12 (0.05)***				
Real estate			-0.40 (0.11)***	-0.45 (0.05)***				
Business services			-0.34 (0.09)***	-0.33 (0.05)***				
Education			-0.31 (0.11)***	-0.46 (0.06)***				
Information			-0.57 (0.11)***	-0.31 (0.05)***				
Atlantic			-0.14 (0.10)	-0.15 (0.04)***				
Quebec			-0.13 (0.06)**	-0.19 (0.03)***				
Alberta			-0.07 (0.06)	-0.06 (0.03)**				
British Columbia			-0.12 (0.05)**	-0.03 (0.03)				
Manitoba			-0.05 (0.09)	-0.17 (0.05)***				
Saskatchewan			-0.27 (0.09)***	-0.22 (0.04)***				
Year01	-0.10 (0.06)*	-0.03 (0.03)	-0.13 (0.06)**	-0.07 (0.03)**				
Year03	-0.19 (0.07)***	-0.08 (0.04)**	-0.18 (0.07)***	-0.06 (0.03)**	0.02 (0.04)	0.04 (0.02)**	0.02 (0.04)	0.04 (0.02)**
Year05	-0.10 (0.06)*	-0.05 (0.03)*	-0.08 (0.06)	-0.04 (0.03)	0.08 (0.03)**	0.05 (0.02)***	0.08 (0.03)**	0.06 (0.02)***
LnL*LnL	0.04 (0.01)***		0.04 (0.01)***		0.05 (0.04)		0.05 (0.03)	
LnK*LnK	0.02 (0.00)***		0.01 (0.00)***		0.01 (0.01)		0.01 (0.01)	
LnL*LnK	0.00 (0.01)		0.00 (0.01)		-0.04 (0.02)**		-0.04 (0.02)**	
Difference in absence rate parameters with no team	-0.18 (0.31)		-0.06 (0.33)		-0.33 (0.53)		-0.36 (0.51)	
Difference in absence rate parameters with team	-0.89 (0.88)		-0.86 (0.94)		-1.21 (1.72)		-1.31 (1.71)	
Difference in team parameters	0.12 (0.10)		0.13 (0.08)		0.06 (0.12)		0.07 (0.12)	

D.2.3 Sub-samples: Cobb-Douglas production function

Table D.11. Parameter estimates using restricted models for small firms and large firms

	NLS (small firms)				NLS (large firms)			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.56 (0.15)***	9.52 (0.09)***	11.09 (0.27)***	10.57 (0.17)***	9.33 (0.19)***	8.92 (0.14)***	10.35 (0.25)***	10.25 (0.17)***
Log (employment)	0.87 (0.03)***	1.04 (0.02)***	0.88 (0.03)***	1.07 (0.02)***	1.08 (0.02)***	1.02 (0.02)***	1.10 (0.02)***	1.03 (0.02)***
Log (stock)	0.03 (0.01)***	0.04 (0.01)***	0.00 (0.02)	-0.03 (0.01)***	0.09 (0.01)***	0.08 (0.01)***	0.00 (0.01)	-0.01 (0.01)
Absence rate	-0.85 (0.39)**	-0.69 (0.23)***	-0.98 (0.42)**	-0.90 (0.19)***	-1.46 (0.69)**	-1.50 (0.49)***	-0.95 (0.62)	-0.95 (0.40)**
Team	0.53 (0.23)**	0.27 (0.09)***	0.21 (0.15)	0.02 (0.05)	0.82 (0.14)***	0.70 (0.11)***	0.25 (0.09)***	0.13 (0.07)*
$35 \leq$ Age < 55			0.27 (0.09)***	0.24 (0.04)***			0.45 (0.11)***	0.40 (0.09)***
$55 \leq$ Age			-0.06 (0.18)	0.16 (0.06)***			0.43 (0.17)***	0.39 (0.10)***
Female			-0.25 (0.07)***	-0.24 (0.03)***			-0.27 (0.05)***	-0.33 (0.04)***
> a bachelor's degree			0.26 (0.14)*	0.30 (0.08)***			0.15 (0.18)	0.46 (0.13)***
Managers/professionals			0.62 (0.18)***	0.75 (0.12)***			1.31 (0.26)***	1.54 (0.22)***
Technical/sales/clerical			0.67 (0.17)***	0.37 (0.08)***			0.97 (0.13)***	0.66 (0.10)***
Others			-0.15 (0.11)	-0.06 (0.07)			-0.17 (0.08)**	-0.05 (0.08)
Minorities			-0.01 (0.09)	-0.05 (0.05)			0.06 (0.09)	-0.04 (0.05)
Immigrants			-0.04 (0.09)	-0.08 (0.04)*			-0.10 (0.09)	0.08 (0.07)
Bargaining agreement			0.45 (0.29)	0.20 (0.10)**			0.07 (0.06)	0.13 (0.04)***
International market			0.47 (0.11)***	0.17 (0.03)***			-0.03 (0.05)	-0.02 (0.06)
Foreign owned			0.74 (0.13)***	0.32 (0.06)***			0.20 (0.06)***	0.03 (0.06)
Labour tertiary manufacturing			-0.51 (0.08)***	-0.35 (0.05)***			-0.16 (0.12)	-0.29 (0.05)***
Primary product manufacturing			-0.41 (0.09)***	-0.25 (0.05)***			-0.07 (0.11)	-0.10 (0.05)*
Secondary product manufacturing			-0.22 (0.09)**	-0.09 (0.05)*			-0.15 (0.11)	-0.22 (0.06)***
Capital tertiary manufacturing			-0.29 (0.10)***	-0.16 (0.05)***			-0.16 (0.11)	-0.18 (0.05)***
Construction			-0.43 (0.14)***	-0.18 (0.05)***			-0.30 (0.10)***	-0.23 (0.06)***
Transportation			-0.11 (0.09)	-0.13 (0.05)***			-0.14 (0.11)	-0.22 (0.06)***

	NLS (small firms)				NLS (large firms)			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Communication			-0.48 (0.08)***	-0.26 (0.05)***			-0.31 (0.11)***	-0.31 (0.05)***
Retail trade			-0.72 (0.10)***	-0.79 (0.06)***			-0.68 (0.10)***	-0.82 (0.06)***
Finance			-0.02 (0.11)	-0.13 (0.05)**			-0.01 (0.12)	-0.17 (0.06)***
Real estate			-0.44 (0.12)***	-0.45 (0.05)***			-0.14 (0.13)	-0.20 (0.09)**
Business services			-0.34 (0.11)***	-0.33 (0.06)***			-0.37 (0.13)***	-0.35 (0.06)***
Education			-0.20 (0.12)*	-0.45 (0.07)***			-0.66 (0.12)***	-0.66 (0.07)***
Information			-0.62 (0.14)***	-0.30 (0.06)***			-0.48 (0.12)***	-0.36 (0.07)***
Atlantic			-0.17 (0.11)	-0.16 (0.05)***			0.01 (0.09)	-0.12 (0.05)**
Quebec			-0.16 (0.07)**	-0.20 (0.03)***			-0.12 (0.07)*	-0.15 (0.05)***
Alberta			-0.08 (0.07)	-0.06 (0.04)			-0.05 (0.06)	-0.08 (0.04)*
British Columbia			-0.14 (0.06)**	-0.03 (0.03)			-0.04 (0.07)	-0.01 (0.03)
Manitoba			-0.06 (0.10)	-0.17 (0.06)***			0.03 (0.11)	-0.17 (0.04)***
Saskatchewan			-0.31 (0.10)***	-0.25 (0.05)***			-0.01 (0.09)	0.00 (0.07)
Year01	-0.09 (0.06)	-0.04 (0.03)	-0.12 (0.06)*	-0.07 (0.03)**	-0.18 (0.07)**	0.05 (0.04)	-0.24 (0.06)***	-0.01 (0.03)
Year03	-0.20 (0.08)**	-0.11 (0.05)**	-0.19 (0.08)**	-0.08 (0.03)**	-0.15 (0.07)**	0.13 (0.05)***	-0.23 (0.06)***	0.05 (0.04)
Year05	-0.10 (0.06)	-0.07 (0.03)**	-0.08 (0.07)	-0.05 (0.03)*	-0.16 (0.07)**	0.09 (0.04)**	-0.25 (0.06)***	0.01 (0.04)
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference in absence rate parameters	-0.16 (0.30)		-0.08 (0.33)		0.04 (0.43)		0.00 (0.40)	
Difference in absence rate parameters with team								
Difference in team parameters	0.26 (0.18)		0.19 (0.13)		0.11 (0.10)		0.12 (0.07)*	

Table D.12. Parameter estimates using complete models for small firms and large firms

	NLS (small firms)				NLS (large firms)			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.56 (0.15)***	9.52 (0.09)***	11.10 (0.27)***	10.57 (0.17)***	9.38 (0.19)***	8.95 (0.14)***	10.37 (0.25)***	10.26 (0.17)***
Log (employment)	0.87 (0.03)***	1.04 (0.02)***	0.88 (0.03)***	1.07 (0.02)***	1.07 (0.02)***	1.01 (0.02)***	1.10 (0.02)***	1.03 (0.02)***
Log (stock)	0.03 (0.01)***	0.04 (0.01)***	0.00 (0.02)	-0.03 (0.01)***	0.09 (0.01)***	0.08 (0.01)***	0.00 (0.01)	-0.01 (0.01)
Absence rate with no team	-0.69 (0.42)*	-0.62 (0.25)**	-0.88 (0.44)**	-0.87 (0.20)***	-2.60 (0.98)***	-2.28 (0.67)***	-1.71 (0.89)*	-1.46 (0.54)***
Absence rate with team	-6.67 (2.44)***	-3.15 (1.12)***	-5.03 (2.05)**	-2.18 (1.07)**	0.89 (0.90)	0.24 (0.79)	1.04 (0.89)	0.54 (0.74)
Team	0.74 (0.27)***	0.34 (0.10)***	0.32 (0.19)*	0.05 (0.06)	0.67 (0.15)***	0.60 (0.12)***	0.17 (0.10)*	0.07 (0.07)
35 ≤ Age < 55			0.27 (0.09)***	0.24 (0.04)***			0.45 (0.11)***	0.40 (0.09)***
55≤ Age			-0.06 (0.18)	0.16 (0.06)***			0.44 (0.17)***	0.40 (0.10)***
Female			-0.25 (0.07)***	-0.24 (0.03)***			-0.27 (0.05)***	-0.33 (0.04)***
> a bachelor’s degree			0.26 (0.14)*	0.30 (0.08)***			0.16 (0.18)	0.46 (0.13)***
Managers/professionals			0.62 (0.18)***	0.75 (0.12)***			1.32 (0.26)***	1.55 (0.22)***
Technical/sales/clerical			0.67 (0.17)***	0.37 (0.08)***			0.97 (0.13)***	0.66 (0.10)***
Others			-0.15 (0.11)	-0.06 (0.07)			-0.17 (0.08)**	-0.05 (0.08)
Minorities			0.00 (0.09)	-0.05 (0.05)			0.06 (0.09)	-0.03 (0.05)
Immigrants			-0.04 (0.09)	-0.08 (0.04)*			-0.11 (0.09)	0.07 (0.07)
Bargaining agreement			0.45 (0.29)	0.20 (0.10)**			0.07 (0.06)	0.12 (0.04)***
International market			0.47 (0.11)***	0.17 (0.03)***			-0.04 (0.05)	-0.02 (0.06)
Foreign owned			0.74 (0.13)***	0.32 (0.06)***			0.20 (0.06)***	0.03 (0.06)
Labour tertiary manufacturing			-0.52 (0.08)***	-0.35 (0.05)***			-0.15 (0.12)	-0.28 (0.05)***
Primary product manufacturing			-0.41 (0.08)***	-0.26 (0.05)***			-0.06 (0.11)	-0.09 (0.05)*
Secondary product manufacturing			-0.23 (0.09)**	-0.09 (0.05)*			-0.14 (0.10)	-0.21 (0.06)***
Capital tertiary manufacturing			-0.29 (0.10)***	-0.16 (0.05)***			-0.14 (0.11)	-0.17 (0.05)***
Construction			-0.43 (0.14)***	-0.18 (0.05)***			-0.29 (0.10)***	-0.22 (0.06)***
Transportation			-0.12 (0.09)	-0.13 (0.05)***			-0.13 (0.11)	-0.22 (0.06)***
Communication			-0.49 (0.08)***	-0.26 (0.05)***			-0.31 (0.11)***	-0.31 (0.05)***
Retail trade			-0.73 (0.10)***	-0.79 (0.06)***			-0.67 (0.10)***	-0.81 (0.06)***

	NLS (small firms)				NLS (large firms)			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Finance			-0.03 (0.11)	-0.13 (0.05)**			0.00 (0.12)	-0.16 (0.06)***
Real estate			-0.45 (0.12)***	-0.46 (0.05)***			-0.13 (0.13)	-0.20 (0.09)**
Business services			-0.35 (0.11)***	-0.33 (0.06)***			-0.36 (0.13)***	-0.34 (0.06)***
Education			-0.21 (0.12)*	-0.46 (0.07)***			-0.65 (0.12)***	-0.66 (0.07)***
Information			-0.62 (0.14)***	-0.30 (0.06)***			-0.47 (0.12)***	-0.35 (0.07)***
Atlantic			-0.17 (0.11)	-0.16 (0.05)***			0.01 (0.09)	-0.12 (0.05)**
Quebec			-0.16 (0.07)**	-0.20 (0.03)***			-0.12 (0.07)*	-0.15 (0.05)***
Alberta			-0.08 (0.07)	-0.06 (0.04)			-0.05 (0.06)	-0.08 (0.04)*
British Columbia			-0.13 (0.06)**	-0.03 (0.03)			-0.04 (0.07)	-0.01 (0.03)
Manitoba			-0.06 (0.10)	-0.17 (0.06)***			0.03 (0.11)	-0.17 (0.04)***
Saskatchewan			-0.31 (0.10)***	-0.25 (0.05)***			-0.01 (0.09)	0.00 (0.07)
Year01	-0.09 (0.06)	-0.04 (0.03)	-0.12 (0.06)*	-0.07 (0.03)**	-0.18 (0.07)**	0.05 (0.04)	-0.24 (0.06)***	-0.01 (0.03)
Year03	-0.20 (0.08)**	-0.10 (0.05)**	-0.19 (0.08)**	-0.08 (0.03)**	-0.16 (0.07)**	0.13 (0.05)***	-0.24 (0.06)***	0.05 (0.04)
Year05	-0.10 (0.06)	-0.07 (0.03)**	-0.08 (0.07)	-0.05 (0.03)	-0.17 (0.07)**	0.09 (0.04)**	-0.25 (0.06)***	0.01 (0.04)
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference in absence rate parameters with no team	-0.08 (0.31)		-0.01 (0.34)		-0.32 (0.50)		-0.25 (0.51)	
Difference in absence rate parameters with team	-3.52 (1.71)**		-2.85 (1.61)*		0.65 (0.82)		0.50 (0.86)	
Difference in team parameters	0.40 (0.21)*		0.27 (0.16)*		0.07 (0.10)		0.10 (0.07)	

D.3 Full sample: The impacts of the equal absence rate assumption

Table D.13. Comparing Nonlinear Least Squares estimates with and without assuming equal absence rates between team workers and non-team workers

	Equal absence rates		Unequal absence rates	
	Production	Wage	Production	Wage
Baseline controls†				
Attendance rate with no team	0.37 (0.12)***	0.38 (0.07)***	0.37 (0.12)***	0.38 (0.07)***
Attendance rate with team	2.78 (1.44)*	1.83 (0.84)**	3.28 (1.86)*	1.76 (0.60)***
Team	0.75 (0.17)***	0.45 (0.08)***	0.76 (0.17)***	0.45 (0.08)***
Difference in attendance parameters with no team	-0.01 (0.10)		-0.01 (0.09)	
Difference in attendance parameters with team	0.95 (0.95)		1.52 (1.50)	
Difference in team parameters	0.30 (0.12)**		0.30 (0.13)**	
All controls‡				
Attendance rate with no team	0.43 (0.13)***	0.45 (0.07)***	0.43 (0.12)***	0.45 (0.06)***
Attendance rate with team	2.38 (1.40)*	1.43 (0.75)*	3.35 (1.82)*	1.49 (0.58)**
Team	0.32 (0.12)**	0.10 (0.05)**	0.34 (0.12)***	0.10 (0.05)**
Difference in attendance parameters with no team	-0.02 (0.10)		-0.02 (0.10)	
Difference in attendance parameters with team	0.95 (1.00)		1.87 (1.51)	
Difference in team parameters	0.21 (0.10)**		0.23 (0.10)**	

†Model adjusted for employment, capital stock, and years; ‡Model adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, international market, foreign owned, region, industry and year;
***p≤0.01; **0.01<p≤0.05; *0.05<p≤0.1

Table D.14. Comparing first differences estimates with and without assuming equal absence rates between team workers and non-team workers

	Equal absence rates		Unequal absence rates	
	Production	**Wage**	**Production**	**Wage**
Baseline controls†				
Attendance rate with no team	0.27 (0.39)	0.01 (0.11)	0.20 (0.36)	0.00 (0.10)
Attendance rate with team	2.72 (2.08)	0.71 (0.62)	2.14 (1.82)	0.45 (0.57)
Team	0.13 (0.17)	0.00 (0.04)	0.13 (0.17)	0.00 (0.04)
Difference in attendance parameters with no team	0.27 (0.35)		0.20 (0.33)	
Difference in attendance parameters with team	2.02 (1.85)		1.69 (1.57)	
Difference in team parameters	0.13 (0.16)		0.13 (0.16)	
All controls‡				
Attendance rate with no team	0.29 (0.37)	0.01 (0.11)	0.21 (0.34)	0.00 (0.10)
Attendance rate with team	2.73 (1.92)	0.71 (0.64)	2.17 (1.84)	0.45 (0.60)
Team	0.14 (0.18)	0.00 (0.04)	0.13 (0.18)	0.00 (0.04)
Difference in attendance parameters with no team	0.28 (0.33)		0.21 (0.31)	
Difference in attendance parameters with team	2.02 (1.70)		1.72 (1.58)	
Difference in team parameters	0.14 (0.17)		0.14 (0.16)	

†Model adjusted for employment, capital stock, and years; ‡Model adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, and year; Standard error in the bracket;
$^{***}p \leq 0.01$; $^{**}0.01 < p \leq 0.05$; $^{*}0.05 < p \leq 0.1$

D.4 Sub-samples: The impacts of the equal absence rate assumption

Table D.15. Comparing Nonlinear Least Squares estimates with and without assuming equal absence rates between team workers and non-team workers

	Equal absence rates		Unequal absence rates	
	Production	**Wage**	**Production**	**Wage**
Small firms‡				
Attendance rate with no team	0.47 (0.14)***	0.44 (0.06)***	0.47 (0.14)***	0.44 (0.06)***
Attendance rate with team	4.97 (1.87)***	2.25 (0.95)**	5.91 (1.63)***	1.96 (1.03)*
Team	0.33 (0.18)*	0.06 (0.06)	0.36 (0.18)*	0.06 (0.05)
Difference in attendance parameters with no team	0.03 (0.12)		0.03 (0.12)	
Difference in attendance parameters with team	2.72 (1.49)*		3.96 (1.34)***	
Difference in team parameters	0.27 (0.16)*		0.30 (0.16)*	
Large firms‡				
Attendance rate with no team	1.32 (0.70)*	1.08 (0.47)**	1.13 (0.66)*	0.85 (0.44)*
Attendance rate with team	-0.76 (0.73)	-0.33 (0.64)	0.00 (0.08)	0.54 (0.49)
Team	0.19 (0.10)*	0.09 (0.07)	0.22 (0.09)**	0.12 (0.07)*
Difference in attendance parameters with no team	0.24 (0.37)		0.28 (0.34)	
Difference in attendance parameters with team	-0.43 (0.72)		-0.54 (0.52)	
Difference in team parameters	0.10 (0.07)		0.10 (0.07)	

‡Model adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, international market, foreign owned, region, industry and year;
***p≤0.01; **0.01<p≤0.05; *0.05<p≤0.1

Table D.16. Comparing first differences estimates with and without assuming equal absence rates between team workers and non-team workers

	Equal absence rates		Unequal absence rates	
	Production	**Wage**	**Production**	**Wage**
Small firms‡				
Attendance rate with no team	0.49 (0.47)	0.02 (0.12)	0.20 (0.43)	0.00 (0.11)
Attendance rate with team	4.36 (2.23)*	1.25 (1.07)	3.44 (2.07)*	0.78 (0.85)
Team	0.07 (0.28)	0.08 (0.07)	0.09 (0.28)	0.07 (0.07)
Difference in attendance parameters with no team	0.47 (0.43)		0.20 (0.41)	
Difference in attendance parameters with team	3.11 (2.04)		2.66 (1.92)	
Difference in team parameters	-0.01 (0.25)		0.02 (0.25)	
Large firms‡				
Attendance rate with no team	0.19 (0.36)	0.16 (0.18)	0.40 (0.31)	0.09 (0.16)
Attendance rate with team	-0.73 (1.40)	0.02 (0.33)	-0.10 (0.07)	0.39 (0.26)
Team	0.05 (0.11)	-0.06 (0.05)	0.06 (0.10)	-0.05 (0.05)
Difference in attendance parameters with no team	0.03 (0.32)		0.31 (0.26)	
Difference in attendance parameters with team	-0.74 (1.38)		-0.48 (0.30)	
Difference in team parameters	0.11 (0.12)		0.11 (0.11)	

‡Model adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, and year; Standard error in the bracket;
***p≤0.01; **0.01<p≤0.05; *0.05<p≤0.1

Appendix E **Additional results for Chapter 7**

E.1 Full sample: Cobb-Douglas production function

Table E.1. Parameter estimates of the restricted models for all workplaces

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.16 (0.13)***	9.31 (0.10)***	11.12 (0.26)***	10.53 (0.19)***				
Log (employment)	0.93 (0.02)***	1.05 (0.02)***	0.94 (0.02)***	1.09 (0.01)***	0.50 (0.09)***	0.65 (0.04)***	0.48 (0.08)***	0.66 (0.04)***
Log (stock)	0.05 (0.01)***	0.05 (0.01)***	-0.01 (0.02)	-0.04 (0.01)***	-0.01 (0.03)	0.01 (0.01)	0.00 (0.03)	0.01 (0.01)
Reduction=often	-0.10 (0.16)	-0.09 (0.12)	-0.05 (0.19)	0.01 (0.14)	0.75 (1.09)	0.01 (0.08)	0.34 (0.80)	-0.03 (0.08)
Reduction=sometime	0.22 (0.14)	0.03 (0.11)	0.22 (0.13)*	0.05 (0.08)	0.88 (0.45)**	-0.04 (0.06)	0.49 (0.31)	-0.06 (0.07)
Reduction=no								
Reduction=n/a	-0.83 (0.07)***	-0.17 (0.08)**	-0.80 (0.08)***	0.00 (0.09)	-0.96 (0.03)***	-0.27 (0.17)	-0.96 (0.03)***	-0.24 (0.19)
Team	0.57 (0.18)***	0.41 (0.09)***	0.19 (0.12)*	0.08 (0.06)	0.20 (0.24)	0.05 (0.04)	0.20 (0.23)	0.05 (0.04)
35 ≤ Age < 55			0.27 (0.08)***	0.77 (0.13)***			0.07 (0.12)	0.06 (0.07)
55≤ Age			0.17 (0.10)	0.44 (0.09)***			-0.13 (0.23)	-0.02 (0.05)
Female			-0.18 (0.05)***	-0.10 (0.08)			-0.03 (0.19)	0.05 (0.07)
> a bachelor's degree			0.28 (0.13)**	-0.28 (0.03)***			-0.31 (0.12)**	-0.03 (0.05)
Managers/professionals			0.73 (0.14)***	0.30 (0.05)***			0.13 (0.23)	0.04 (0.03)
Technical/sales/clerical			0.71 (0.13)***	0.20 (0.07)***			-0.19 (0.13)	-0.04 (0.04)
Others			-0.27 (0.10)***	0.40 (0.10)***			-0.48 (0.21)**	-0.02 (0.07)
Minorities			-0.03 (0.07)	-0.09 (0.06)			0.01 (0.18)	-0.01 (0.04)
Immigrants			-0.01 (0.08)	-0.03 (0.05)			0.11 (0.26)	-0.01 (0.04)
Bargaining agreement			0.41 (0.17)**	0.15 (0.07)**			-0.18 (0.24)	0.02 (0.08)
Difficulty			0.06 (0.11)	-0.01 (0.06)			0.73 (0.35)**	0.06 (0.05)
International market			0.38 (0.10)***	0.15 (0.03)***				
Foreign owned			0.62 (0.08)***	0.27 (0.04)***				
Labour tertiary			-0.57 (0.09)***	-0.34 (0.06)***				

	NLS				First differences			
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
manufacturing								
Primary product manufacturing			-0.41 (0.08)***	-0.21 (0.05)***				
Secondary product manufacturing			-0.32 (0.09)***	-0.16 (0.05)***				
Capital tertiary manufacturing			-0.39 (0.11)***	-0.18 (0.05)***				
Construction			-0.45 (0.09)***	-0.25 (0.06)***				
Transportation			-0.32 (0.09)***	-0.19 (0.05)***				
Communication			-0.54 (0.09)***	-0.28 (0.05)***				
Retail trade			-0.93 (0.11)***	-0.85 (0.06)***				
Finance			-0.15 (0.11)	-0.15 (0.06)**				
Real estate			-0.62 (0.12)***	-0.49 (0.06)***				
Business services			-0.57 (0.11)***	-0.38 (0.07)***				
Education			-0.47 (0.12)***	-0.52 (0.09)***				
Information			-0.73 (0.14)***	-0.33 (0.06)***				
Atlantic			-0.24 (0.10)**	-0.15 (0.05)***				
Quebec			-0.16 (0.07)**	-0.20 (0.03)***				
Alberta			-0.12 (0.06)**	-0.08 (0.04)**				
British Columbia			-0.17 (0.06)***	-0.03 (0.03)				
Manitoba			-0.03 (0.10)	-0.18 (0.06)***				
Saskatchewan			-0.39 (0.10)***	-0.27 (0.05)***				
Year03	-0.10 (0.06)	-0.05 (0.04)	-0.06 (0.05)	0.00 (0.03)				
Year05	-0.01 (0.05)	-0.03 (0.03)	0.03 (0.04)	0.03 (0.03)	0.08 (0.03)***	0.05 (0.02)***	0.09 (0.03)***	0.06 (0.02)***
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference for often	-0.01 (0.13)		-0.06 (0.15)		0.74 (1.10)		0.38 (0.79)	
Difference for sometime	0.19 (0.11)*		0.16 (0.10)		0.92 (0.44)**		0.55 (0.30)*	
Difference for no								
Difference for n/a	-0.66 (0.09)***		-0.80 (0.14)***		-0.69 (0.18)***		-0.72 (0.20)***	

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Difference in team parameters	0.16 (0.12)		0.11 (0.09)		0.15 (0.22)		0.15 (0.22)	

†Model adjusted for employment, capital stock, and years; ‡ Nonlinear Least Squares (NLS) estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, international market, foreign owned, region, industry and year; First differences estimates adjusted for employment, capital stock, occupation, age, sex, education, race, immigrant, bargaining agreement, difficulty, and year; Standard error in the bracket; $^{***}p \le 0.01$; $^{**}0.01 < p \le 0.05$; $^{*}0.05 < p \le 0.1$

Table E.2. Parameter estimates of the complete models for all workplaces

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.16 (0.13)***	9.31 (0.10)***	11.12 (0.26)***	10.53 (0.19)***				
Log (employment)	0.93 (0.02)***	1.05 (0.01)***	0.94 (0.02)***	1.09 (0.01)***	0.49 (0.09)***	0.65 (0.04)***	0.47 (0.08)***	0.66 (0.04)***
Log (stock)	0.05 (0.01)***	0.05 (0.01)***	-0.01 (0.02)	-0.04 (0.01)***	-0.01 (0.03)	0.01 (0.01)	0.00 (0.03)	0.01 (0.01)
Reduction=often, team	-0.16 (0.26)	0.05 (0.34)	-0.22 (0.27)	0.12 (0.13)	-0.59 (0.30)**	0.09 (0.12)	-0.84 (0.13)***	0.05 (0.13)
Reduction=sometime, team	0.08 (0.46)	0.23 (0.25)	-0.36 (0.29)	-0.19 (0.18)	0.18 (0.58)	0.03 (0.16)	-0.30 (0.48)	0.00 (0.17)
Reduction=no, team	0.65 (0.19)***	0.44 (0.10)***	0.26 (0.13)**	0.10 (0.06)*	0.36 (0.30)	0.05 (0.05)	0.37 (0.29)	0.05 (0.05)
Reduction=n/a, team	9.21 (3.48)***	1.75 (3.02)	8.13 (4.05)**	1.37 (2.98)	1.26 (0.80)	0.13 (0.20)	1.28 (0.85)	0.23 (0.20)
Reduction=often, no team	-0.05 (0.17)	-0.07 (0.13)	-0.01 (0.20)	0.01 (0.15)	1.00 (1.30)	0.01 (0.09)	0.54 (0.95)	-0.04 (0.08)
Reduction=sometime, no team	0.25 (0.15)*	0.04 (0.11)	0.26 (0.14)*	0.07 (0.08)	1.00 (0.51)**	-0.04 (0.06)	0.57 (0.34)*	-0.06 (0.07)
Reduction=n/a, no team	-0.83 (0.07)***	-0.17 (0.07)**	-0.81 (0.08)***	0.00 (0.08)	-0.96 (0.03)***	-0.27 (0.17)	-0.96 (0.03)***	-0.24 (0.20)
Team								
35 ≤ Age < 55			0.27 (0.08)***	0.77 (0.13)***			0.08 (0.12)	0.06 (0.07)
55≤ Age			0.17 (0.11)	0.44 (0.09)***			-0.13 (0.24)	-0.02 (0.05)
Female			-0.18 (0.05)***	-0.10 (0.08)			-0.01 (0.19)	0.05 (0.07)
> a bachelor's degree			0.27 (0.13)**	-0.28 (0.03)***			-0.31 (0.13)**	-0.03 (0.05)
Managers/professionals			0.74 (0.14)***	0.30 (0.05)***			0.14 (0.24)	0.04 (0.03)
Technical/sales/clerical			0.71 (0.13)***	0.20 (0.07)***			-0.19 (0.14)	-0.04 (0.04)
Others			-0.27 (0.10)***	0.39 (0.10)***			-0.49 (0.21)**	-0.02 (0.07)
Minorities			-0.03 (0.07)	-0.09 (0.06)			0.01 (0.18)	-0.01 (0.04)
Immigrants			-0.01 (0.08)	-0.03 (0.05)			0.10 (0.26)	-0.01 (0.04)
Bargaining agreement			0.41 (0.17)**	0.16 (0.07)**			-0.19 (0.24)	0.03 (0.08)
Difficulty			0.05 (0.11)	-0.01 (0.06)			0.78 (0.36)**	0.06 (0.05)
International market			0.38 (0.10)***	0.15 (0.03)***				
Foreign owned			0.62 (0.08)***	0.27 (0.04)***				
Labour tertiary manufacturing			-0.57 (0.09)***	-0.34 (0.06)***				
Primary product			-0.41 (0.08)***	-0.21 (0.05)***				

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
manufacturing								
Secondary product manufacturing			-0.33 (0.09)***	-0.16 (0.05)***				
Capital tertiary manufacturing			-0.39 (0.11)***	-0.18 (0.05)***				
Construction			-0.46 (0.09)***	-0.25 (0.06)***				
Transportation			-0.32 (0.09)***	-0.19 (0.05)***				
Communication			-0.54 (0.09)***	-0.28 (0.05)***				
Retail trade			-0.94 (0.11)***	-0.85 (0.06)***				
Finance			-0.15 (0.11)	-0.15 (0.06)**				
Real estate			-0.62 (0.12)***	-0.49 (0.06)***				
Business services			-0.57 (0.11)***	-0.38 (0.07)***				
Education			-0.48 (0.12)***	-0.52 (0.09)***				
Information			-0.73 (0.14)***	-0.33 (0.06)***				
Atlantic			-0.24 (0.10)**	-0.15 (0.05)***				
Quebec			-0.16 (0.07)**	-0.20 (0.03)***				
Alberta			-0.12 (0.06)**	-0.08 (0.04)**				
British Columbia			-0.17 (0.06)***	-0.03 (0.03)				
Manitoba			-0.02 (0.10)	-0.18 (0.06)***				
Saskatchewan			-0.39 (0.10)***	-0.27 (0.05)***				
Year03	-0.10 (0.06)	-0.05 (0.04)	-0.06 (0.05)	0.00 (0.03)				
Year05	-0.01 (0.05)	-0.03 (0.03)	0.03 (0.04)	0.03 (0.03)	0.08 (0.03)***	0.05 (0.02)***	0.09 (0.03)***	0.06 (0.02)***
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference for often, team	-0.21 (0.42)		-0.34 (0.30)		-0.68 (0.24)***		-0.89 (0.12)***	
Difference for sometime, team	-0.15 (0.27)		-0.17 (0.18)		0.15 (0.49)		-0.30 (0.38)	
Difference for no, team	0.22 (0.13)*		0.16 (0.10)		0.31 (0.29)		0.32 (0.28)	
Difference for n/a, team	7.46 (4.51)*		6.77 (4.04)*		1.13 (0.63)*		1.05 (0.71)	
Difference for often, no	0.02 (0.14)		-0.02 (0.16)		1.00 (1.30)		0.58 (0.94)	

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
team								
Difference for sometime, no team	0.21 (0.12)*		0.19 (0.11)*		1.04 (0.50)**		0.63 (0.33)*	
Difference for n/a, no team	-0.66 (0.09)***		-0.81 (0.13)***		-0.69 (0.18)***		-0.72 (0.21)***	
Difference in team parameters								

E.2 Full sample: Translog production function

Table E.3. Parameter estimates of the restricted models for all workplaces

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	13.36 (0.52)***	9.31 (0.10)***	14.59 (0.93)***	10.53 (0.19)***				
Log (employment)	0.71 (0.08)***	1.05 (0.02)***	0.82 (0.08)***	1.09 (0.01)***	0.56 (0.30)*	0.65 (0.04)***	0.50 (1.02)	0.66 (0.04)***
Log (stock)	-0.42 (0.08)***	0.05 (0.01)***	-0.53 (0.13)***	-0.04 (0.01)***	-0.32 (0.30)	0.01 (0.01)	-0.27 (0.33)	0.01 (0.01)
Reduction=often	-0.12 (0.22)	-0.09 (0.12)	-0.06 (0.23)	0.01 (0.14)	0.73 (0.65)	0.01 (0.08)	0.38 (2.30)	-0.04 (0.08)
Reduction=sometime	0.28 (0.19)	0.03 (0.11)	0.24 (0.15)	0.05 (0.08)	0.78 (0.51)	-0.03 (0.06)	0.47 (5.48)	-0.06 (0.07)
Reduction=no								
Reduction=n/a	-0.91 (0.05)***	-0.17 (0.08)**	-0.86 (0.07)***	0.00 (0.09)	-0.94 (0.10)***	-0.28 (0.17)	-0.95 (0.15)***	-0.24 (0.21)
Team	0.63 (0.26)**	0.41 (0.09)***	0.15 (0.13)	0.08 (0.06)	0.09 (0.19)	0.05 (0.04)	0.09 (1.22)	0.05 (0.04)
35 ≤ Age < 55			0.29 (0.10)***	0.77 (0.13)***			0.07 (0.43)	0.06 (0.07)
55≤ Age			0.16 (0.13)	0.44 (0.09)***			-0.10 (1.00)	-0.02 (0.05)
Female			-0.22 (0.06)***	-0.10 (0.08)			-0.06 (0.73)	0.05 (0.07)
> a bachelor's degree			0.28 (0.17)*	-0.28 (0.03)***			-0.34 (1.04)	-0.03 (0.05)
Managers/professionals			0.91 (0.22)***	0.30 (0.05)***			0.14 (1.85)	0.04 (0.03)
Technical/sales/clerical			0.83 (0.20)***	0.20 (0.07)***			-0.21 (1.38)	-0.04 (0.05)
Others			-0.31 (0.12)***	0.40 (0.10)***			-0.47 (1.32)	-0.02 (0.07)
Minorities			-0.03 (0.08)	-0.09 (0.06)			0.01 (0.24)	-0.01 (0.04)
Immigrants			-0.02 (0.10)	-0.03 (0.05)			0.06 (0.47)	-0.01 (0.04)
Bargaining agreement			0.35 (0.21)*	0.15 (0.07)**			-0.14 (0.73)	0.02 (0.08)
Difficulty			0.08 (0.14)	-0.01 (0.06)			0.69 (12.97)	0.06 (0.05)
International market			0.35 (0.11)***	0.15 (0.03)***				
Foreign owned			0.57 (0.08)***	0.27 (0.04)***				
Labour tertiary manufacturing			-0.48 (0.08)***	-0.34 (0.06)***				
Primary product			-0.40 (0.08)***	-0.21 (0.05)***				

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
manufacturing								
Secondary product manufacturing			-0.24 (0.08)***	-0.16 (0.05)***				
Capital tertiary manufacturing			-0.30 (0.11)***	-0.18 (0.05)***				
Construction			-0.35 (0.09)***	-0.25 (0.06)***				
Transportation			-0.20 (0.09)**	-0.19 (0.05)***				
Communication			-0.53 (0.09)***	-0.28 (0.05)***				
Retail trade			-0.86 (0.10)***	-0.85 (0.06)***				
Finance			-0.05 (0.12)	-0.15 (0.06)**				
Real estate			-0.57 (0.12)***	-0.49 (0.06)***				
Business services			-0.54 (0.10)***	-0.38 (0.07)***				
Education			-0.56 (0.12)***	-0.52 (0.09)***				
Information			-0.71 (0.14)***	-0.33 (0.06)***				
Atlantic			-0.23 (0.10)**	-0.15 (0.05)***				
Quebec			-0.15 (0.07)**	-0.20 (0.03)***				
Alberta			-0.13 (0.06)**	-0.08 (0.04)**				
British Columbia			-0.16 (0.06)***	-0.03 (0.03)				
Manitoba			-0.03 (0.10)	-0.18 (0.06)***				
Saskatchewan			-0.38 (0.10)***	-0.27 (0.05)***				
Year03	-0.09 (0.06)	-0.05 (0.04)	-0.06 (0.05)	0.00 (0.03)				
Year05	0.00 (0.05)	-0.03 (0.03)	0.04 (0.04)	0.03 (0.03)	0.09 (0.03)***	0.05 (0.02)***	0.09 (0.03)***	0.06 (0.02)***
LnL*LnL	0.05 (0.01)***		0.05 (0.01)***		0.13 (0.03)***		0.13 (0.04)***	
LnK*LnK	0.02 (0.00)***		0.02 (0.00)***		0.01 (0.01)		0.01 (0.02)	
LnL*LnK	0.00 (0.01)		-0.01 (0.01)		-0.04 (0.02)*		-0.04 (0.07)	
Difference for often	-0.03 (0.18)		-0.06 (0.18)		0.72 (0.65)		0.42 (2.31)	
Difference for sometime	0.25 (0.15)		0.18 (0.12)		0.81 (0.51)		0.54 (5.49)	
Difference for no								
Difference for n/a	-0.74 (0.08)***		-0.86 (0.12)***		-0.67 (0.22)***		-0.71 (0.30)**	

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Difference in team parameters	0.22 (0.20)		0.07 (0.10)		0.04 (0.17)		0.03 (1.22)	

Table E.4. Parameter estimates of the complete models for all workplaces

	NLS				First differences			
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
Constant	13.37 (0.53)***	9.30 (0.10)***	14.60 (0.94)***	10.53 (0.19)***				
Log (employment)	0.70 (0.08)***	1.05 (0.01)***	0.82 (0.08)***	1.09 (0.01)***	0.57 (0.31)*	0.65 (0.05)***	0.50 (0.87)	0.66 (0.04)***
Log (stock)	-0.43 (0.08)***	0.05 (0.01)***	-0.54 (0.13)***	-0.04 (0.01)***	-0.33 (0.30)	0.01 (0.01)	-0.29 (0.32)	0.01 (0.01)
Reduction=often, team	-0.23 (0.45)	0.07 (0.35)	-0.27 (0.28)	0.14 (0.14)	-0.36 (0.36)	0.09 (0.12)	-0.71 (0.63)	0.04 (0.16)
Reduction=sometime, team	-0.07 (0.59)	0.22 (0.26)	-0.45 (0.33)	-0.20 (0.18)	0.06 (0.44)	0.03 (0.16)	-0.37 (1.24)	0.00 (0.17)
Reduction=no, team	0.75 (0.30)**	0.43 (0.10)***	0.22 (0.15)	0.10 (0.06)*	0.20 (0.23)	0.05 (0.05)	0.22 (3.24)	0.05 (0.05)
Reduction=n/a, team	14.33 (7.53)*	1.60 (3.04)	9.73 (5.97)	1.32 (2.99)	0.85 (0.61)	0.13 (0.20)	0.96 (1.82)	0.23 (0.20)
Reduction=often, no team	-0.06 (0.25)	-0.07 (0.13)	-0.01 (0.25)	0.01 (0.15)	0.89 (0.70)	0.01 (0.09)	0.52 (3.09)	-0.04 (0.08)
Reduction=sometime, no team	0.32 (0.21)	0.04 (0.11)	0.28 (0.16)*	0.07 (0.08)	0.84 (0.55)	-0.03 (0.06)	0.54 (6.24)	-0.06 (0.07)
Reduction=n/a, no team	-0.91 (0.05)***	-0.16 (0.08)**	-0.86 (0.06)***	0.00 (0.08)	-0.94 (0.11)***	-0.28 (0.17)	-0.95 (0.14)***	-0.24 (0.21)
Team								
35 ≤ Age < 55			0.29 (0.10)***	0.77 (0.13)***			0.07 (0.36)	0.06 (0.07)
55≤ Age			0.16 (0.13)	0.44 (0.09)***			-0.10 (0.82)	-0.02 (0.05)
Female			-0.21 (0.06)***	-0.10 (0.08)			-0.04 (0.72)	0.05 (0.07)
> a bachelor’s degree			0.27 (0.17)	-0.28 (0.03)***			-0.34 (0.86)	-0.03 (0.05)
Managers/professionals			0.91 (0.22)***	0.30 (0.05)***			0.14 (1.68)	0.04 (0.03)
Technical/sales/clerical			0.83 (0.20)***	0.20 (0.07)***			-0.20 (1.14)	-0.04 (0.05)
Others			-0.31 (0.12)***	0.40 (0.10)***			-0.47 (1.12)	-0.02 (0.07)
Minorities			-0.03 (0.08)	-0.09 (0.06)			0.01 (0.23)	-0.01 (0.04)
Immigrants			-0.02 (0.10)	-0.03 (0.05)			0.05 (0.40)	-0.01 (0.04)
Bargaining agreement			0.35 (0.21)*	0.15 (0.07)**			-0.15 (0.61)	0.02 (0.08)
Difficulty			0.07 (0.14)	-0.01 (0.06)			0.72 (10.70)	0.06 (0.05)
International market			0.35 (0.11)***	0.15 (0.03)***				
Foreign owned			0.57 (0.08)***	0.27 (0.04)***				
Labour tertiary manufacturing			-0.48 (0.08)***	-0.34 (0.06)***				
Primary product			-0.40 (0.08)***	-0.21 (0.05)***				

	NLS				First differences			
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
manufacturing								
Secondary product manufacturing			-0.25 (0.08)***	-0.16 (0.05)***				
Capital tertiary manufacturing			-0.30 (0.11)***	-0.18 (0.05)***				
Construction			-0.35 (0.09)***	-0.25 (0.06)***				
Transportation			-0.20 (0.09)**	-0.19 (0.05)***				
Communication			-0.53 (0.09)***	-0.28 (0.05)***				
Retail trade			-0.87 (0.10)***	-0.85 (0.06)***				
Finance			-0.05 (0.12)	-0.15 (0.06)**				
Real estate			-0.58 (0.12)***	-0.49 (0.06)***				
Business services			-0.54 (0.10)***	-0.38 (0.07)***				
Education			-0.56 (0.12)***	-0.52 (0.09)***				
Information			-0.70 (0.14)***	-0.33 (0.06)***				
Atlantic			-0.23 (0.10)**	-0.15 (0.05)***				
Quebec			-0.15 (0.07)**	-0.20 (0.03)***				
Alberta			-0.12 (0.06)**	-0.08 (0.04)**				
British Columbia			-0.16 (0.06)***	-0.03 (0.03)				
Manitoba			-0.03 (0.10)	-0.18 (0.06)***				
Saskatchewan			-0.38 (0.10)***	-0.27 (0.05)***				
Year03	-0.09 (0.06)	-0.05 (0.04)	-0.06 (0.05)	0.00 (0.03)				
Year05	0.00 (0.05)	-0.03 (0.03)	0.04 (0.04)	0.03 (0.03)	0.09 (0.03)***	0.05 (0.02)***	0.09 (0.03)***	0.06 (0.02)***
LnL*LnL	0.05 (0.01)***		0.05 (0.01)***		0.12 (0.03)***		0.13 (0.03)***	
LnK*LnK	0.02 (0.00)***		0.02 (0.00)***		0.02 (0.01)		0.01 (0.01)	
LnL*LnK	0.00 (0.01)		-0.01 (0.01)		-0.04 (0.02)*		-0.04 (0.06)	
Difference for often, team	-0.30 (0.57)		-0.41 (0.33)		-0.45 (0.34)		-0.75 (0.70)	
Difference for sometime, team	-0.29 (0.37)		-0.25 (0.20)		0.03 (0.36)		-0.37 (1.24)	
Difference for no, team	0.31 (0.23)		0.12 (0.12)		0.15 (0.22)		0.16 (3.24)	
Difference for n/a, team	12.73 (8.14)		8.41 (5.79)		0.72 (0.46)		0.73 (1.74)	
Difference for often, no	0.01 (0.20)		-0.02 (0.19)		0.88 (0.70)		0.56 (3.10)	

	NLS				First differences			
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
team								
Difference for sometime, no team	0.29 (0.17)*		0.21 (0.14)		0.88 (0.54)		0.60 (6.25)	
Difference for n/a, no team	-0.75 (0.08)***		-0.86 (0.12)***		-0.66 (0.22)***		-0.71 (0.29)**	
Difference in team parameters								

E.3 Sub-samples: Cobb-Douglas production function

Table E.5. Parameter estimates of the restricted models for small firms and large firms with all controls

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	11.33 (0.34)***	10.67 (0.24)***	10.16 (0.27)***	10.28 (0.17)***				
Log (employment)	0.86 (0.03)***	1.08 (0.02)***	1.10 (0.02)***	1.03 (0.01)***	0.40 (0.10)***	0.64 (0.05)***	0.68 (0.08)***	0.67 (0.05)***
Log (stock)	-0.01 (0.02)	-0.04 (0.02)***	-0.01 (0.02)	-0.01 (0.01)	-0.01 (0.04)	0.01 (0.02)	-0.03 (0.03)	-0.01 (0.01)
Reduction=often	-0.02 (0.23)	0.05 (0.16)	-0.38 (0.15)***	-0.44 (0.14)***	0.66 (1.19)	-0.02 (0.08)	-0.74 (0.20)***	-0.26 (0.12)**
Reduction=sometime	0.25 (0.15)*	0.08 (0.09)	-0.02 (0.17)	-0.13 (0.11)	0.76 (0.49)	-0.06 (0.08)	-0.44 (0.15)***	-0.12 (0.06)**
Reduction=no								
Reduction=n/a	-0.85 (0.06)***	0.02 (0.09)	-0.43 (0.25)*	-0.19 (0.36)	-0.98 (0.02)***	-0.23 (0.21)	0.18 (1.03)	0.11 (0.37)
Team	0.20 (0.18)	0.03 (0.06)	0.12 (0.08)	0.07 (0.07)	0.20 (0.43)	0.11 (0.08)	-0.08 (0.08)	-0.02 (0.03)
35 ≤ Age < 55	0.26 (0.09)***	0.70 (0.15)***	0.46 (0.11)***	1.62 (0.27)***	0.07 (0.16)	0.07 (0.08)	0.06 (0.09)	0.00 (0.06)
55≤ Age	0.15 (0.12)	0.38 (0.11)***	0.28 (0.14)**	0.78 (0.12)***	-0.14 (0.32)	-0.02 (0.06)	0.24 (0.16)	0.02 (0.06)
Female	-0.18 (0.06)***	-0.12 (0.09)	-0.29 (0.05)***	-0.07 (0.09)	-0.04 (0.27)	0.06 (0.09)	0.01 (0.09)	0.01 (0.04)
> a bachelor's degree	0.24 (0.15)	-0.26 (0.03)***	0.47 (0.22)**	-0.36 (0.04)***	-0.38 (0.17)**	-0.04 (0.06)	-0.09 (0.19)	0.00 (0.04)
Managers/professionals	0.74 (0.18)***	0.29 (0.06)***	1.25 (0.25)***	0.42 (0.08)***	0.15 (0.30)	0.04 (0.03)	0.01 (0.18)	0.05 (0.03)
Technical/sales/clerical	0.68 (0.17)***	0.18 (0.08)**	1.05 (0.13)***	0.41 (0.11)***	-0.29 (0.19)	-0.07 (0.05)	0.08 (0.13)	0.12 (0.06)**
Others	-0.34 (0.11)***	0.37 (0.10)***	-0.11 (0.09)	0.57 (0.16)***	-0.59 (0.26)**	0.02 (0.07)	-0.01 (0.15)	0.02 (0.08)
Minorities	-0.04 (0.08)	-0.10 (0.06)*	0.10 (0.09)	0.07 (0.08)	0.00 (0.25)	-0.03 (0.05)	-0.08 (0.12)	0.10 (0.05)**
Immigrants	-0.03 (0.09)	-0.04 (0.06)	-0.10 (0.09)	-0.01 (0.06)	0.17 (0.38)	0.00 (0.04)	-0.12 (0.13)	-0.11 (0.04)***
Bargaining agreement	0.60 (0.41)	0.21 (0.14)	0.09 (0.06)	0.12 (0.04)***	-0.54 (0.19)***	-0.10 (0.09)	0.28 (0.21)	0.13 (0.13)
Difficulty	0.06 (0.13)	-0.02 (0.07)	0.17 (0.18)	0.13 (0.13)	1.06 (0.54)**	0.06 (0.05)	0.26 (0.22)	0.11 (0.06)*
International market	0.49 (0.15)***	0.19 (0.04)***	-0.07 (0.06)	0.03 (0.03)				
Foreign owned	0.80 (0.12)***	0.39 (0.06)***	0.25 (0.06)***	0.08 (0.03)***				
Labour tertiary manufacturing	-0.68 (0.10)***	-0.37 (0.07)***	-0.11 (0.12)	-0.31 (0.06)***				

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Primary product manufacturing	-0.59 (0.10)***	-0.30 (0.07)***	-0.02 (0.10)	-0.11 (0.06)*				
Secondary product manufacturing	-0.34 (0.11)***	-0.14 (0.07)**	-0.12 (0.11)	-0.23 (0.06)***				
Capital tertiary manufacturing	-0.44 (0.13)***	-0.20 (0.06)***	-0.10 (0.12)	-0.19 (0.06)***				
Construction	-0.48 (0.11)***	-0.26 (0.07)***	-0.27 (0.11)**	-0.25 (0.07)***				
Transportation	-0.34 (0.11)***	-0.20 (0.07)***	-0.13 (0.11)	-0.26 (0.07)***				
Communication	-0.63 (0.11)***	-0.31 (0.07)***	-0.30 (0.12)**	-0.33 (0.07)***				
Retail trade	-0.96 (0.13)***	-0.86 (0.08)***	-0.74 (0.11)***	-0.82 (0.06)***				
Finance	-0.19 (0.14)	-0.17 (0.08)**	0.00 (0.12)	-0.18 (0.07)***				
Real estate	-0.68 (0.14)***	-0.51 (0.07)***	-0.04 (0.12)	-0.17 (0.10)*				
Business services	-0.60 (0.13)***	-0.41 (0.09)***	-0.41 (0.14)***	-0.38 (0.07)***				
Education	-0.48 (0.14)***	-0.54 (0.11)***	-0.58 (0.13)***	-0.66 (0.08)***				
Information	-0.82 (0.18)***	-0.32 (0.07)***	-0.39 (0.11)***	-0.39 (0.09)***				
Atlantic	-0.28 (0.11)***	-0.16 (0.06)***	0.02 (0.10)	-0.11 (0.07)*				
Quebec	-0.21 (0.08)***	-0.22 (0.04)***	-0.05 (0.07)	-0.16 (0.05)***				
Alberta	-0.14 (0.07)**	-0.08 (0.04)*	-0.03 (0.07)	-0.08 (0.04)*				
British Columbia	-0.20 (0.07)***	-0.03 (0.04)	0.01 (0.06)	-0.06 (0.04)*				
Manitoba	-0.05 (0.12)	-0.18 (0.07)**	0.07 (0.12)	-0.19 (0.05)***				
Saskatchewan	-0.45 (0.11)***	-0.31 (0.06)***	0.03 (0.09)	0.03 (0.08)				
Year03	-0.07 (0.06)	-0.01 (0.04)	0.00 (0.05)	0.06 (0.04)				
Year05	0.03 (0.05)	0.03 (0.03)	-0.02 (0.05)	0.02 (0.04)	0.08 (0.04)**	0.06 (0.02)***	0.10 (0.02)***	0.03 (0.01)*
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference for often	-0.07 (0.18)		0.06 (0.12)		0.68 (1.18)		-0.47 (0.18)***	
Difference for sometime	0.17 (0.12)		0.11 (0.13)		0.81 (0.48)*		-0.33 (0.15)**	
Difference for no								
Difference for n/a	-0.87 (0.13)***		-0.23 (0.22)		-0.75 (0.22)***		0.07 (0.68)	

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
Difference in team parameters	0.17 (0.14)		0.04 (0.07)		0.09 (0.40)		-0.06 (0.07)	

Table E.6. Parameter estimates of the complete models for small firms and large firms with all controls

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
Constant	11.32 (0.34)***	10.67 (0.24)***	10.16 (0.27)***	10.28 (0.17)***				
Log (employment)	0.86 (0.03)***	1.08 (0.02)***	1.10 (0.02)***	1.03 (0.01)***	0.40 (0.10)***	0.64 (0.05)***	0.68 (0.08)***	0.66 (0.05)***
Log (stock)	-0.01 (0.02)	-0.04 (0.02)***	-0.01 (0.02)	-0.01 (0.01)	-0.01 (0.04)	0.01 (0.02)	-0.03 (0.03)	-0.01 (0.01)
Reduction=often, team	-0.17 (0.34)	0.13 (0.15)	-0.26 (0.30)	0.04 (0.30)	-0.73 (0.32)**	0.27 (0.10)***	-0.95 (0.15)***	0.02 (0.20)
Reduction=sometime, team	-0.60 (0.42)	-0.38 (0.28)	0.05 (0.28)	0.16 (0.20)	-0.73 (0.75)	-0.07 (0.30)	0.08 (0.29)	0.03 (0.11)
Reduction=no, team	0.29 (0.20)	0.05 (0.07)	0.11 (0.08)	0.05 (0.07)	0.43 (0.61)	0.10 (0.08)	-0.09 (0.08)	-0.03 (0.03)
Reduction=n/a, team	75.48 (27.37)***	2.44 (0.62)***	0.31 (1.89)	0.10 (2.96)			0.36 (0.48)	0.00 (0.19)
Reduction=often, no team	0.01 (0.25)	0.05 (0.16)	-0.39 (0.16)**	-0.55 (0.15)***	0.76 (1.30)	-0.03 (0.09)	-0.67 (0.30)**	-0.33 (0.14)**
Reduction=sometime, no team	0.29 (0.16)*	0.10 (0.09)	-0.02 (0.20)	-0.22 (0.11)*	0.84 (0.52)	-0.05 (0.08)	-0.60 (0.16)***	-0.17 (0.06)***
Reduction=n/a, no team	-0.85 (0.06)***	0.03 (0.09)	-0.44 (0.23)*	-0.21 (0.27)	-0.98 (0.02)***	-0.23 (0.21)	0.12 (1.16)	0.11 (0.42)
Team								
35 ≤ Age < 55	0.26 (0.09)***	0.70 (0.15)***	0.46 (0.10)***	1.64 (0.27)***	0.08 (0.16)	0.07 (0.08)	0.07 (0.09)	0.00 (0.06)
55≤ Age	0.15 (0.12)	0.38 (0.11)***	0.28 (0.13)**	0.78 (0.12)***	-0.14 (0.32)	-0.02 (0.06)	0.25 (0.16)	0.02 (0.06)
Female	-0.17 (0.06)***	-0.12 (0.09)	-0.29 (0.05)***	-0.07 (0.09)	-0.04 (0.27)	0.06 (0.09)	-0.01 (0.09)	0.01 (0.04)
> a bachelor’s degree	0.24 (0.15)	-0.26 (0.03)***	0.47 (0.22)**	-0.36 (0.04)***	-0.38 (0.17)**	-0.04 (0.06)	-0.10 (0.19)	0.00 (0.04)
Managers/professionals	0.74 (0.18)***	0.29 (0.06)***	1.25 (0.25)***	0.42 (0.08)***	0.14 (0.30)	0.04 (0.03)	0.04 (0.18)	0.05 (0.03)
Technical/sales/clerical	0.68 (0.17)***	0.18 (0.08)**	1.05 (0.13)***	0.41 (0.11)***	-0.30 (0.19)	-0.07 (0.05)	0.08 (0.14)	0.12 (0.06)**
Others	-0.34 (0.11)***	0.37 (0.10)***	-0.11 (0.09)	0.57 (0.16)***	-0.60 (0.26)**	0.02 (0.07)	-0.01 (0.15)	0.02 (0.08)
Minorities	-0.04 (0.08)	-0.10 (0.06)*	0.10 (0.09)	0.07 (0.08)	-0.01 (0.25)	-0.03 (0.05)	-0.08 (0.11)	0.11 (0.05)**
Immigrants	-0.03 (0.09)	-0.04 (0.06)	-0.10 (0.09)	-0.01 (0.06)	0.17 (0.38)	0.00 (0.04)	-0.13 (0.13)	-0.11 (0.04)***
Bargaining agreement	0.60 (0.41)	0.21 (0.14)	0.09 (0.06)	0.12 (0.04)***	-0.56 (0.19)***	-0.10 (0.09)	0.26 (0.21)	0.12 (0.12)
Difficulty	0.06 (0.13)	-0.02 (0.07)	0.16 (0.18)	0.14 (0.13)	1.11 (0.58)*	0.06 (0.05)	0.25 (0.22)	0.10 (0.05)*
International market	0.49 (0.15)***	0.19 (0.04)***	-0.07 (0.06)	0.02 (0.03)				
Foreign owned	0.80 (0.12)***	0.39 (0.06)***	0.25 (0.06)***	0.08 (0.03)***				
Labour tertiary manufacturing	-0.68 (0.10)***	-0.37 (0.07)***	-0.11 (0.12)	-0.30 (0.06)***				

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
Primary product manufacturing	-0.58 (0.10)***	-0.29 (0.07)***	-0.02 (0.10)	-0.10 (0.06)				
Secondary product manufacturing	-0.34 (0.11)***	-0.14 (0.07)**	-0.12 (0.11)	-0.23 (0.06)***				
Capital tertiary manufacturing	-0.44 (0.13)***	-0.20 (0.06)***	-0.10 (0.12)	-0.19 (0.06)***				
Construction	-0.48 (0.11)***	-0.26 (0.07)***	-0.27 (0.11)**	-0.25 (0.07)***				
Transportation	-0.34 (0.11)***	-0.20 (0.07)***	-0.13 (0.11)	-0.26 (0.07)***				
Communication	-0.63 (0.11)***	-0.31 (0.07)***	-0.30 (0.12)**	-0.33 (0.07)***				
Retail trade	-0.96 (0.13)***	-0.86 (0.08)***	-0.74 (0.11)***	-0.82 (0.07)***				
Finance	-0.19 (0.14)	-0.17 (0.08)**	0.00 (0.12)	-0.17 (0.07)**				
Real estate	-0.68 (0.14)***	-0.51 (0.07)***	-0.04 (0.12)	-0.16 (0.10)*				
Business services	-0.59 (0.13)***	-0.41 (0.09)***	-0.41 (0.15)***	-0.38 (0.07)***				
Education	-0.48 (0.14)***	-0.53 (0.11)***	-0.58 (0.13)***	-0.66 (0.08)***				
Information	-0.82 (0.18)***	-0.32 (0.07)***	-0.39 (0.11)***	-0.39 (0.09)***				
Atlantic	-0.28 (0.11)***	-0.16 (0.06)***	0.02 (0.10)	-0.11 (0.07)*				
Quebec	-0.21 (0.08)**	-0.22 (0.04)***	-0.05 (0.07)	-0.15 (0.05)***				
Alberta	-0.14 (0.07)**	-0.07 (0.04)*	-0.03 (0.07)	-0.08 (0.04)*				
British Columbia	-0.20 (0.07)***	-0.03 (0.04)	0.01 (0.06)	-0.06 (0.04)*				
Manitoba	-0.05 (0.12)	-0.18 (0.07)**	0.07 (0.12)	-0.19 (0.05)***				
Saskatchewan	-0.45 (0.11)***	-0.31 (0.06)***	0.03 (0.09)	0.04 (0.08)				
Year03	-0.07 (0.06)	-0.01 (0.04)	0.00 (0.05)	0.05 (0.04)				
Year05	0.03 (0.05)	0.03 (0.03)	-0.02 (0.05)	0.02 (0.04)	0.08 (0.04)**	0.06 (0.02)***	0.10 (0.02)***	0.03 (0.01)**
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference for often, team	-0.31 (0.37)		-0.31 (0.24)		-0.99 (0.27)***		-0.97 (0.28)***	
Difference for sometime, team	-0.22 (0.24)		-0.10 (0.25)		-0.65 (0.58)		0.05 (0.28)	
Difference for no, team	0.24 (0.17)		0.07 (0.07)		0.33 (0.58)		-0.06 (0.07)	

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
Difference for n/a, team	73.04 (27.52)***		0.21 (1.27)				0.37 (0.34)	
Difference for often, no team	-0.03 (0.19)		0.16 (0.14)		0.79 (1.29)		-0.34 (0.26)	
Difference for sometime, no team	0.19 (0.13)		0.20 (0.15)		0.89 (0.51)*		-0.43 (0.15)***	
Difference for n/a, no team	-0.87 (0.13)***		-0.23 (0.17)		-0.75 (0.22)***		0.01 (0.76)	
Difference in team parameters								

Table E.7. Parameter estimates of the restricted models for small firms and large firms with baseline controls

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
Constant	10.45 (0.17)***	9.41 (0.12)***	9.00 (0.22)***	8.90 (0.16)***				
Log (employment)	0.85 (0.03)***	1.06 (0.02)***	1.06 (0.03)***	1.01 (0.02)***	0.44 (0.10)***	0.64 (0.05)***	0.67 (0.08)***	0.67 (0.05)***
Log (stock)	0.04 (0.01)***	0.04 (0.01)***	0.10 (0.02)***	0.09 (0.01)***	-0.01 (0.04)	0.01 (0.02)	-0.03 (0.03)	-0.01 (0.01)
Reduction=often	-0.07 (0.19)	-0.06 (0.13)	-0.41 (0.21)**	-0.44 (0.18)**	1.25 (1.65)	0.02 (0.09)	-0.67 (0.27)**	-0.19 (0.14)
Reduction=sometime	0.25 (0.16)	0.04 (0.12)	0.03 (0.27)	-0.09 (0.16)	1.32 (0.72)*	-0.03 (0.07)	-0.33 (0.18)*	-0.04 (0.05)
Reduction=no								
Reduction=n/a	-0.87 (0.05)***	-0.17 (0.08)**	-0.59 (0.31)*	-0.24 (0.45)	-0.98 (0.02)***	-0.29 (0.18)	0.28 (1.21)	0.19 (0.47)
Team	0.46 (0.26)*	0.25 (0.11)**	0.68 (0.14)***	0.70 (0.13)***	0.20 (0.43)	0.10 (0.08)	-0.08 (0.08)	-0.02 (0.03)
35 ≤ Age < 55								
55≤ Age								
Female								
> a bachelor’s degree								
Managers/professionals								
Technical/sales/clerical								
Others								
Minorities								
Immigrants								
Bargaining agreement								
Difficulty								
International market								
Foreign owned								
Labour tertiary manufacturing								
Primary product manufacturing								
Secondary product								

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
manufacturing								
Capital tertiary manufacturing								
Construction								
Transportation								
Communication								
Retail trade								
Finance								
Real estate								
Business services								
Education								
Information								
Atlantic								
Quebec								
Alberta								
British Columbia								
Manitoba								
Saskatchewan								
Year03	-0.11 (0.07)	-0.07 (0.05)	0.02 (0.07)	0.08 (0.05)				
Year05	-0.01 (0.06)	-0.03 (0.03)	0.01 (0.07)	0.04 (0.05)	0.07 (0.04)*	0.06 (0.02)***	0.09 (0.02)***	0.02 (0.01)*
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference for often	-0.01 (0.16)		0.03 (0.11)		1.23 (1.66)		-0.48 (0.23)**	
Difference for sometime	0.21 (0.13)		0.12 (0.16)		1.35 (0.72)*		-0.28 (0.18)	
Difference for no								
Difference for n/a	-0.70 (0.08)***		-0.36 (0.20)*		-0.69 (0.18)***		0.09 (0.74)	
Difference in team	0.22 (0.19)		-0.02 (0.10)		0.10 (0.40)		-0.06 (0.07)	

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
parameters								

Table E.8. Parameter estimates of the complete models for small firms and large firms with baseline controls

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Constant	10.44 (0.17)***	9.41 (0.12)***	9.01 (0.22)***	8.92 (0.15)***				
Log (employment)	0.85 (0.03)***	1.06 (0.02)***	1.06 (0.03)***	1.01 (0.02)***	0.44 (0.10)***	0.64 (0.05)***	0.67 (0.08)***	0.67 (0.05)***
Log (stock)	0.04 (0.01)***	0.04 (0.01)***	0.10 (0.02)***	0.09 (0.01)***	-0.01 (0.04)	0.01 (0.02)	-0.03 (0.03)	-0.01 (0.01)
Reduction=often, team	-0.15 (0.28)	-0.06 (0.34)	0.18 (0.38)	0.67 (0.37)*	-0.27 (0.60)	0.30 (0.09)***	-0.93 (0.25)***	0.07 (0.22)
Reduction=sometime, team	-0.37 (0.51)	-0.13 (0.27)	0.87 (0.66)	0.99 (0.46)**	0.18 (1.30)	-0.01 (0.28)	0.18 (0.31)	0.09 (0.11)
Reduction=no, team	0.59 (0.30)*	0.29 (0.12)**	0.66 (0.15)***	0.65 (0.14)***	0.39 (0.59)	0.09 (0.08)	-0.09 (0.08)	-0.03 (0.03)
Reduction=n/a, team	77.81 (24.56)***	1.80 (0.96)*	2.70 (2.00)	2.30 (3.55)			0.36 (0.39)	-0.06 (0.13)
Reduction=often, no team	-0.03 (0.21)	-0.04 (0.14)	-0.46 (0.27)*	-0.60 (0.18)***	1.39 (1.83)	0.01 (0.09)	-0.61 (0.37)	-0.25 (0.16)
Reduction=sometime, no team	0.29 (0.17)	0.06 (0.12)	0.01 (0.32)	-0.18 (0.20)	1.40 (0.77)*	-0.03 (0.07)	-0.50 (0.22)**	-0.09 (0.06)
Reduction=n/a, no team	-0.87 (0.05)***	-0.16 (0.08)**	-0.62 (0.26)**	-0.27 (0.31)	-0.98 (0.02)***	-0.29 (0.18)	0.25 (1.37)	0.20 (0.54)
Team								
$35 \leq$ Age < 55								
$55 \leq$ Age								
Female								
> a bachelor's degree								
Managers/professionals								
Technical/sales/clerical								
Others								
Minorities								
Immigrants								
Bargaining agreement								
Difficulty								
International market								
Foreign owned								
Labour tertiary manufacturing								

	NLS				First differences			
	Small firms		Large firms		Small firms		Large firms	
	Production	Wage	Production	Wage	Production	Wage	Production	Wage
Primary product manufacturing								
Secondary product manufacturing								
Capital tertiary manufacturing								
Construction								
Transportation								
Communication								
Retail trade								
Finance								
Real estate								
Business services								
Education								
Information								
Atlantic								
Quebec								
Alberta								
British Columbia								
Manitoba								
Saskatchewan								
Year03	-0.11 (0.07)	-0.07 (0.05)	0.02 (0.07)	0.07 (0.05)				
Year05	-0.01 (0.06)	-0.03 (0.03)	0.01 (0.07)	0.04 (0.05)	0.08 (0.04)*	0.06 (0.02)***	0.10 (0.02)***	0.03 (0.01)*
LnL*LnL								
LnK*LnK								
LnL*LnK								
Difference for often, team	-0.09 (0.46)		-0.48 (0.30)		-0.56 (0.52)		-1.00 (0.36)***	
Difference for sometime, team	-0.24 (0.31)		-0.12 (0.38)		0.19 (1.15)		0.09 (0.29)	
Difference for no, team	0.30 (0.22)		0.01 (0.10)		0.29 (0.56)		-0.06 (0.08)	

	NLS				First differences			
	Small firms		**Large firms**		**Small firms**		**Large firms**	
	Production	**Wage**	**Production**	**Wage**	**Production**	**Wage**	**Production**	**Wage**
Difference for n/a, team	76.01 (24.97)***		0.40 (1.83)				0.42 (0.29)	
Difference for often, no team	0.01 (0.17)		0.14 (0.17)		1.38 (1.83)		-0.36 (0.30)	
Difference for sometime, no team	0.23 (0.14)*		0.19 (0.18)		1.43 (0.77)*		-0.40 (0.22)*	
Difference for n/a, no team	-0.71 (0.08)***		-0.35 (0.10)***		-0.69 (0.18)***		0.06 (0.83)	
Difference in team parameters								