The impacts of Smart Working

De effecten van Slim Werken

EY
Building a better working world

Management Samenvatting

"Slim werken" houdt in dat u overal kunt werken waar en wanneer u maar wilt. Dit betekent dat werknemers waarde kunnen toevoegen aan hun organisaties, ongeacht hun geografische locatie of uur van de dag. Slim werken heeft meerdere effecten voor zowel de werknemer, zijn werkgever als de samenleving als geheel.

Er is de afgelopen jaren veel onderzoek gedaan naar de impact van slim werken. Het meeste onderzoek is echter gericht op onderdelen (zoals de milieu-impact) en daarom ontbreekt tot op heden het integrale en geconsolideerde beeld.

De resultaten van dit project bieden een holistisch en geïntegreerd beeld van de belangrijkste gevolgen van slim werken. Aangezien het een eerste verkenning is, zijn niet alle potentiele effecten meegenomen, zoals congestie effecten maar ook toegenomen stress door slim werken bijvoorbeeld.
We hebben deze integrale visie voor acht van de meest relevante directe effecten voor werknemer, de werkgever en de samenleving als geheel op een kwantitatieve en gemonetariseerde manier vastgesteld. Voor zover ons bekend is dit het eerste onderzoek dat de geïntegreerde directe impact op individuele belanghebbenden in kaart brengt. De belangrijkste resultaten van deze aanpak zijn de volgende.

Ten eerste schatten we dat er ongeveer 5 miljard euro aan potentieel beschikbaar is in de Nederlandse samenleving. Deze waarde kan worden ontsloten door een groter deel van de Nederlandse beroepsbevolking over te zetten naar slimme werkconcepten. Hoewel dit getal tot stand is gekomen op basis van macro-economische schattingen en daarom verschillende onzekerheden kent, biedt het wel een orde van grootte voor het enorme potentieel dat nog kan worden ontgrendeld in de toekomst.

Ten tweede hebben de uitkomsten duidelijk aangetoond dat slim werken een kwestie is van 'we all beneft'. De integrale impact van slim werken is positief voor alle belanghebbenden: werknemer, zijn werkgever en de samenleving als geheel. Bij het bekijken van deze groepen belanghebbenden is de ontvanger van het grootste voordeel - in de meeste gevallen - de werknemer. Dus concluderen we dat slim werken, indien correct toegepast, vooral goed is voor medewerkers zelf.

Ten derde laat de integrale visie op slim werken, door middel van gematigde impactstatements, zien dat de sociaaleconomische gevolgen dominant zijn over de milieueffecten. Het grootste voordeel van slim werken is 'waarde van tijd', kostenbesparingen, productiviteitswinsten en vermeden verkeersincidenten.

Ten vierde hebben we verschillende werknemersprofielen beoordeeld en verschillende scenario's gemodelleerd voor slim werken voor deze groepen. De uitkomsten laten zien dat voor het profiel 'intellectuele werker', die op elk moment en op elke plaats een groot deel van zijn werk kan uitvoeren, vooral geschikt is voor het toepassen van slim werken.

Ten slotte stellen we voor dat organisaties dit model gebruiken voor de besluitvorming. Het zou hen kunnen helpen met het inschatting van de potentiele voordelen van slim werken voor mens, organisatie en maatschappij.

Management Summary

“Smart working” entails the concept of being able to work wherever you want and whenever you are. This means that employees can add value to their organizations regardless their geographical location or hour of the day. Enabling employees to work smart has multiple effects on employee, its employer and society at large.

Much research has been done over the past years highlighting the impact of smart working. However, most research is focused on one of the issues (such as the environmental impact) and hence an integral and consolidated view is missing.

The results of this project provide a holistic and integrated view of the most important impacts of smart working. Since this is a first exploration of the subject, not all potential effects could be included, such as congestion effects or increased stress due to smart working for example.

We have established this integral view for eight of the most relevant direct impacts for employee, its employer and society at large in a quantitative and monetized way. To our knowledge this is the first research that maps the integrated direct impacts to individual stakeholders. The most important results of this approach include the following.

Firstly we estimate that there is about €5 billion of potential available in the Dutch society. This value could be unlocked by transitioning a larger part of the Dutch workforce to smart working concepts. Although this number is based on macro economic estimates and hence has several uncertainties, it does provide an order of magnitude for the enormous potential that remains to be unlocked in the future.

Secondly, the outcomes clearly showed that smart working is a matter of ‘we all benefit’. The integral impact of smart working is positive for all three stakeholder groups assessed: employee, its employer and society at large. When looking at these stakeholder groups, the receiver of the biggest benefit is –in most cases- the employee. So we conclude that smart working, if applied correctly is mostly good for employees themselves.

Thirdly, the integral view of smart working, by means of monetized impact statements, shows that the socio-economic impacts are dominant over the environmental impacts. The biggest benefit of smart working is ‘value of time’, cost savings, productivity gains and avoided traffic incidents.

Fourthly, we assessed different employee profiles and modelled various scenario’s for smart working for these groups. The outcomes reveal that for the profile ‘intellectual worker’, who has the ability to perform a large share of its work at any time and at any place, is especially suitable for applying smart working.

Finally, we propose that organizations use this model for decision making. It could help them assess if their organization would benefit from smart working.

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How to read this document

This report summarizes an impact study about ‘smart working’ which we performed for VodafoneZiggo. The document is structured in various sections. In the introduction we explain the project rationale, its scope and the most important foundational definitions. The results section highlights the most important findings and their interpretation. We provide interested readers with methodological details in the approach section. In this section we also explain the most important limitations of the approach used. This chapter is structured along the lines of the various impacts (social, environmental, economic). In the subsequent appendix section we provide additional details such as details outcomes and assumptions used and an FAQ overview.

At the top of each page we highlight the relevant section to ease navigation.

Introduction

project rationale

Remote working in a nutshell

The concept of “smart working” has been around for quite some time and it is here to stay. It was after the adoption of the internet that smart working picked up momentum and the corporate world embraced a concept of working which allowed employees to work whenever, wherever they wanted. Continuous technological advancements and the emergence of a digitally native generation have resulted in the rise of an online economy in which value is created and delivered in an entirely different manner. For example, video conferencing enabled multinationals to avoid time consuming and expensive flights as well as reducing its environmental footprint. For several companies smart working has resulted in significant cost savings. One of the most striking examples is IBM, which managed to reduce its office space with 78 million square feet resulting in annual cost savings of over 100 million euro’s. Besides reducing air miles, also regular commuting has drawn attention due to its impacts. Employees are increasingly enabled to work from home and nowadays it is even perceived as an advantage by employees to have the luxury of scheduling their working day around kindergartens and sports activities. Smart working also requires investments like IT equipment and training. Also higher structural costs are associated with smart working since the work environment will be organized in a more decentralized manner.

The integral view is missing

Several of the impacts of smart working are easily quantified but other effects are less easily surfaced. Therefore the question remains, what are the impacts and which benefits are attributed to whom? In most research, specific elements of smart working are highlighted and hence there is a need to get a view of the impacts of smart working that is better integrated and one that shows the impacts in relation to each other. A view that explains who is receiving which benefits and which costs.

Impact measurement

With over 4,9 million subscribers in the Netherlands alone, and part of them already “working smartly”, VodafoneZiggo therefore wanted to measure the impact of the concept “smart working”. This provides clients of VodafoneZiggo with valuable insights to make better decisions regarding smart working. This research aims to help companies in building the business case for smart working by explaining, quantifying and monetizing the impact per stakeholder category.

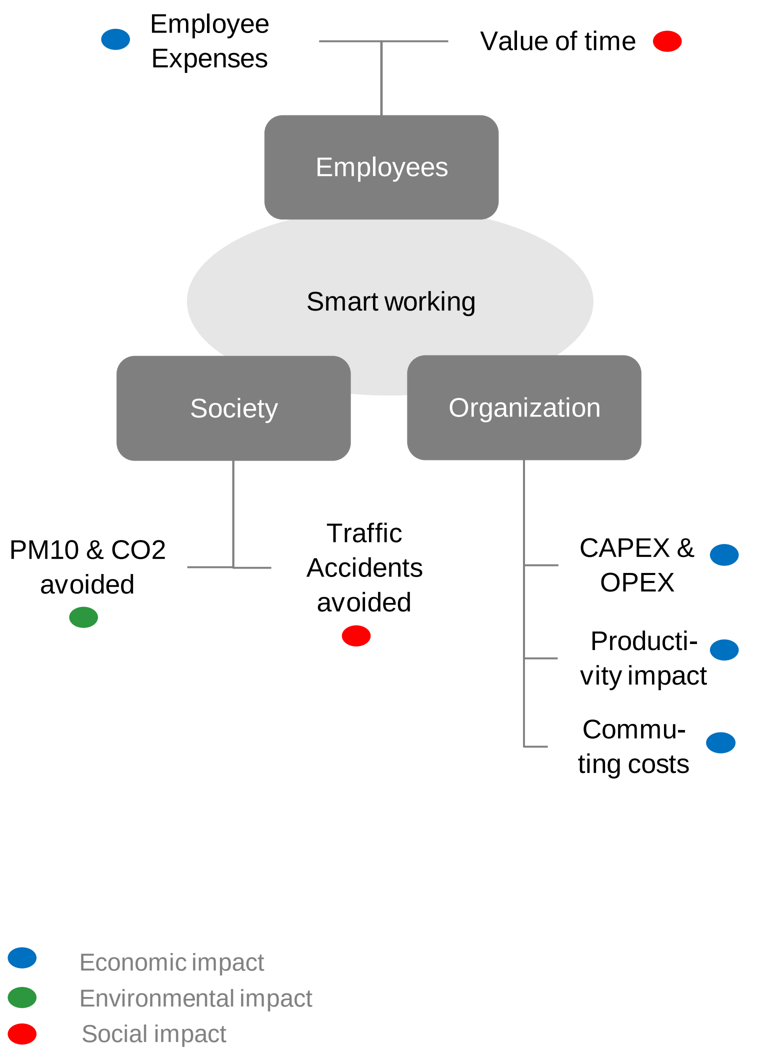
Introduction

scope & definitions

Throughout this report we describe, interpret, quantify and monetize various impacts. On this page we provide the reader with the scope of our analysis and the respective definitions of all impact categories. At the right hand side of this page we also link these impacts to relevant stakeholders and impact categories (social, environmental and economic). All analyses performed are based on the impact categories described below. The shortlist of these categories was defined in the initial stage of this project, limiting ourselves to 'most material' impacts only.

Economic impact categories	
Employee expenses	Is defined as the direct expenses by employees as a consequence of smart working. Includes meal costs, coffee, as well as increased costs of energy used when working at home.
OPEX	Is defined as the additional operational expenditure by organizations to enable smart working. It includes e.g. costs for virtualization, license costs for windows365 and increased network capacity, but also savings of costs for office space.
CAPEX	Is defined as the capital expenditure by organizations to enable smart working. Includes a write-off / depreciation method. It includes adaptation costs for meeting rooms, training for employees as well as equipment costs.
Productivity impact	Is the monetized impact for productivity changes. It is based on modeling assumptions based on percentages for non-creative and creative tasks, the related net increase or decrease in productivity and the associated salary costs
Commuting costs	Is defined as the difference on direct travel costs made by organizations for employees commuting.
Social impact categories	
Value of Time	Is defined as the monetized impact that accounts for the 'time saved' by employees that they can spend on other activities
Traffic Accidents avoided	Is defined as the monetized impact of avoided traffic incidents based on the avoided km's of car traffic used for commuting.
Environmental impact categories	
CO2 avoided	Monetized environmental impact as a consequence of avoided CO2 emissions
PM10 avoided	Monetized environmental impact as a consequence of avoided PM10 emissions. PM10 is an indicator for emissions related to particulate matter.

Smart working impacts in scope of this report



Impact potential for the Netherlands

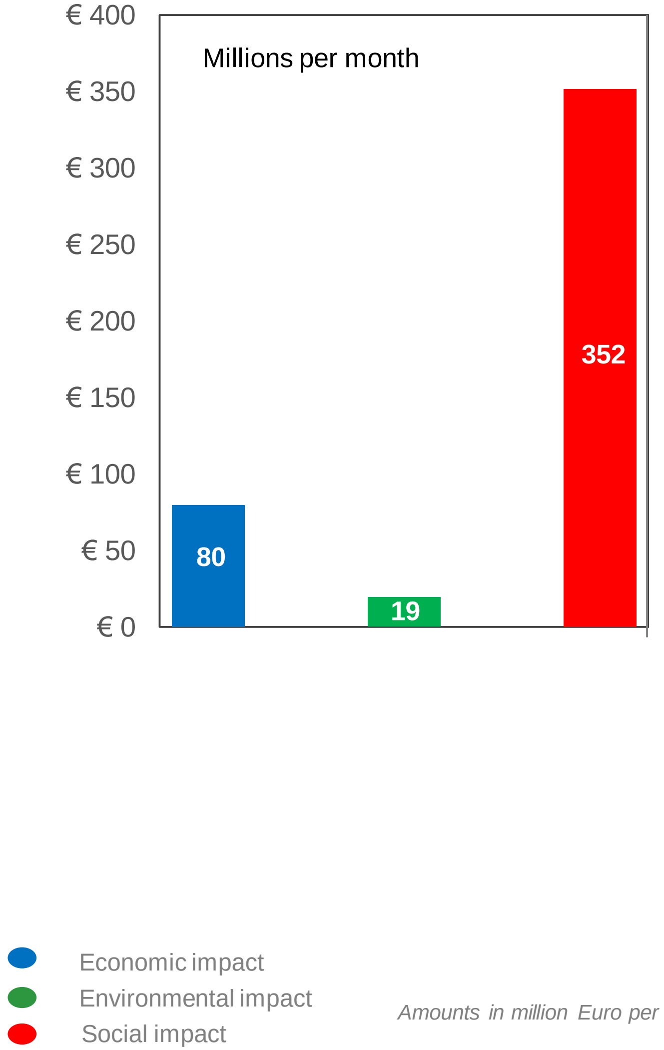
Smart working could unlock €5 billion per annum of potential societal impact

In a country like the Netherlands with a solid digital infrastructure, the potential of smart working is expected to be significant. A significant part of the total Dutch workforce employees (in total equaling 8.3 million) are already applying some sort of smart working (CBS, 2015). However, the majority of the Dutch workforce (64% of all employees in The Netherlands) do not yet apply smart working concepts, indicating a large potential to achieve further societal impact. However, certain job requirements limit the transition to smart working, mostly for 'first line workers'. Based on the assumption that roughly half of the amount of employees, not yet applying smart working, could apply smart working, we estimate that there is a remaining potential for ~2-3 million employees in The Netherlands that could adopt smart working practices.

If 2.6 million Dutch employees would adopt smart working practices, the impact created is estimated to equal €450 million per month, equaling an impact in the range of €5 billion per year. This impact mainly consists of social impact, through reduction of traffic incidents as well as 'value of time'. The second largest impact is economic impact, mostly driven by cost savings and productivity gains. From an emission perspective smart working will reduce CO_2 emission with approximately 370 kton (this includes the emissions associated with remote working)

These estimates have been created by assuming that each of the potential smart workers would work from home one day and travel outside of rush-hour both for one day per week. Hence we are calculating the value of smart working for everyone who is not already working smartly. Moreover, The average Dutch salary of € 2.739,- in 2015 is used (CPB 2015), and we have assumed that 50% of tasks are routine & repetitive.

Total estimated impact per category for the Netherlands on monthly basis



Amounts in million Euro per month

Smart working: who benefits and why?

Various stakeholders benefit from smart working

Smart working proves to be a concept that is beneficial to all stakeholders: transitioning to smart working has a positive impact on employees, organizations and society at large. Smart working, if successfully implemented, is therefore envisaged as a 'we all benefit' type of project.

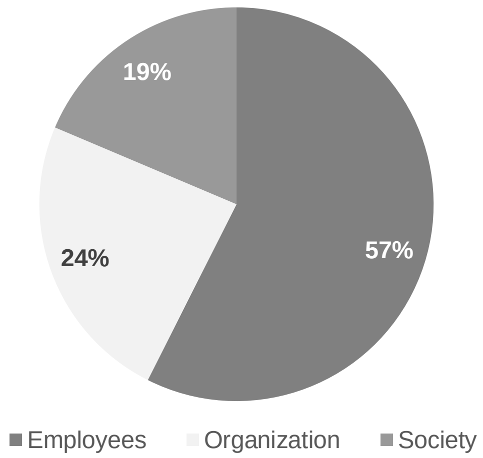
Based on an average scenario (one day per week working from home and one day per week travel outside of rush-hour) we have calculated the benefits for the three stakeholder groups indicated. The results are presented in the figures at the right hand side of this page and discussed below.

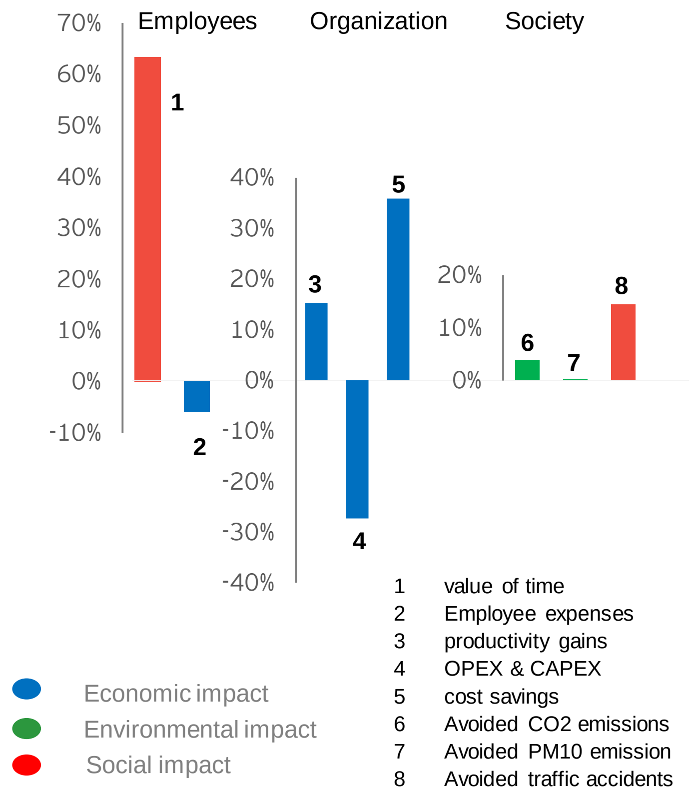
The largest portion of impact is received by employees themselves (57%), originating mostly from 'value of time' gained by spending less time on commuting. Employees may face additional costs due to working from home, but in monetary terms these costs are insignificant compared to the value of time gains. It should also be noted that in relation to net wages, these additional costs are relatively small.

Organizations that transition to smart working are the second largest receiver of impact, driven by economics. This impact includes productivity gains as well as cost savings. Our model reveals that a successful transition leads to an overall positive business case in economic terms.

Society at large also benefits from smart working due to the creation of social and environmental impact. 19% Of the overall impact is created for society mainly driven by a lower number of traffic incidents and, to lesser extent, the lowered environmental impact.

Impact distribution of smart working for various stakeholder groups





Defining employee archetypes

The ‘one size fits all’ principle does not apply to smart working

Within organizations people perform different tasks, earn different wages, have different backgrounds, ambitions and responsibilities and may have distinct extents to which “smart working” is applicable to their situation. One can imagine that the average hotelier or first aid doctor may not be able to deliver as much added value to their organization when working from home (or a lunchroom around the corner), compared to being at work.

Next to that, scientific research shows that some tasks are more suitable to perform at home than others. Research (Dutcher 2012; see our reference chapter) shows that non-routine tasks (such as creative tasks) tasks are done more efficiently when working from home, whereas dull and hence repetitive tasks are done less efficiently when at home. In order to quantify the impact of smart working, we have developed 5 archetype employees which we describe in more detail below:

1. First-line workers form the basis of our analysis. These workers are e.g. hoteliers, manufacturing operators, grocery store cashiers, mechanics or hospital nurses whom are unable to add value without being physically present. Such employees are expected to commute on a daily basis and thus have no primary benefits from smart working

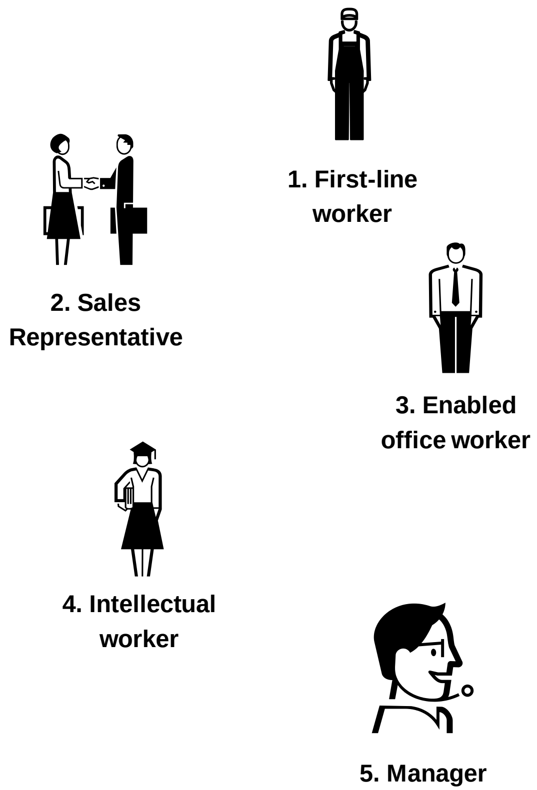
2. The second archetype are sales representatives. These employees have frequent client interactions for which they need to travel on a daily basis. This group of people rarely works full days at home, however this group does have the ability to avoid rush-hours and hence to work in a flexible way.

3. The third group is named enabled office workers. This typically includes jobs with repetitive tasks and regular interactions with colleagues. This could for instance include personnel from logistics that perform tasks such as order fulfillment or bank personal performing control activities. This group has high potential to work from home as their task can be performed anywhere. But this group may also face potential negative productivity effects due to the repetitive character of their work.

4. The fourth archetype used in our analysis are named intellectual workers. This group consists of employees in various types of jobs that have a low percentage of repetitive tasks and with activities that can be performed anytime and anywhere. This includes for instance research employees or consultants often with above average wages.

5. Finally, there is the manager group. This group of employees are reasonably flexible in their working hours but require frequent ‘live’ interactions with colleagues and therefore need to be at the office most of the time.

These archetypes are used as a basis for the analysis. Although the profiles have been carefully selected, they are fictitious in nature. Details regarding these archetypes are provided in the appendix.



Five archetypes of workers used in our analysis

Impact per employee archetype

One size fits all does not apply for smart working

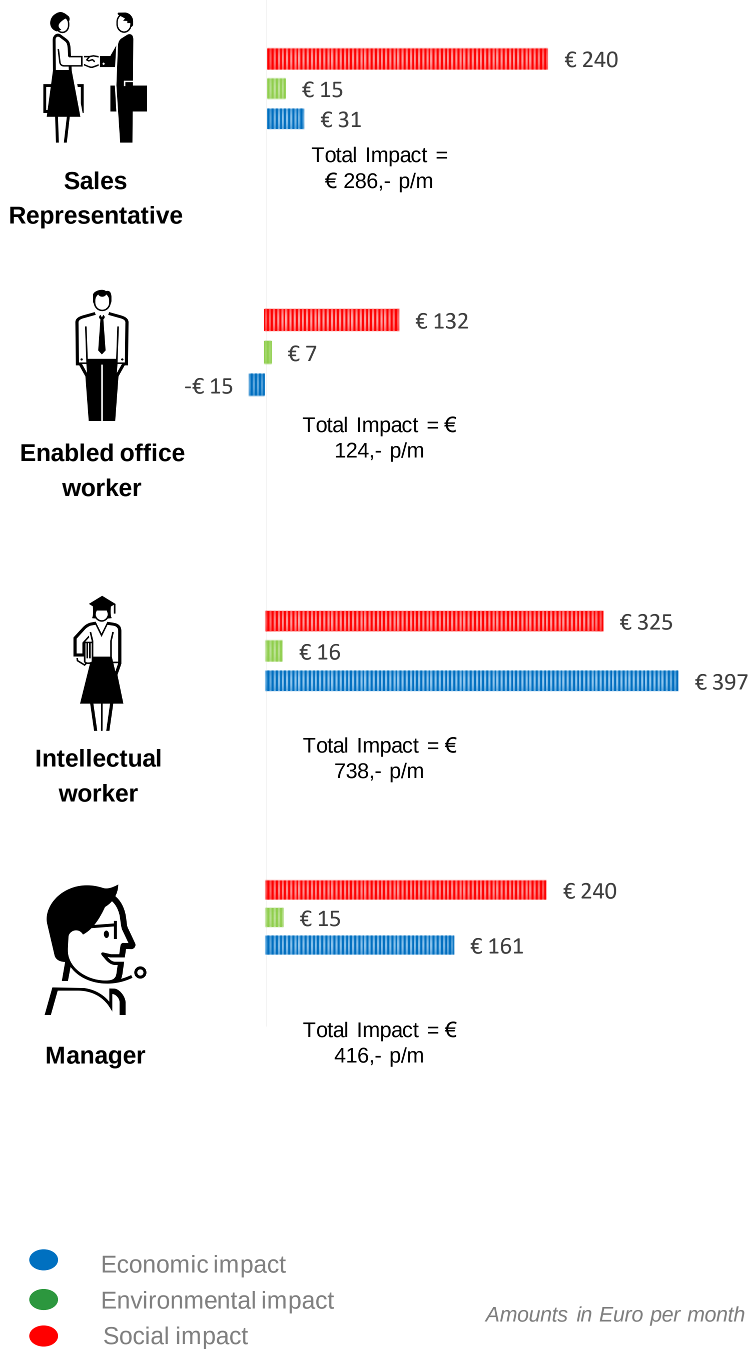
We have calculated the total and cumulative impact for the different archetypes outlined on the previous page. The results are shown at the right hand side of this page.

These results show that the intellectual worker profile is the type of job with the most significant impact. This is resulting from the fact that this type of job allows the work to be performed anytime and anywhere. Moreover, this type of work is expected to benefit from productivity gains due to the nature of the work. The enabled office worker, with a large percentage of repetitive tasks, benefits much less from smart working and even may face negative productivity effects due to the nature of the work. The manager and sales representative archetypes both also show positive benefits from transitioning to smart working, mostly originating from 'value of time' gains for employees.

For all employee profiles, the social impact created is material, regardless their salary and type of work they perform.

The environmental impact gains originating from transitioning to smart working are marginal when monetized, in comparison to the direct social and economic impact.

Total impact per category for four employee archetypes



Impact per organization archetype

Overall impact of smart working differs per organization type

The impact of smart working for organizations is dependent on the organization profile. It is the type of employee profiles that companies need, in combination with company culture and ways of collaboration that determine the potential for smart working in the end. Therefore, a ´one size fits all´ approach is irrelevant for a transition to smart working. Such a transition, requires a thorough analysis of current working practices for various functions within the company. Some employee groups may not benefit from smart working at all, while other employee groups may benefit from working from home for several days per week. We highlight several fictitious companies below as an example (details on these three case studies are provided in the appendix).

Manufacturing plant

This type of organization has a large proportion of first-line workers. One can think of hospitals, hotels and manufacturing plants. A relative high share of the workforce performs repetitive tasks which need to be performed on site. Therefore only a small share of the activities can be transitioned to smart working for a limited number of employees. Therefore, for a manufacturing company, only a limited impact is received when transitioning to smart working.

Bank

Banks already have embraced smart working over the past years. A bank tends to have a relatively higher percentage of intellectual workers and does not by default require employees to start their working day at a fixed point of time during the day. Therefore the benefit of smart working are significantly larger in comparison to the manufacturing plant. However, given the nature of a bank, one can think of possible side effects related to smart working, such as the confidentiality of data, privacy and other security related issues. Please note that such qualitative factors have not been taken into consideration in our model and require additional research.

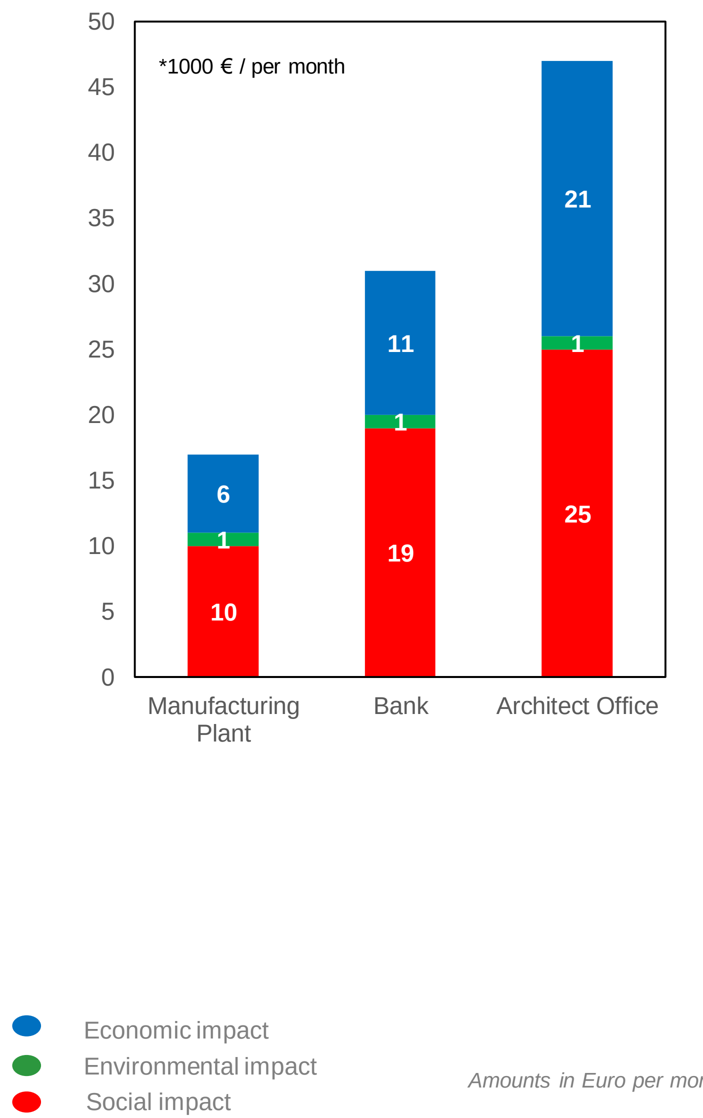
Architect office

These companies typically employ staff that perform mostly non-repetitive and creative tasks. In this case smart working also will have a positive impact on employee productivity. Similar types of organizations include a marketing agency or the editorial office of a newspaper. These types of organizations show the most significant impacts in our analysis.

Materialize untapped potential

From CBS data we learned that there is much untapped potential available in the market. A manufacturing plant with a significant marketing department would equally benefit from implementing smart working compared to a medium sized architect office. The advice to companies would be to assess this more at micro level rather than organizations as a whole as specific roles or functions could benefit from smart working within each organization.

Total impact per category for three archetype organizations (all 100 employees)



Amounts in Euro per month

Project approach

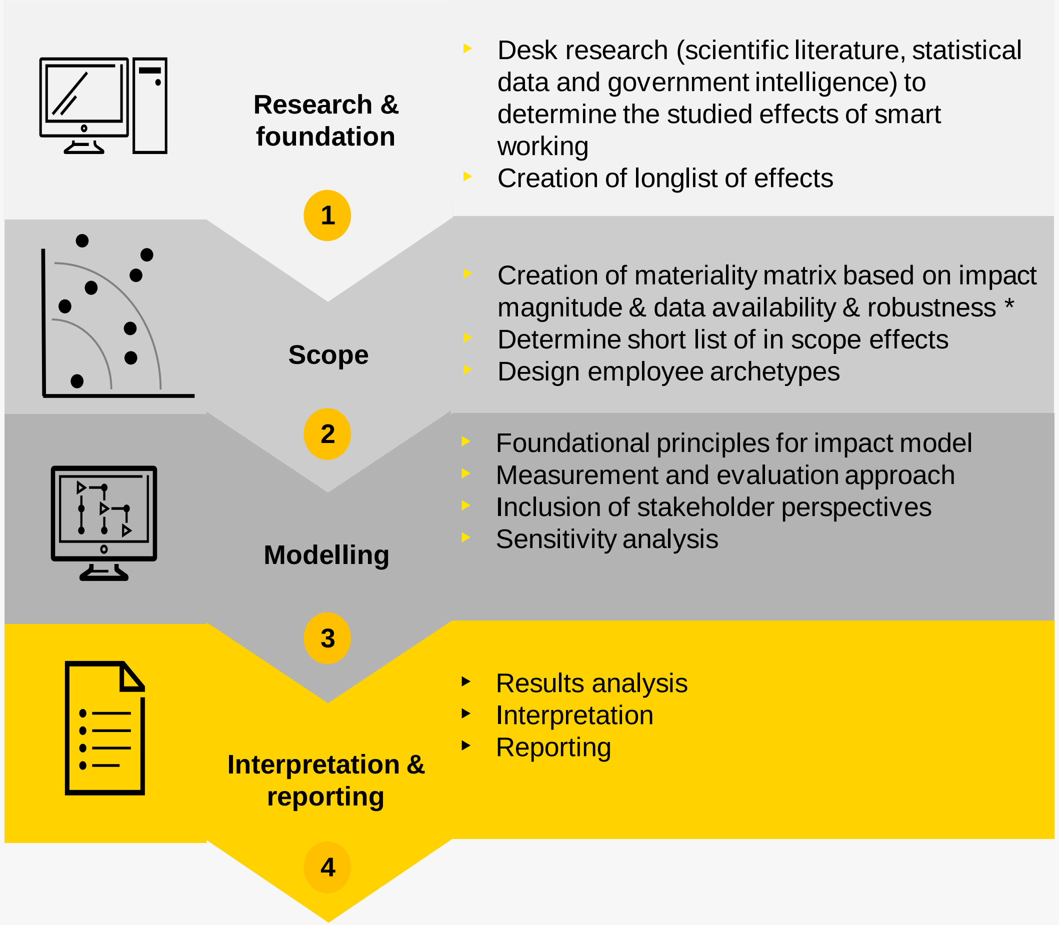
Our approach was based on four key steps

We have used four key steps in our approach that are highlighted in the figure. Firstly and because of the fact that much research has already been done over the past year, the approach taken was based on leveraging and integrating existing studies on smart working. Hence we commenced with basic desk research to obtain a holistic view of all the effects of smart working. We include a list of references used in this appendix.

Secondly we built in a 'deduction' step to determine the scope and boundaries of the project. As it is not possible to include all effects, we have focused this work on the most material effects of smart working. Material in this sense embodies the concept of focusing on what is essential and most relevant to key stakeholders. Several of the impacts that have not been included in this project are listed at the bottom of this slide.

Thirdly, we built a model to quantify and monetize the impacts. This model was based on a comparative impact modelling approach described on the next page. Moreover we applied a measurement & valuation approach for each impact, based on several assumptions and limitations. These are explained in detail in the subsequent pages of this report. During the modelling phase we performed several sensitivity analyses to assess the robustness of the model.

Finally, results of the model were analyzed and interpreted. These have been summarized in this underlying report.



**Our approach was focused on limited set of most material (and first order) impacts, therefore several impacts were not included in the analysis such as:*

- *Reduction of congestion*
- *Enhanced perceived flexibility and autonomy*
- *Reduced cohesion among employees*
- *Increased stress level due to blurred work-life balance*
- *Reduced health due to less physical activity and poor ergonomic home office*
- *Improved employee motivation causing high productivity / output*

Foundation for impact modeling

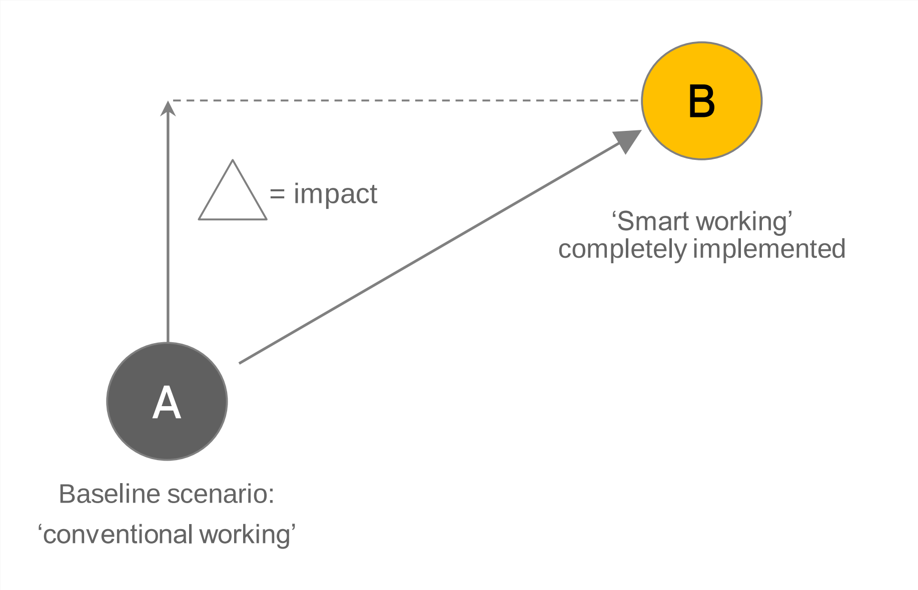
We choose a comparative modelling approach

The basis for the model is that we make a comparison of smart working to the baseline scenario. The calculated impacts in this project are therefore solely based on the changes ('delta') of the standard work routine (situation A in the figure) by applying smart work (situation B in the figure). We have made the assumption that in this situation, smart working was completely implemented in an effective way in situation B. The model fulfills the role of a fictional case where a company wants to apply smart working.

The model is built bottom-up in a way that the impacts per employee provide the basis for the calculated economic, ecological and social impacts, but also for each stakeholder; the employee, the company and the society. The results are calculated per calendar month. The model calculates the impacts by means of five basic average variables: Income, number of days working at home, number of days traveled outside rush hour, percentage of creative tasks and percentage of routine tasks performed. These variables enable the model to create "personas" of employees, which in turn can be aggregated to model business profiles. The impact, or delta, is determined by starting from a basic persona who is unable to work smart, because, for example, these employees are responsible for customer contact or perform other physical tasks at the workplace.

Income is used to calculate productivity impacts, including the impacts on absence from work by applying smart working. For the calculation of productivity impacts, the percentages of creative versus routine tasks are used. The number of days per week expected per type of employee to be able to work at home is used to model the differences in CO_2 and PM10 emissions by transport, gas and electricity, as well as reduction of time lost while commuting, avoided travel costs, cost differences for electricity and gas use, the difference in office costs and the differences in social costs of road accidents. The number of flexible travel days (hence, avoidance of peak travel during rush hour) a week is not modelled to affect the travel distance, but does affect the travel time and transport emissions.

Obviously, the direct costs of smart work are included in the model, such as the OPEX and CAPEX that need to be incurred in order to enable employees to work smart. However, these are fixed monthly costs and are not affected in the model by the basic variables in the model described above. In other words, OPEX and CAPEX are modelled binary (workers are enabled or not enabled)



This study is the first step in quantifying the value of smart working for employees, companies and society at large. Due to the nature of this study, a selection of material impacts has been included in the model to arrive at an initial overview of the value creation of implementing smart working enabled by VodafoneZiggo solutions. Since this is an initial model, assumptions are required to enable the calculation model to produce these initial results. Emphasis has been given to the robustness of external scientific sources for the most important variables in the model. Other sources include data provided by VodafoneZiggo as well as expert estimations.

The results in this report reflect the outcomes of the calculated impacts using the data, scenarios, assumptions and estimates described in this report. Due to the explorative character of this project, a dynamic model has been built to facilitate any future insights, such as new or better data or additional impacts. Details on the model are provided in the next pages.

Modeling the Economic impacts

Modeling of Productivity change, Travel costs, Home-working costs, OPEX, and CAPEX of smart working

Productivity impact
The modelling of productivity is based on (Dutcher 2012) which shows an increase in productivity of 15,5% for creative tasks and a decrease of 8% in productivity for non-creative (routine) tasks when working from home. This is incorporated in the model by calculating the net increase or decrease in overall productivity using the inputs for creative and non-creative tasks of each persona, combined with the amount of home-working days. This percentage in productivity is then multiplied with the respective wage costs of a persona, following the reasoning that if productivity is increased with 1% a company would require 1% less employees to achieve the same business results.

Commuting costs
For each day one employee works from home, no home-work travel is needed, which is modeled as avoided costs from car, train, and bus/metro/tram travel. For each transport modality, specific data was used for the average two-way home-work distance per selected modality: 66km for car travel, 96km for train travel and 20km for bus/metro/tram travel (Research Vodafone). CBS data is used to establish the average amount of workers using each selected modality (source: CBS Transport en mobiliteit 2016). Subsequently, the amount of avoided km’s per modality is multiplied with the average costs per km for each transport modality, where 23,3 cents/km is used for car travel (source: Nibud 2017) and 19 cents/km (Belastingdienst 2017) is assumed for the public transport modalities.

Expenses
The economic costs incurred by the employee when working from home are built-up from heating and electricity costs, as well as costs estimations for coffee and lunch. For coffee and lunch costs, a total of € 2,31 is modelled (Belastingdienst, Nibud, Albert Heijn). The gas and electricity costs are extrapolated by multiplying the increased use of gas and electricity required for working from home with their current costs: € 0,20/kWh and € 0,65/m3 natural gas.

OPEX
The operational expenditures are obtained from VodafoneZiggo for direct costs, such as software applications and increased network capacity. These costs are modelled as monthly recurring costs, independent of the degree to which an employee applies smart working. However, due to the fact that smart working will reduce the required office space, the OPEX decreases based on the average costs of a workplace (NFC Index kantoren 2016).

CAPEX
The capital expenditures are partly obtained from VodafoneZiggo (headset) as well as established by estimating increased costs for conference rooms, migration and training. Both CAPEX and OPEX costs are calculated based on Vodafone research.

Modeling Environmental impacts

The impact of smart working on CO2 and PM10 emissions

CO_2 and PM10 avoided
For each day one employee works from home, no home-work travel is needed, which is modelled as avoided emissions from car, train, and bus/metro/tram travel. For each transport modality, specific data was used for the average two-way home-work distance per selected modality: 66km for car travel, 96km for train travel and 20km for bus/metro/tram travel (Vodafone research). CBS data is used to establish the average amount of workers using each selected modality (CBS 2016). Subsequently, the amount of avoided km's per modality is multiplied with the emission factors for CO_2/km (CO2emissiefactoren.nl) and PM 10/km (CBS & CROW) for each transport modality included in this study. The obtained emissions avoided for each day working from home are then monetized using values of €102,- euro/ton of emitted CO_2 and € 49.898,- euro/ton of emitted PM10. It is assumed that travelling outside of rush-hour does not significantly influence CO_2 and PM10 emissions of home-work travel, and is therefore not modeled as having an impact here, even though it will have an impact in reality.

CO_2 and PM10 emissions from heating and electricity
Working from home also affects the heating and electricity consumption at home, but also in offices. Domestic energy consumption in m^3 natural gas and kWh of electricity per day are based on (Röder 2014 & CO2emissiefactoren.nl) assuming that if an employee would not work from home, the employee's house is not heated and does not consume electricity. On the other hand, working from home should eventually lead to lower energy consumption in the office, partially redeeming the increased emission of home energy usage. The model assumes that offices are 50% more efficient per employee with regards to heating energy and electricity use. This is a course estimation, but due to the insignificant contribution of these emitted impacts this is not further investigated in this project. The fact that avoiding rush-hour also leads to a slight shift in energy use from the office to the residence of the employee has not been taken into account as well, since this also is not deemed to be material to the results of this study.

An important limitation in this initial study is the inclusion of CO_2 and PM 10 emissions, whereas the range of emissions and other environmental impacts is broader than this. Even if CO_2 equivalents are being applied in the model, these would not include the impacts such as resource depletion. This would suggest that inclusion of more environmental impacts (up to 16 different so-called "characterization factors") such as resource depletion, acidification, eutrophication etc. would paint a more complete picture of the environmental benefits of smart working applied in practice. However, compared the e.g. the value of time for employees, current valuations of environmental impacts are still likely to remain relatively insignificant.

Modeling Social impacts

The Value of Time and societal costs of accidents

Value of Time

For each day one employee works from home, no home-work travel is needed, which is modeled as avoided loss of personal time from car, train, and bus/metro/tram travel. For each transport modality, specific data was used for the average two-way home-work distance per selected modality: 66km for car travel, 96km for train travel and 20km for bus/metro/tram travel ((Vodafone research). CBS data is used to establish the average amount of workers using each selected modality (CBS 2016). Subsequently, the amount of avoided km's per modality is multiplied with the average minutes/km commuting requires: 1,19 minutes/km for car travel (CBS), 3 minutes/km for train travel (KPVV 2013) and 3,84 minutes/km for bus/metro/tram travel (CBS). Combining the average amount of km's travelled with the amount of time/km yields the average amount of time spent on during home-work travel, which is then monetized using the concept of Value of Time (KIM 2013). This source shows how much it is worth for an average person to avoid 1 hour of car, train and bus/tram/metro travel. After correcting these values for inflation, the value 1 hour of car travel is € 10,01, € 12,45 for 1 hour of train travel and € 8,39 for one hour of bus travel. Additionally, the model also includes the avoided commuting time by enabling employees to travel outside of rush-hour. It is estimated that commuting outside of rush-hour will save the employee 50% of their normal travel time. The additional time savings for commuting outside of rush-hour are added to the time saved by not commuting due to working from home, and together constitute the total Value of Time experienced for type of employee defined in the persona's.

Traffic accidents avoided

Not having to commute also reduces the risk of traffic accidents: the underlying assumption is that if there are less commuters, there are less

accidents. For modeling of the impacts of smart working, data on the average annual societal costs of car traffic accidents in The Netherlands is combined with the total amount of km's driven by car in The Netherlands to estimate the average cost/km of road accidents. According to (CE Delft 2016), annual accident costs are 14 billion, and total km's driven by car in The Netherlands is estimated at 131 billion km's (CBS). Having established the avoided km's per day and combining with the societal costs of accidents the model arrives at calculated figures for the estimated avoided societal costs of car traffic accidents due to less km's driven by the employees. Only car traffic data was available and incorporated in the model, future work could include other transport modalities as well: for now the impacts for public transport are expected to be insignificant, but for bicycle transport this might not be the case.

References

Category	Source	URL
# smart workers in NL	CBS, 2015	https://www.cbs.nl/nl-nl/achtergrond/2017/04/thuiswerken-door-werknemers-en-zelfstandigen
Productivity gains creative vs routine tasks	Dutcher, 2012	http://www.sciencedirect.com/science/article/pii/S0167268112000893
Value of Time	KIM 2013	https://www.kimnet.nl/publicaties/rapporten/2013/11/18/de-maatschappelijke-waarde-van-kortere-en-betrouwbaardere-reistijden
Average income	CPB, 2015	http://www.gemiddeld-inkomen.nl/inkomens-vanaf-1970/
Average commuting distance	CBS, 2016	https://www.cbs.nl/nl-nl/publicatie/2016/25/transport-en-mobiliteit-2016
Public transport costs	Belanstingdienst, 2017	https://www.belastingdienst.nl/bibliotheek/handboeken/html/boeken/HL/thema_s-vervoer_en_reiskosten.html
Car transport costs	Nibud, 2017	https://www.nibud.nl/consumenten/wat-kost-een-auto/
Lunch at home	Nibud, 2017	https://www.nibud.nl/consumenten/wat-geeft-u-uit-aan-voeding/
Coffee at home (average cupprice)	Albert Heijn	www.ah.nl
Lunch at work	ING 2015	https://www.ing.nl/particulier/economisch-bureau/archief/archief-economische-berichten/2016/01/prijzen-bedrijfskantine-stijgen-drie-keer-sneller-dan-inflatie.html
Lunch at work	Belanstingdienst	https://download.belastingdienst.nl/belastingdienst/docs/nieuwsbrief_loonheffingen_2017_lh2091t72fd.pdf
Average trafer distance	Vodafone research	Smart working Direct research (Jeroen Jansen & Jeroen Boukens)
CAPEX & OPEX	Vodafone research	OPEX and CAPEX calculation
Breakdown travel modalities	CBS, 2016	https://www.cbs.nl/nl-nl/publicatie/2016/25/transport-en-mobiliteit-2016
CO2 emissionfactors (cars, public transport)	co2emissiefactoren.nl	www.co2emissiefactoren.nl
PM10 emissions car & bus	CBS	http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=7063&D1=12,16,24,44,48,56&D2=0-8&D3=2,12,22,l&VW=T en https://www.crow.nl/documents/kpvv-kennisdocumenten/ce-delft-stream-
PM10 emissions Public transport	CROW	https://www.crow.nl/documents/kpvv-kennisdocumenten/ce-delft-stream-personenvervoer-2014.aspx?ext=.pdf
kWh consumption at home	Röder 2014	http://www.sciencedirect.com/science/article/pii/S1877050914006796
CO2 Emission per kWh	co2emissiefactoren.nl	www.co2emissiefactoren.nl
PM10 emssion per kWh	SimaPro - EcoInvent	SimaPro - EcoInvent
Travelspeed Public transport	KPVV	https://kpvvdashboard-16.blogspot.co.uk/2013/02/ov-in-steden-sneller-dan-in-landelijke.html
Travelspeed car & bike	CBS	Personenmobiliteit in Nederland; vervoerwijzen en reismotieven, regio's
Costs per transport accident	CE Delft	https://www.government.nl/binaries/government/documents/reports/2016/11/16/the-cost-of-road-crashes-in-the-netherlands/The+Cost+of+Road+Traffic+Accidents+in+the+Netherlands.pdf.
Kilometers travelled per year by car	CBS	Verkeersprestaties personenauto's; kilometers, brandstofsoort, grondgebied (Excel dump from site)
Average cost of office space	NFC Index 2016	https://www.nfcindex.nl/file/1497258236.9951crotry/nfc-jaarbericht-nl-2016.pdf
Average gasprice per M3	energiesite.nl	http://www.energiesite.nl/veelgestelde-vragen/wat-is-de-gasprijs-per-m3/
Average kWhprice	Consumentenbond	https://www.consumentenbond.nl/energie-vergelijken/kwh-prijs

Appendix I: detailed breakdown results, archetype employees & organizations

Scenario's for persona's and organizations

Throughout this report we have used scenario's to describe functions (persona's) and organizations. Below, we provide the reader with the detailed results of our calculations for each of the effects of smart working included in this study.

	Archetype employees				Organizations		
Effects	Enabled office worker	Sales representative	Manager	Intellectual worker	Architect office	Bank	Manufacturing Plant
Costs of Smart working	-€ 10	-€ 10	-€ 10	-€ 30	-€ 1.927	-€ 1.319	-€ 710
OPEX	-€ 25	-€ 25	-€ 25	-€ 7	-€ 3.105	-€ 2.760	-€ 1.380
CAPEX	-€ 12	-€ 12	-€ 12	-€ 12	-€ 1.108	-€ 984	-€ 492
Value of Productivity	-€ 28	€ 18	€ 148	€ 264	€ 15.379	€ 7.955	€ 4.591
Value of Commuting costs	€ 61	€ 61	€ 61	€ 183	€ 11.570	€ 7.916	€ 4.263
∑ Economic impact	-€ 15	€ 31	€ 161	€ 397	€ 20.809	€ 10.808	€ 6.271
Value of Time	€ 108	€ 216	€ 216	€ 252	€ 20.130	€ 15.996	€ 8.088
Value of Accidents	€ 24	€ 24	€ 24	€ 73	€ 4.623	€ 3.163	€ 1.703
∑ Social impact	€ 132	€ 240	€ 240	€ 325	€ 24.752	€ 19.159	€ 9.791
Value CO2	€ 7	€ 15	€ 15	€ 16	€ 1.294	€ 1.046	€ 525
Value PM10	€ 0	€ 1	€ 1	€ 1	€ 53	€ 44	€ 22
∑ Environmental impact	€ 7	€ 15	€ 15	€ 16	€ 1.347	€ 1.090	€ 547
Total impact	€ 125	€ 287	€ 416	€ 738	€ 46.908	€ 31.057	€ 16.610
Smart working days	1	1	1	3			
Flextravel day	1	4	4	1			
Wages	3.000	3.750	6.250	5.000		n/a	
%routine tasks	90%	60%	20%	30%			
%First line workers					10	20	60
%Enabled office worker					10	20	10
%Sales representatives		n/a			15	25	10
%Managers					15	10	5
%Intellectual worker					50	25	15

Appendix II: FAQ

Frequently Asked Questions

Q: What triggered this project?
It is the objective to provides readers with a holistic view of the impacts of smart working. Much has been written about smart working. However, from literature it is not easy to come to an integrated and consolidated view. Many research papers cover one or several selected impacts. It was the objective of this project to leverage existing information to create this integrated and consolidated view. Hence we choose to create 'integrated impact statements' with an economic, social and environmental dimension. This enables reader to see things in perspective as one common dimension is used.

Q: To whom is this project of interest and why?
This research provides insight in several of the most relevant primary impacts of smart working for society at large, the organizations and its employees. Therefore this project is of primary interest to decision makers within organizations that are considering smart working for (parts of) their workforce. The method applied will help reveal the expected benefits for each stakeholder. Moreover it will help identify employee groups for which smart working is most relevant.

Q: What are the most important results?
This project revealed that there is an untapped potential for smart working in the Netherlands of about €5 billion per annum. Moreover, this project revealed the various impacts for various function types in organizations. Organizations can use this information to make smart working 'fit for purpose'. The results also put the various impacts in perspective: the social and economic impacts are significantly higher than the environmental impact.

Q: which impacts were considered and which ones have been excluded?
It was not the objective to be complete. However we have choosen a scope and boundary that is focused on the most relevant impacts for society at large (CO2 & PM10), traffic incidents), employees (costs and value of time) and the organization (CAPEX,OPEX, commuting costs, and productivity). Note that second order effects have not been included in the analysis. Second order effects may include effects such as altered employee satisfaction affecting employee output. We also choose to exclude impacts that lack data maturity and hence could not be applied in a reliable way. An example impact category is ''increased stress level due to blurred work-life balance'.

Q: What are the most important limitations?
We have used the concept of impact measurement which means that we model the gap between two situation ('traditional working' versus 'smart working'). We thereby assume that smart working is completely and successfully implemented. Moreover, we have used proxy's and modelling to calculate various impact which are often based on market averages (please refer to the approach section for more details). This model thereby provides direction and does not have the objective to be perfect.

Q: Can I apply this method to my own organization?
Yes that is possible as long as you keep the limitations in mind and use input values that match to your organization. It is the type of organization (including e.g. culture etc.) and its employee groupds that e.g. will determine how many days certain employee groups could work from home.

Q: What is next?
This is a report in which we reveal the most important outcomes of the model. As a next step we propose to disclose the model to a wider audience in the form of a tool that can be used for decision making on company specific cases.

Appendix II: FAQ continued

Frequently Asked Questions

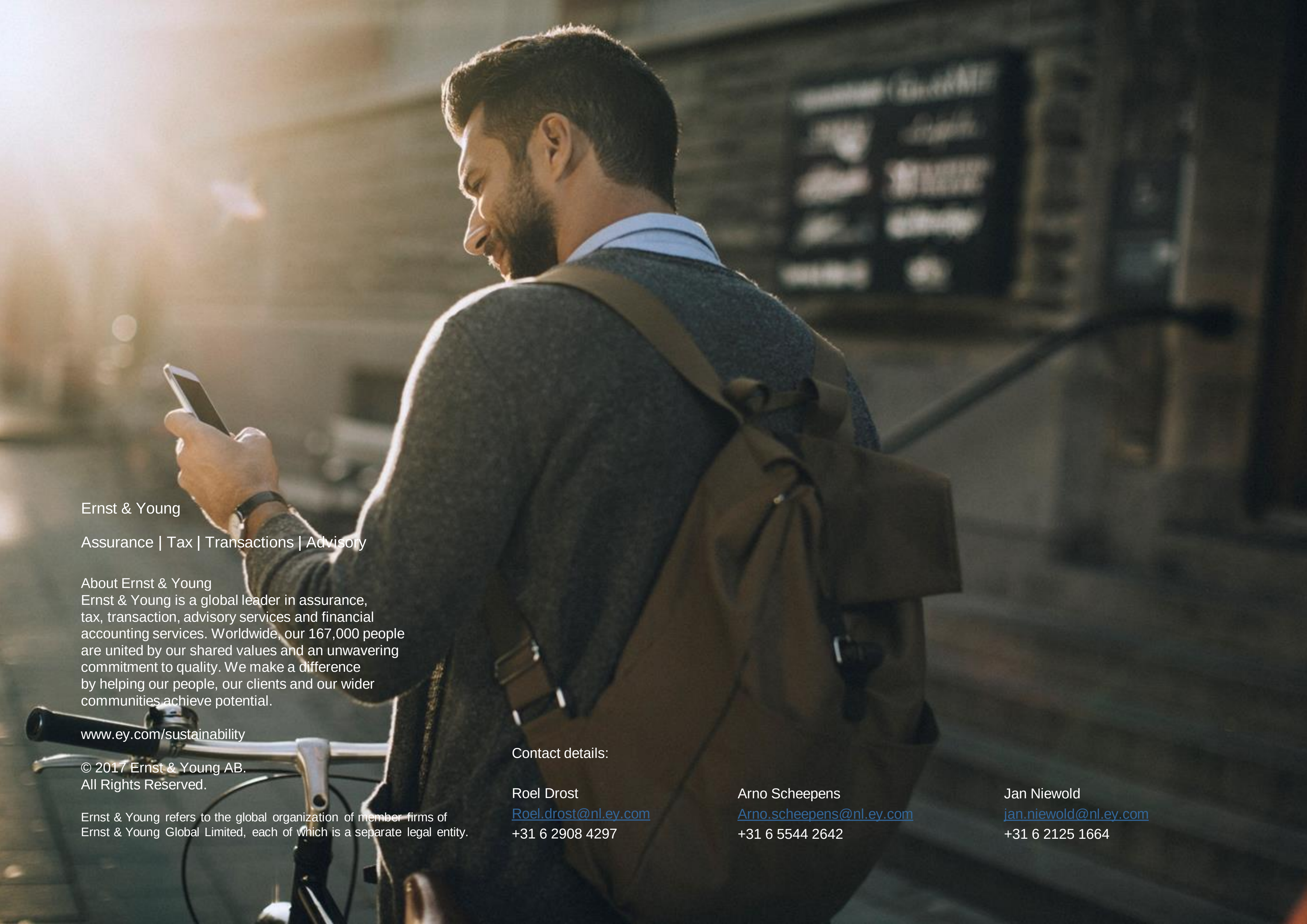
Q: Can you explain what the most important assumptions are that affect results and their interpretation?

This research is based on data from reliable sources as much as possible, but also several assumptions and estimations are required, which we explain in more detail in the approach section of this report. However, we provide the reader with indicative level of accuracy in the table below (the larger the number of dots, the higher the indicative accuracy with regards to the calculations). We have estimated the data quality used in our calculations by estimating the average data quality used for each impact category included in this study. Our estimations are based upon the Data quality indicators used in Life-Cycle Assessment, following ISO 14044:Time-related coverage, Geographic coverage, Technology coverage, Reproducibility, Source reliability, Consistency, Representativeness, Precision (variability of the data), and Uncertainty (EPA, 2016:Guidance on Data Quality Assessment for Life Cycle Inventory Data).

Impact category	Indicative accuracy	Explanation for accuracy scoring
Value of Time	●●●●	Measured travel distances per transport modality are used, and combined with data on time/per distance traveled for each transport modality as well as data on Value of time. Few assumptions and estimations are used, however *e.g.* more transport modalities could have been included to provide a more precise figure.
Productivity impact	●●	We estimate that there is medium source reliability as we based our modeling on the work of Dutcher. However the productivity impact is subject to uncertainty, since there still is much debate on the actual effects on productivity attributable to working from home and that it varies on a case by case basis.
Commuting costs	●●●●	The commuting costs are also based on the measured commuting distances for different transport modalities, and combined with relatively reliable data on direct costs per km in The Netherlands.
Traffic Accidents avoided	●●●	This calculation involves a straightforward method, but uses macro level data to estimate the avoided contribution to traffic accident costs of car travel alone.
OPEX	●●●	OPEX are calculated using primary data from VodafoneZiggo, combined with reasonable assumptions, but also high-level generic data on office costs leading to potentially high variability.
Employee expenses	●●●	Expenses have been based on generic assumptions such as average energy consumption data and external sources for lunch, coffee etc. This number will vary from person to person but on average high quality data is available regarding this category. However more elements might be included.
CO2 avoided	●●●	The use of emission factors combined with a low precision in the valuation of CO2 emissions leads to a medium data quality estimation.
CAPEX	●●●●	The calculations Include a write-off / depreciation method based on few assumptions and estimations combined with primary data received from VodafoneZiggo.
PM10 avoided	●●●	The use of emission factors combined with a low precision in the valuation of PM10 emissions leads to a medium data quality estimation.

Q: Which standards have been applied?

Natural & social capital accounting is an emerging discipline for which rule-based standards are not readily available. The standards we used include the greenhouse gas protocol (WBCSD), the natural capital protocol (NCC) and the social capital protocol (WBCSD).



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