<u>Off-Shoring, Taxpayers, and the Coronavarus Pandemic</u>

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1.0 Introduction

MAKE OR BUY OPTIMIZATION is a classical Operations Management problem. The present illustration is developed from Example 4.3 (p. 168+) of the textbook <u>Intro to Operations Management,</u> by Anderson, Sweeney et al. It was used as a *Case Study* in our two SUNYIT[1] Management Science courses (MGS411, Seniors; MGS511, Graduates) taught every semester, from 2012 until 2017, as well as in our Syracuse University Quality Engineering (MFE634, Graduates) taught yearly from 2007 to present.

We made *several modifications* to the original problem statement. *First*, we considered an *outsourcing or rather off-shoring* (outsourcing to a far-away country) *problem*. *Secondly*, we *implemented three models (solutions):* not considering any impact of job losses to society; consideration of such an impact with the initial constrains; and consideration of such impact, and increasing the production capacity.

Off-shoring of much of American industry is an important national concern that has taken place for over a quarter of a century under both, Republican and Democratic administrations. Off-shoring has sent abroad tens of thousands of industrial jobs, individually and by exporting complete factories[2], thus increasing domestic unemployment and influencing social issues such as the *1% movement*, political issues with the emergence of candidates Bernie Sanders and Donald Trump, and the election of the latter as *President*. Most importantly, however, has been the resulting loss of much American industrial capacity. Such has fostered chronic unemployment for many middle aged, old-core white and African-American industry[3] workers, who could not find another job or had to accept a lower-paying one, and has seriously limited the production of critical Coronavarus Personal Protection Equipment (PPEs), ventilators, masks, etc.

Another objective of the present numerical illustration is *to show* how the *off-shoring of American jobs* has been *underwritten by the American taxpayer*, through the transference to the government of burdens created by the ensuing job losses, as well as their corresponding human and social costs.

2.0 Original *Make or Buy* Problem Statement

We illustrate our concepts through a well-known industrial optimization problem. The *Janders Company* markets various business and engineering products, and is ready to introduce two new calculators. The first calculator is targeted for the business market; the second one is for the engineering market. Each calculator consists of a base, an electronic cartridge, and a faceplate or top. Both calculators share the same base, but their cartridges and tops are different. Calculator components can be manufactured in-house, or purchased (outsourced, off-shored) from external suppliers.

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[1] SUNY Institute of Technology, recently renamed SUNY Poly, for SUNY Polytechnic Institute.
[2] For example, in Syracuse NY, Carrier Corporation off-shored its Carrier Circle plant in the early 2000s, laying off its 7000 workers, demolishing its ample and excellent factory building, and replacing it with a grass lawn.
[3] Such as steel production, coal mining, electro-domestic devices, etc.

Given its limited manufacturing capacity, *Janders Company* wants to assess whether to manufacture or purchase said components. *Janders goal* is to *minimize its costs*, while still meeting product demand, by determining how many parts of each type they should manufacture in-house, and how many should they purchase (outsource or off-shore), as well as how many expensive overtime hours, they should schedule.

The LP Problem Variables used will be denoted with the following name codes:

BM= number of bases manufactured in-house
BP= number of bases purchased (off-shored)
FCM= number of Financial cartridges manufactured
FCP= number of Financial cartridges purchased
TCM= number of Technician cartridges manufactured
TCP= number of Technician cartridges purchased
FTM= number of Financial tops manufactured
FTP=number of Financial tops purchased
TTM= number of Technician tops manufactured
TTP= number of Technician tops purchased

In addition, there is one variable for Overtime hours scheduled: OT – overtime

The Economics of the *Janders Company* Optimization problem are shown in the table below. We wanted to use a classical example and took *Janders* as is. Puchase/Off-shore costs are higher than manufactured ones, which is the opposite of what occurs in real life. Having used smaller Purchasing costs would have only increased the number of Off-shored jobs.

Component	**Manufactured**	**Purchased/Off-shored**	**Manufacturing Time**
Base	$0.50	$0.60	1.0 min.
Financial Cartridge	$3.75	$4.00	3.0 min.
Technician Cartridge	$3.30	$3.90	2.5 min.
Financial Top	$0.60	$0.65	1.0 min.
Technician Top	$0.75	$0.78	1.5 min.

The initial production parameters of *Janders Company* are given in the table below. Required workforce is obtained by adding the manufacturing times (minutes) of the entire daily production. The required work force is obtained by dividing Total Daily Production time by Daily Work Time per worker (480 minutes). Total production time is the Daily Capacity plus Overtime multiplying the

Daily total work time	480	Minutes/day per men
Required Workforce:	52	No. of workers per day
Total Production Time	25000	Daily Production in Minutes
Total Daily Capacity	24400	Of factory time in minutes
Available Overtime	600	In minutes

Based on such Economics, the Linear Programming model for the optimization is as follows:

Objective Function (OF):

Min = 0.5BM+0.6BP+3.75FCM+4FCP+3.3TCM+3.9TCP+0.6FTM+0.65FTP+0.75TTM+0.78TTP+9OT

Subject to five constraints, governing the number of each component production requirements:

```
 BM + BP  = 5000 Bases
FCM + FCP = 3000 Financial cartridges
TCM + TCP = 2000 Technician cartridges
FTM + FTP = 3000 Financial tops
TTM + TTP = 2000 Technician tops
```

Plus, two additionsl constraints governing the manufacturing capacity and the overtime hour limits:

```
BM + 3FCM + 2.5TCM + FTM + 1.5TTM <= 24,400 + 60*OT = 25,000 min.
OT <= 10 min.
```

We run the LP above using LINGO, considering a daily time horizon of *= 8*60 = 480 minutes/day*

Lingo Solution:

```
Global optimal solution found.

  Objective value:                              24150.00
```

The optimal allocation of production, that minimizes cost is:

Calculator Component	Manufactured In-House	Manufactured Off-shore
Base	0	5000
Financial Cartridge	3000	0
Technician Cartridge	2000	0
Financial Top	3000	0
Technician Top	2000	0

There is Zero Overtime. No. Unemployed: 10.4. Percent workers Off-Shored: 20%

Results Interpretation:

The optimal solution is: 5000 bases (BM) should be Purchased/Off-shored. But all Financial Manager cartridges (FMC), Technician cartridges (TCM), Financial Manager tops (FTP), and Technician Tops (TTP) should be manufactured in-house. No overtime manufacturing is used.

Workers Unemployed	10.42	Off-shored employment
No. Workers Employed	41.67	In the factory
Percent Employed	80%	In the factory
Percent Unemployed	20%	Jobs Off-Shored

The *total cost* associated with this Optimal Solution to the *make or buy plan is $24,150.00*

3.0 Second Model: Off-shore and no concern for impact on other members of economic system

Assume now that *Janders* decides to transfer abroad half its manufacturing capacity. This would reduce its in-house capacity from 25,000 daily minutes to 12,000. To compensate, Overtime will be increased to 50 hours (300 minutes). The remaining 12,500 daily minutes of production capacity are now abroad.

We will first analyze the problem, using a classical Linear Programming approach, from the strict point of view of optimizing the *Janders Company* economic benefit (no concern for the impact on others).

Philosophy: Economy of each production unit (company) is independent. No concern on how society will be impacted by worker layoffs.

We submit the new LP problem to Lingo:

The Lingo Model:

```
Model:

!Objective Function;

Min = .5*BM + .6*BP + 3.75*FCM + 4*FCP + 3.3*TCM + 3.9*TCP + .6*FTM + .65*FTP
+ .75*TTM + .78*TTP + 9*OT;

!Subject to;

 BM + BP  = 5000;
FCM + FCP = 3000;
TCM + TCP = 2000;
FTM + FTP = 3000;
TTM + TTP = 2000;
BM + 3*FCM + 2.5*TCM + FTM + 1.5*TTM - 60*OT <= 12000;
OT <= 50;

END
```

Lingo Solution:

```
Global optimal solution found.

  Objective value:                              24443.33

  Model Class:                                        LP
  Total variables:                       11
  Total constraints:                      8


                               Variable           Value        Reduced Cost
                                     BM        5000.000            0.000000
                                     BP        0.000000          0.1666E-01
                                    FCM        666.6667            0.000000
                                    FCP        2333.333            0.000000
                                    TCM        2000.000            0.000000
                                    TCP        0.000000           0.3916667
                                    FTM        0.000000           0.333E-01
```

FTP	3000.000	0.000000
TTM	**0.000000**	**0.950E-01**
TTP	2000.000	0.000000
OT	**0.000000**	**4.000000**

Interpretation: the optimal allocation of production, that minimizes cost is:

Calculator Component	Manufactured In-House	Manufactured Off-shore
Base	5000	0
Financial Cartridge	666.7	**2333.3**
Technician Cartridge	2000	0
Financial Top	**0**	**3000**
Technician Top	**0**	**2000**

There is Zero Overtime.
Number of workers Laid Off: 27.08.
Percent of workers Laid Off: 52%

Results Interpretation:

The optimal solution indicates that all 5000 bases (BM), 667 Financial Manager cartridges (FCM0, and 2000 Technician cartridges (TCM) should be manufactured. The remaining 2,333 Financial Manager cartridges, all of the Financial Manager tops (FTP), and all Technician Tops (TTP) should be purchased. No overtime manufacturing is allowed. The corresponding *reduced costs* show that the cost of Overtime Production has to decrease by $4 per hour, and that the costs of Financial and Technician Tops have to decrease by $0.33E-01 and $0.95E-01 per hour, to enter the optimal solution.

The *total cost* associated with the Optimal Solution to the *make or buy plan is $24,4433.33*.

Interpretation of the *Sensitivity Analysis* for the eight problem constraints:

Row	Slack or Surplus	Dual Price
1	0.000000	-0.583333
2	0.000000	-4.000000
3	0.000000	-3.508333
4	0.000000	-0.650000
5	0.000000	-0.780000
6	0.000000	0.8333E-01
7	50.00000	0.000000

A Binding Constraint is one whose Slack or Surplus value is Zero (as its availability has been completely used by the problem). In the current problem all constraints except OT are Binding.

The Dual Price or Value is the cost of adding an additional unit of the constraint, as well as the change it produces in the Value of the Optimal Solution, when such additional unit is added.

The dual value for Binding constraint 1 (Base) is -0.583.

For constraint 2 the dual value is -4.0.

For constraint 3 the dual value is -3.50833.

For constraint 4 the dual value is -0.65.

For constraint 5 the dual value is -0.78.

The dual value for the manufacturing constraint 6 is -0.

For constraint 7, the dual value is 0. This indicates that *Janders* will use no Overtime.

Interpretation of the OF equation coefficients and their Ranges:

The OF Coefficients may change, within the ranges given below, and the Optimal Solution does not change. Notice, however, that the Value of such Optimal Solution does change.

Objective Coefficient Ranges:

Variable	Current Coeff	Allowable Increase	Allowable Decrease
BM	0.500	0.16666E-01	INFINITY
BP	0.600	INFINITY	0.166E-01
FCM	3.75	0.1000000	0.500E-01
FCP	4.00	0.50000E-01	0.1000000
TCM	3.30	0.3916667	INFINITY
TCP	3.90	INFINITY	0.3916667
FTM	0.600	INFINITY	0.333E-01
FTP	0.650	0.33333E-01	INFINITY
TTM	0.750	INFINITY	0.950E-01
TTP	0.780	0.95000E-01	INFINITY
OT	9.00	INFINITY	4.000000

Interpretation of the Right Hand Side or Resource Availability Ranges:

The Right Hand Side or Resource Availability may change, within the ranges given below. Notice that the Optimal Solution does change, and the Value of such new Optimal Solution also changes.

Right Hand Side Ranges:

Row	Current RHS	Allowable Increase	Allowable Decrease
2	5000.0	2000.00	5000.00
3	3000.0	INFINITY	2333.3
4	2000.0	800.00	2000.00
5	3000.0	INFINITY	3000.0
6	2000.0	INFINITY	2000.0
7	50.000	INFINITY	50.000
8	12000.00	7000.0	2000.0

4.0 Third Model: Considering the input of all other elements of the economic system

Philosophy: the Economy of each production unit (company) is inter-independent with that of other units, and includes how society is impacted by worker layoffs. Manufacturer considers that it pays off to expand its Overtime and Plant Capacity. Such attitude may be fostered by providing financial and tax incentives

New Changes: OT = 50 and New Total Capacity = 12000

When a worker is laid off, he is paid unemployment compensation. He and his family also lose medical insurance and receive Medicaid. If his type of job has disappeared, the worker must be retrained. The unemployed are not deducted payroll taxes. Finally, there may be additional costs from social problems derived with long-term unemployment: alcoholism, abusive behavior, delinquency, drug addiction etc. all of which are addressed by society at a cost. The table below has made-up values for all these expenses:

Expenses derived by Lay Offs:	**Value**
Unemployment	100
Retraining	15
Health Care	20
Unpaid Taxes	15
Other	10
Total	160

We consider in the LP model these extra government expenses, incurred by each new Laid-off worker, as additional constraints that will affect the number of layoffs, due to shifting production abroad.

We multiply the *number of workers laid off* per day, obtained from the times of manufacturing parts, by the total daily expense ($160) of laying one worker off. This is the cost to society (tax payer) of layoffs in this industry. Such expenses are not absorbed by industry, but by the government (tax payer) and should be included in the LP model.

The Updated LP Objective Function now becomes:

Lingo Model:

```
Model:

!Objective Function;

Min = .5*BM + .6*BP + 3.75*FCM + 4*FCP + 3.3*TCM + 3.9*TCP + .6*FTM + .65*FTP
+ .75*TTM + .78*TTP + 9*OT

            +160*(BP/480+FCP/160+TCP/192+FTP/480+TTP/320);
```

Notice how the last (composite) term in the above OF (**in red**) corresponds to the total cost of labor lost to shifting work abroad (off-shoring) and will be also used to obtain the OF or value to minimize.

```
!Subject to;
```

```
BM + BP = 5000;
FCM + FCP = 3000;
TCM + TCP = 2000;
FTM + FTP = 3000;
TTM + TTP = 2000;
BM + 3*FCM + 2.5*TCM + FTM + 1.5*TTM - 60*OT <= 12000;
OT <= 50;

END
```

Now, we calculate the true cost of off-shoring work, combining the costs for the company and for society. This is the Optimization Function that would calculate, for example, an Operations Research Engineer working for the US Labor Department.

Solution:

```
Global optimal solution found.

  Objective value:                              27976.67

  Total variables:                    11
  Total constraints:                   8


                                Variable           Value        Reduced Cost
                                      BM        5000.000            0.000000
                                      BP        0.000000           0.1667E-01
                                     FCM        1666.667            0.000000
                                     FCP        1333.333            0.000000
                                     TCM        2000.000            0.000000
                                     TCP        0.000000           0.3916667
                                     FTM        0.000000           0.3333E-01
                                     FTP        3000.000            0.000000
                                     TTM        0.000000           0.9500E-01
                                     TTP        2000.000            0.000000
                                      OT        50.00000            0.000000
```

Interpretation: the optimal allocation of production, that minimizes cost is:

Component	Manufacture In-House	Manufacture Off-shore
Base	5000	0
Financial Cartridge	**1666.7**	**1333.3**
Technician Cartridge	2000	0
Financial Top	**0**	3000
Technician Top	**0**	2000

There are now 50 hours of Overtime. No. workers Laid-off = 20.8. Percent Lay Offs: 40%

Notice how now the available Overtime has been completely used (50 hours), and the percent of Laid Off workers has been reduced from 52% to 40%, which only 27 positions lost. This is due to the fact that we are now including in the model government (tax payer) expenses that the manufacturer did not previously considered, such as societal expenses derived from laying off workers.

Sensitivity Analysis interpretation is similar to the one discussed above, for the First Model.

Row	Slack or Surplus	Dual Price
1	27976.67	-1.000000
2	0.000000	-0.9166667
3	0.000000	-5.000000
4	0.000000	-4.341667
5	0.000000	-0.9833333
6	0.000000	-1.280000
7	0.000000	0.4166667
8	0.000000	16.00000

Ranges in which the basis is unchanged:

Objective Coefficient Ranges:

Variable	Current Coefficient	Allowable Increase	Allowable Decrease
BM	0.5000000	0.1666667E-01	INFINITY
BP	0.9333333	INFINITY	0.1666667E-01
FCM	3.750000	0.1000000	0.5000000E-01
FCP	5.000000	0.5000000E-01	0.1000000
TCM	3.300000	0.3916667	INFINITY
TCP	4.733333	INFINITY	0.3916667
FTM	0.6000000	INFINITY	0.3333333E-01
FTP	0.9833333	0.3333333E-01	INFINITY
TTM	0.7500000	INFINITY	0.9500000E-01
TTP	1.280000	0.9500000E-01	INFINITY
OT	9.000000	16.00000	INFINITY

Righthand Side Ranges:

Row	Current RHS	Allowable Increase	Allowable Decrease
2	5000.000	5000.000	4000.000
3	3000.000	INFINITY	1333.333
4	2000.000	2000.000	1600.000
5	3000.000	INFINITY	3000.000
6	2000.000	INFINITY	2000.000
7	12000.00	4000.000	5000.000
8	50.00000	66.66667	50.00000

These ranges can be used in **Post Optimality (Sensitivity) Analysis**, whereby analysts and researchers can change some problem parameters and assess the changes in results. Sometimes, this type of analysis is also referred to as the **What If Game.**

7.0 Discussion

In this paper we are researching two *issues*: (1) the manner Taxpayers have underwritten the Off-shoring of American industrial jobs, during the past quarter of century, and (2) how Off-shoring has impacted the American society and thus influenced the current Coronavarus Pandemic response.

Regarding *the first issue,* we showed how traditional *Make of Buy* optimization modeling, by individually considering the economics of each organization, transfers to government expenses related to Layoffs that are caused by Off-shoring, ultimately transfers to Society at large (i.e. to Tax Payers). By comparing the results of different Linear Programming optimization models, we showed ways in which the number of outsourced (Off-shored) jobs can be reduced (e.g. increasing production capacity and overtime).

We have used (possibly conservative) made-up values for the expenses caused by worker Layoff. But this is inconsequential. First, our objective has been to demonstrate that, when considering such expenses in optimization models, the number of Layoffs is reduced. Secondly, the specialist with access to the real information and data can redo our analysis using these, and obtain the actual numerical values.

Below we show a comparison of the three optimization models used in this research:

Variable	Original Model	Second Model	Third Model
Solution Value	24150	24443	27976
No. Layoffs	10.4	27.1	20.8
Percent Layoff	20%	52%	40%

We see from the above table how the third LP model that includes the set of expenses from Off-shored jobs, results in a lower number of jobs lost than the second (that doesn't include them).
We now examine *the second issue, the impact of Off-shoring on the Coronavarus Pandemic*, which can be *divided into* two parts: *material* impact *and social, political and economic consequences*

First, *Off-shoring* of important segments of our industry left the United States economy dependent from foreign countries. We now have to import PPEs for Healthcare workers that are fighting the Coronavarus Pandemic, because we are no longer able to manufacture a sufficient number within the country.

Secondly, by Off-shoring tens (and maybe hundreds) of thousands of jobs, the traditional *Social Contract* between government and the people, whereby the latter hand over power to the former in exchange for the governing elite to look after the people. This *breach of contract* had severe social consequences.

Many workers lost their jobs to Off-shoring, or had to accept lower paid ones, thus becoming chronically unemployed or sub-employed. Some of them developed radical *social, political and economic* positions such as the *Occupy Wall Street and One Percent Movements*[4], or supported emerging anti-establishment candidates such as Senator Sanders, on the left (living wage, medicare for all, free college tuition, etc.), and Mr. Trump, on the right (America First, isolationism, no climate change, etc.).

The big winners in the Off-shoring operation were the large corporations, banks and investment houses, and their officers and stockholders. These were seen by some as integrating *the richest One Percent*.

The losers were Off-shored workers, many of them traditional Democratic Party voters that had formerly supported Senator Sanders and President Obama. In the 2016 presidential elections many of these stayed home or voted for candidate Trump, providing the margin that got Mr. Trump elected President.

[4] See, for example, https://en.wikipedia.org/wiki/Occupy_movement

After the 2016 Presidential election, an on-going feud between the new President and his adversaries has further soured the political environment in the country, complicating the governing task.

For example, in January of 2020 the country became immersed in Mr. Trump's Impeachment process. This event likely distracted the attention of both, Leaders and public, from the impending Coronavarus Pandemic that was fast approaching. In the month of February, the Trump administration minimized the importance of the Coronavarus Pandemic, comparing it to the usual Flu season, and blaming the political opposition for overstating its real importance.

This resulted in two months of time lost, that could have been used, to prepare the country, its medical staff and its hospitals, to confront the Covid-19 Pandemic, as well as to implement efficient mitigation strategies. The result is that, at the time of writing this paper, there are over 100K deaths.

8,0 Conclusions

The objective of this article is not to stir blame about the causes of the *Off-shoring* phenomenon, but to point out some of its long-term consequences so that, in the future, similar critical decisions are better and more completely assessed.

For, few events during the last quarter of a Century have had such relevant impact in American industrial, social, political and economic life, as the *Off-shoring* of tens of thousands of industrial jobs, and even of entire production plants. Off-shoring or outsourcing are valid management tools that have their legitimate use in time and place. But like with any other tool, *Off-shoring* can be miss-used, thereby producing more harm than benefit, if applied inadequately or incorrectly.

Off-shoring had both benefits and problems. It allowed, for those who kept their jobs and income levels (or increased them) to acquire less expensive items; this was its positive side. But *Off-shoring* created, as shown in this paper, very serious economic and social problems that have had long-term impact.

Finally, *Off-shoring* was partially underwritten by taxpayers. This money could have been better used in improving American education, health care and infrastructure, among other things.

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