Remote vs. On-Site Work: Predictive Modeling of Employee Productivity

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Course: Managerial Decision Making & Modeling	

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Abstract

Background: This document addresses an optimization problem for scheduling employees within a company to maximize net productivity. Given the total number of employees and current work distribution (on-site vs. remote), the company aims to optimize their operational setup in light of various constraints.

Purpose: The goal is to determine the optimal number of employees working on-site and remotely, and to decide on the number of offices required to accommodate the on-site workforce, while maximizing the company's net productivity.

Methodology: The problem is modeled using linear programming with the ‘pulp’ library in Python. Key variables include the productivity of on-site and remote employees, office rent, and carbon tax costs. Constraints ensure that employees with specific needs work remotely, a minimum number of employees are on-site, and office capacities are not exceeded.

Results: The model calculates the number of employees working on-site and remotely, the number of offices needed, and evaluates the total productivity, costs, and profit based on the optimal solution.

Conclusion: The solution provides a balance between maximizing productivity and managing operational costs. The company can adjust its work distribution and office space to achieve the best financial outcome while adhering to all constraints.

Summary

Problem statement

Generali is an insurance company having its activity in Italy. Its Executive Board decides to agree to a form of **hybrid contract** for its employees. The HR director has the objective to maximize the company's profits considering both on-site and remote employees, accounting for the costs associated with office management and the carbon tax. The model must consider the smart working exemption for fragile employees and those with children under 14 (assuming all take advantage of this exemption), and the constraint that there must always be a minimum number of on-site employees (including emergency personnel and people managers, who are the area officials).

System

Generali, an insurance company operating in Italy (we are referring only to the Milan and Mogliano offices), aims to optimize its workforce management to maximize productivity while minimizing costs. The company has introduced a hybrid work model, allowing employees to work either on-site or remotely. The decision-making process is guided by the Country Chief HR Officer, who needs to consider various factors such as employee productivity, office management costs, and environmental sustainability.

Assumptions:

- All employees eligible for smart working exemptions (such as parents of children under 14 and individuals with disabilities) choose to work from home.
- Employees with emergency duties and people managers must work in the office every day, regardless of other factors.
- The productivity rates for remote employees and on-site employees are constant and do not vary between individuals within each group.
- The costs associated with remote employees and on-site employees are fixed and do not vary between individuals within each group.
- Linear Relationship Between Productivity and Number of Employees: the total productivity of the company is a linear function of the number of remote and on-site employees.

Elements

The **Country Chief HR Officer (DM)** of the company has the objective to **maximize productivity**, while keeping lower costs, also considering the **negative externalities in terms of environmental sustainability**. There's a number N = (1,…,,n) of total employees **(entities)** , in which **Nh** = (1,…, nh) is the number of employees which work from home, and **Np** = N-Nh is the number of people working in office. Their in-office-days can be established to meet the objective, also considering that the employees are classified in different areas: DNA, AUTO, VITA, CONTABILITA'.

- There's a national agreement that allows all the people with certain characteristics to **always** work from home (i.e. parents of under 14, people with disabilities, etc..). We assume that all of them sign the agreement.

- Employees who join the **Emergency Team** or **People Manager** have the duty to go to the office every day.

- **Nh (remote workers)** have cost **c_Nh** and productivity **h**; **Np (in-office workers)** employees have cost **c_Np** and productivity **p**.

- Total costs per capita are made by office renting costs and environmental costs (carbon tax).

- Employees from specific areas can be required to go to the office in a certain %.

Agents/DMs

Country Chief HR Officer (DM): This is the main decision maker (DM). Their objective is to maximize productivity while keeping costs low, also considering negative externalities in terms of environmental sustainability.

Entities

- **Employees (N):** These are the main entities. Their characteristics include their work status (in-office or from home), their productivity, their costs and the area they belong to. Some employees have special characteristics that make them eligible to always work from home, while others are required to go in office.

- **In-office employees (Np):** These employees work in the office. Their characteristics include their productivity (p) and their costs (c_Np).

- **Remote employees (Nh):** These employees work from home. Their characteristics include their productivity (h) and their costs (c_Nh).

- **Employees with SW exceptions (Nf):** list of employees who will never go to the office.

- **Employees with duties (Ns):** list of employees who must go to the office every day.

Relationships among elements

- **Relationship between DM and employees**: The DM makes decisions that affect the employees, such as where they work. These decisions are constrained by various factors, such as national agreements and the company's needs.

- **Relationship between employees and their costs and productivity:** An employee's workplace (in-office or from home) affects their costs and productivity.

Other constituents of the system

- **National agreements**: These agreements allow certain employees to always work from home. These represent a certain internal uncertainty, as we assume that all eligible employees sign the agreement.

- **Environmental costs (carbon tax):** These are external costs that the company must consider. They represent an external disturbance to the system.

- **Office rent costs:** These are costs that the company must bear to keep the offices open. They represent another external disturbance to the system.

Mathematical model(s)

Sets

Set of Employees (E):

- **Description:** This set includes all employees in the company.
- **Elements:** $E = \{0, 1, 2, \ldots, N-1\}$
- **Use:** This set is used to index the decision variables x_i and in the summations within the objective function and constraints.

  i**:** Index representing an individual employee.
  Range: $i \in E$

Variables

- Decision variables

1. **x [i] (Binary)**
   Meaning: indicates whether employee 'i' works on-site or remotely.

   Nature: Binary (0 or 1)
   x [i] = 1 if employee 'i' works on-site
   x [i] = 0 if employee 'i' works remotely

2. **num_offices (Integer)**
   Meaning: represents the number of offices needed to accommodate on-site employees.

   Nature: Integer (non-negative)
   'num_offices' is the total number of office spaces required.

Parameters

- Total number of employees (N)
- Number of on-site employees in 2023 (Np)
- Number of remote employees in 2023 (Nh)
- Annual revenue in 2023 (fatturato_annuo)
- Maximum productivity per employee (max_productivity)
- Productivity percentage for on-site employees relative to the maximum productivity (p_perc)
- Productivity percentage for remote employees relative to the maximum productivity (h_perc)

- Scaling factor for productivity, calculated based on the annual revenue (z)
- Productivity per on-site employee (p)
- Productivity per remote employee (h)
- Annual carbon tax per on-site employee (carbon_tax)
- Number of workstations per office (u)
- Annual office rent for one office (affitto_per_ufficio)
- Employees with children under 14 or fragile conditions that must work remotely (Nf)
- Minimum number of employees that must work on-site (Ns)

Constraints

1. Employees with children under 14 or fragile conditions must work remotely:

$$\sum_{i=0}^{N-1} (1 - x[i]) \geq N_f$$

Ensures that at least 1.640 employees work remotely due to having children under 14 or fragile conditions.

2. Minimum number of employees that must be on-site:

$$\sum_{i=0}^{N-1} x[i] \geq N_s$$

Ensures that at least 2.301 employees (emergency personnel and people managers) work on-site.

3. Number of on-site employees does not exceed office capacity:

$$\sum_{i=0}^{N-1} x[i] \leq \text{num\_offices} \times u$$

Ensures that the number of on-site employees does not exceed the total capacity of the available offices (each office can accommodate ‘u’ workstations).

Objectives

Objective: Maximize Net Productivity (Profit)

The objective of the model is to maximize the net productivity of the company, which is defined as the total productivity of the employees minus the total cost of operating the offices and paying the carbon tax.

The objective function is given by:

Maximize Net Productivity = Total Productivity – Total Cost

$$Total\ Productivity = \sum_{i=0}^{N-1} \left(p \cdot x_i + h \cdot (1 - x_i)\right)$$

$$Total\ Cost = \sum_{i=0}^{N-1} (x[i] \cdot \text{carbon\_tax}) + \text{num\_offices} \cdot \text{affitto\_per\_ufficio}$$

Net Productivity

$$= \sum_{i=0}^{N-1} \left(p \cdot x[i] + h \cdot (1 - x[i])\right) - \left(\sum_{i=0}^{N-1} (x[i] \cdot \text{carbon\_tax}) + \text{num\_offices} \cdot \text{affitto\_per\_ufficio}\right)$$

Model

Maximize

$$\sum_{i=0}^{N-1} \left(p \cdot x_i + h \cdot (1 - x_i)\right) - \left(\sum_{i=0}^{N-1} (x_i \cdot \text{carbon\_tax}) + \text{num\_offices} \cdot \text{affitto\_per\_ufficio}\right)$$

Subject to:

$$\sum_{i=0}^{N-1} (1 - x_i) \geq N_f$$

$$\sum_{i=0}^{N-1} x_i \geq N_s$$

$$\sum_{i=0}^{N-1} x_i \leq \text{num\_offices} \times u$$

Decision Variables:

$$x_i \in \{0,1\} \quad \text{for } i = 0,1,\dots,N-1$$

$$\text{num\_offices} \in Z_{\geq 0}$$

Data collection

Variable	Description
N	Total number of employees
Np	Number of employees working on-site in 2023
Nh	Number of employees working remotely in 2023
fatturato_annuo	Annual revenue in 2023
max_productivity	Maximum productivity
p_perc	Productivity per on-site employee
h_perc	Productivity per remote employee
p	Productivity per on-site employee (calculated)
h	Productivity per remote employee (calculated)
carbon_tax	Annual carbon tax
u	Number of office workstations
affitto_per_ufficio	Annual office rent
Nf	Number of employees with children under 14 or vulnerable conditions
Ns	Minimum number of employees required to be on-site
x	Decision variable (1 if employee works on-site, 0 otherwise)
num_offices	Decision variable (number of offices)
Total Productivity	Total productivity (calculated)
Total Cost	Total cost (calculated)
Optimization Problem	Optimization problem
num_in_sede	Number of on-site employees (result)
num_remote	Number of remote employees (result)
Profit	Total profit (result)

Area	Employees range	Minimum % on-site
DNA	0 - 4299	60%
AUTO	4300 - 7524	45%
VITA	7525 - 9674	30%
CONTABILITA	9675 - 10749	15%

Data are collected by using different sources. In general, data related to employees come from an internal Qlik Sense report of the organization, sent by HR. These data are filtered through a pivot table by site, choosing those based in Milan and Mogliano Veneto (which are the biggest sites) and by year. Others data come from public databases.

Data about areas are assumptions based on the prevailing business of the company: non-life products have a wider market than life products, especially talking about auto and other damages coverage. We consider DNA as the prevailing type of insurance, also considering bad weather conditions that have occurred lately, such as hailstorms, rainstorms, floods etc…

Data about income: Bilancio-d-esercizio-Generali-Italia-2023.pdf

$$\text{Gen\_GWP} = 16.695.921.000$$
$$\text{fatturato\_annuo} = 896.637.000$$

- *Gen_GWP: Generali's gross written premium*
- *fatturato_annuo: Generali's net income for 2023*

Data about office costs: https://urbanplaces.it/wp_urbanplaces/tariffe/

Assumptions: our assumption is that the costs for the office are made by the cost of renting each post. Moreover, we don't know which is the supplier of the company, so we took data about costs from a Coworking service, which also provide posts to companies. Data like: number of posts per office, number of offices in the site (assumption), etc are taken from personal everyday experience.

Data about productivity: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3841567

Data about carbon tax:

(1) environmental costs: https://www.openpolis.it/la-tassazione-ambientale-in-italia/

$$\text{TT\_env\_cost} = 55.000.000.000$$

99% of which is caused by the energetic and transport field (we simplify and take it as 100%). Moreover, the 24% is covered by the service sector:

$$\text{service\_tax} = 24\% \cdot \text{TT\_env\_cost} = 13.200.000.000$$

- *TT_env_cost: total environmental costs.*
- *service_tax: the amount of taxation paid by the service sector.*

(2) insurance sector: https://www.ivass.it/pubblicazioni-e-statistiche/statistiche/numeri-assicurazioni/2023/Focus_I_principali_numeri_2023.pdf

$$\text{ins\_GWP} = 129.200.000.000$$

Moreover,

$$\text{ins\_GDP} = 6\%$$

- *ins_GWP: gross written premium of the whole insurance sector.*
- *Ins_GDP: % of Italian GDP covered by the insurance sector.*

(3) Service sector: https://grafici.altervista.org/composizione-del-pil-per-settore-economico/

$$\text{service\_GDP} = 73\%$$

Assumption:

$$\text{ins\_sector} = \frac{\text{ins\_GDP}}{\text{service\_GDP}} = 9\%$$

- *service_GDP: % of Italian GDP covered by the service sector.*
- *ins_sector: % of the service sector covered by the insurance market.*

(3) How much does the company pay for the environment:

Assumptions:

the insurance sector pays

$$\text{ins\_tax} = \text{service\_tax} \cdot \text{ins\_sector} = 13.200.000.000 \cdot 9\% = 1.188.000.000$$

As previously said, this company has a **Gen_GWP** = **16.695.921.000**, so compared to the total premium of the insurance sector:

$$\text{Gen\_mkt} = \frac{\text{Gen\_GWP}}{\text{ins\_GWP}} = \frac{16.695.921.000}{129.200.000.000} = 13\%$$

We suppose that our company is going to pay

$$\text{TT\_carbon\_tax} = \text{ins\_tax} \cdot \text{Gen\_mkt} = 1.188.000.000 \cdot 13\% = 154.440.000$$

- *ins_tax: the amount of taxation paid by the insurance market.*
- *Gen_mkt: % of the insurance market covered by Generali Italia.*
- *TT_carbon_tax: total taxation paid by the company in 2023.*

(4) How much does the company pay for the environment, per capita:

$$\text{carbon\_tax} = \frac{\text{TT\_carbon\_tax}}{(N - Nf)} = \frac{154.440.000}{9.110} = 16.953$$

- *carbon_tax: the amount of total taxation that the company pays for each employee, except for those under particular conditions.*

Scenario analysis

Model Outputs:

- Solution Status: Optimal
- Number of Employees On-Site: 4.900
- Number of Employees Remote: 5.850
- Number of Offices: 49
- Profit: 743.439.019,4
- Total Cost: 97.769.700
- Total Productivity: 841.208.719,4
- DNA AREA:
    - Employees on-site: 2.580
    - Employees remote: 1.720
- AUTO AREA:
    - Employees on-site: 1.452
    - Employees remote: 1.773
- VITA AREA:
    - Employees on-site: 645
    - Employees remote: 1.505
- CONTABILITA' AREA:
    - Employees on-site: 223
    - Employees remote: 852

Explanation of Data Organization

1. **Number of Employees On-Site:** this is the number of employees working on-site (those with xi = 1)
2. **Number of Employees Remote:** this is the number of employees working remotely (those with xi = 0)
3. **Number of Offices:** the number of offices required to accommodate the on-site employees
4. **Profit:** the net productivity, which is the total productivity minus the total cost
5. **Total Cost:** the sum of the costs associated with the on-site employees (carbon tax) and the rent for the offices
6. **Total Productivity:** the sum of the productivity contributions from all employees, both on-site and remote
7. **Areas:** the evidence of employees from each area working on-site or remotely.

Comment on Model Solutions:

- **Optimality:** the solution is optimal, meaning the objective function (net productivity/profit) has been maximized given the constraints.
- **On-Site and Remote Employees:** the model suggests having 4.900 employees on-site and 5.850 employees working remotely.
  Employees on-site (4.900): this number is greater than the minimum required (2.301), ensuring operational feasibility.
  Employees remote (5.850): this includes the 1.640 employees with special conditions (children under 14 or fragile conditions) who must work remotely.
- **Number of Offices (49):** to accommodate the on-site employees, 49 offices are needed, each with a capacity of 100 workstations.
- **Profit (743.439.019,4):** the high profit indicates the company can achieve significant productivity even with the costs associated with on-site work.
- **Total Cost (97.769.700):** this includes the carbon tax for on-site employees and the rent for 49 offices.
- **Total Productivity (841.208.719,4):** this is the sum of productivity from both on-site and remote employees.
- **Areas:** for each area the constraints are observed. For each area, the optimal result is to have in office the minimum employees required, except for the CONTABILITA' area that has the 20% of in-office workers against the minimum 15% required.

Potential Adjustments for Different Scenarios

1. **Increased Remote Work Application**
2. **Changes in Productivity Rates**
3. **Regulatory Changes**

The model provides a comprehensive framework for maximizing productivity while balancing the costs of on-site work and the benefits of remote work. By considering various constraints and parameters, the model offers a practical approach to decision-making in a corporate setting, with flexibility to adapt to different real-world scenarios.

Scenario 1

In 2024, Generali Assicurazioni implemented a new work policy requiring that at least 45% and no more than 55% of employees work on-site. This decision was driven by several key factors:

Enhancing Company Culture and Collaboration

Generali Assicurazioni decided to ensure that a minimum of 45% of their workforce is on-site to enhance company culture, improve internal communication, and foster team integration. Additionally, the policy stipulates that no more than 55% of employees can work on-site, promoting flexibility, employee well-being, and reducing environmental impact.

Productivity and Customer Service

An internal study by Generali Assicurazioni revealed that certain tasks, especially those involving high levels of coordination and customer interaction, significantly benefit from on-site presence. However, the study also found that maintaining some employees in remote work improved overall job satisfaction and reduced stress**. To reflect these findings, the company increased the productivity rating of remote work from 1.08 to 1.11.**

Employee Feedback

Feedback from employees indicated a preference for a balanced work model. While many valued the flexibility of remote work, they also missed the in-person interactions and sense of belonging that come with being in the office. This balanced approach allows employees to enjoy the benefits of both work environments.

Changes:

- h_perc = 1.11 / max_productivity (remotely updated productivity per employee)

- $\sum_{i=0}^{N-1} x_i \geq 0.45 \cdot N$ (minimum number of employees that must be on site)

- $\sum_{i=0}^{N-1} x_i \leq 0.55 \cdot N$ (maximum number of employees that can be on site)

Model Outputs:

- Solution Status: Optimal
- Number of Employees On-Site: 4838
- Number of Employees Remote: 5912
- Number of Offices: 49

- Profit: € 749.728.612,6498883
- Total Cost: € 96.718.614,00
- Total Productivity: € 846.447.226,6498883

Attachments

The project documentations include the following files:

- Scenario 0.py: Python file that contains the model in Scenario 0.
- Scenario 1.py: Python file that contains the model in Scenario 1.
- InputData.csv: csv file that contains the values of the parameters of the models.
- OutputData.csv: csv file that contains the output data of the models.