Off-Shoring, Taxpayers, and the Coronavarus Pandemic

Jorge Luis Romeu, Ph.D.

Emeritus, State University of New York
Web: http://web.cortland.edu/romeu
Email: romeu@cortland.edu

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 Intro to Operations Management textbook, by Anderson, Sweeney et al[1]. We made *several modifications* to the original problem statement. *First*, we considered an *outsourcing or off-shoring* (outsourcing to a far-away country) *problem*. *Secondly*, we *implemented three LP models (solutions)* comparing the impact that Off-shoring and job losses produced to society.

Off-shoring of much of American industry is an important issue 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 via exporting complete factories[2], thus increasing domestic unemployment and influencing social issues such as the *1% movement*, political issues such as 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 American industrial capacity and the ensuing chronic unemployment for many middle aged, old-core white and African-American industrial workers[3], who could not find another job or had to accept a lower-paying one. Such losses have seriously limited the production of critical Coronavarus Personal Protection Equipment (PPEs), of ventilators, etc.

A final objective of the present paper is *to show* how the *off-shoring of American jobs* has been partially *underwritten by the American taxpayer*, through the transference to the government of expenses created by the ensuing job layoffs, as well as by their corresponding human and social costs.

2.0 Original *Make or Buy* Problem Statement

We will illustrate our concepts through such classical and 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.*Given its manufacturing capacity, *Janders Company* wants to assess whether to manufacture or purchase said components. *Janders Company 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.

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[1] *Case Study* used in our SUNYIT[1] and Syracuse University Management Science graduate courses (2007-present).
[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.

The LP Problem Variables used will be denoted with the following 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 costs, 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. Its Daily Production Capacity is 25,000 minutes. The Required Workforce is obtained by adding the manufacturing times (in minutes) of the required daily production. The required work force is obtained by dividing the Total Daily Production time by Daily Work Time per worker (8*60=480 minutes). Total production time is the Daily Capacity plus the Daily Overtime. Data is summarized in the table below.

Worker Daily 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 additional 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 SW, considering a daily time horizon of *= 8*60 = 480 minutes*

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. Percent of 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 problem 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 would be increased to 50 hours (300 minutes). The remaining 12,500 daily minutes of production capacity are now abroad. It is evident that this transferring decision will impact 50% of the *Janders'* workforce.

We 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: The Economy of each production unit (company) is independent. The model has no concern on how society will be impacted by worker layoffs.

We submit the new LP problem to Lingo:

The Lingo 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;
```

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: 20.83. Percent of workers Laid Off: 40%

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*.

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

Philosophy: the Economy of each production unit (company) is inter-independent with that of other units, and also includes how American society is impacted by worker layoffs.

Given the previous model results we consider, in addition to including social costs, making some changes in the production parameters. The manufacturer will consider expanding its Production Capacity, as well as the number of Overtime hours. Such may be encouraged by developing financial and tax incentives:

New Changes: OT = 60 hrs and New Daily Capacity = 13000 min.

The corresponding LP Lingo Model is similar to the one used in the Second Model (Section 3) with the two modified constraints, to accommodate the two above changes :

```
BM + 3*FCM + 2.5*TCM + FTM + 1.5*TTM - 60*OT <= 13000;
OT <= 60;
```

The American society (tax payers) is impacted by the Laid off workers, who no longer are deducted payroll taxes. They instead receive unemployment compensation and Medicaid, since they lose their medical insurance. If the type of job has disappeared, the worker must be retrained. Finally, there may be additional expenses caused by social problems derived with long-term unemployment such as alcoholism, abusive behavior, delinquency and drug addiction. These expenses are absorbed by society (American tax payers). The table below shows made-up values for these expenses:

Expenses From Lay Offs	Cost/Day
Unemployment	18
Retraining	15
Health Care	15
Unpaid Taxes	15
Other	25
Total	88

We include in the LP model, as an Objective Function additional term (below, **in red**), the value of these extra expenses, incurred by each new Laid-off worker due to having shifted the production abroad:

```
+88*(BP/480+FCP/160+TCP/192+FTP/480+TTP/320);
```

This additional Objective Function term accounts for the daily total cost to government, of all Laid Off workers, due to shifting (off-shoring) of their work abroad. It will be used to obtain the optimal value.

We obtain, using time information given in the problem statement, the number of laid off workers by dividing the *total number of daily off-shored part-minutes***,** by the number of such parts built, per worker, per day. Finally, we multiply this total number of Laid Off workers, by the daily expense ($88).

This figure provides the cost to society (American tax payer) of absorbing layoffs in this industry. This cost is not incurred by industry, but by the government (tax payer) but should be included in the model.

The New LP Objective Function now becomes:

Lingo 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

            +88*(BP/480+FCP/160+TCP/192+FTP/480+TTP/320);

!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 <= 13000;
OT <= 60;
```

Now, we calculate the true value of off-shoring work, by 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, representing the government (tax payer) interests.

Solution:

```
Global optimal solution found.

  Objective value:                              26,140.00

  Total variables:                      11
  Total constraints:                     8
```

The optimal allocation of production, that minimizes cost is:

Component	Manufacture In-House	Manufacture Off-shore
Base	5000	0
Financial Cartridge	**2200**	**800**
Technician Cartridge	2000	0
Financial Top	**0**	3000
Technician Top	**0**	2000

There are now 60 hours of Overtime used.
Number of workers laid-off = 17.5. Percent worker Lay Off: 34%.

Now the available Overtime has been completely used (60 hours), and the percent Laid Off workers has been reduced from 40% to 34%: only 17.5 positions were lost. The LP Model is now considering the total expense of off-shoring. They include government (tax payer's) expenses, both societal and manufacturing derived from having laid-off these workers. *Janders* did not previously include them its Optimization.

5.0 Discussion

In this paper we are considering 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 response to the Coronavarus Pandemic.

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 transferred to Society at large (i.e. to Tax Payers). By comparing the results of three different LP optimization models, we showed ways in which the number of outsourced (Off-shored) jobs can actually be reduced (e.g. by increasing in-house 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 including such expenses in the optimization models, the number of Layoffs is reduced. Secondly, the specialist with access to the actual information and data can redo our analysis using these, and obtain the correct 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	26140
Workers Laid Off	10.4	20.8	17.5
Percent Layoff	20%	52%	34%

We see from the above table how *Sanders*, before Off-shoring half of its industrial capacity, had a lower unemployment. And how, after the Off-shoring, the third LP model, that included in it's OF all expenses produce by shedding jobs, resulted in a lower number of lay-offs than the second, non-inclusive model.

We now examine *the second issue, the impact of Off-shoring on addressing the Coronavarus Pandemic*, which can be *divided into* two parts: *material* impact *and social, political and economic consequences*

First, the *Off-shoring* of important *segments of American industry* left these sectors more dependent from foreign countries. We now have to import PPEs for Healthcare workers that are fighting the Coronavarus Pandemic, because we are not able to manufacture them, within the country, in a sufficient number.

Secondly, Off-shoring tens (and maybe hundreds) of thousands of jobs, *breached the traditional Social Contract* between government and the people. In it, the latter hands 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 Mr. 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 the Off-shored workers. Some of them were traditional Democratic Party voters that had supported Senator Sanders and President Obama. In the 2016 presidential elections many stayed home or voted for candidate Trump, providing the margin that got Mr. Trump elected as President.

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

In January of 2020 the country became immersed in Mr. Trump's Impeachment process. This distracted the attention of Leaders and public from the fast approaching Coronavarus Pandemic. In February, Mr. Trump's administration minimized the importance of the Coronavarus Pandemic, comparing it to the usual Flu season, and blaming political opposition for overstating the Covid-19 Pandemic importance.

These two months 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 American deaths due to the Covid-19 Pandemic.

6,0 Conclusions

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

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 of entire production plants. Outsourcing is a valid management tool that has legitimate use in time and place. But, like any other, it can produce 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 yet increased them) to acquire less expensive items: this was its positive side. But *Off-shoring* created, as shown in this paper, serious, complex economic and social problems that have had a long-term impact.

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

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

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About the Author:

Jorge Luis Romeu was, for sixteen years, a Research Professor at Syracuse University. He is currently an Adjunct Professor of Statistics. Previously, Romeu retired Emeritus from the State University of New York. He taught graduate and undergraduate courses in applied statistics and operations research. He also worked, as Senior Research Engineer, with IIT Research Institute. He created and directs the Juarez Lincoln Marti International. Education Project (https://web.cortland.edu/matresearch/) that support higher education in Ibero-America. He received seven Fulbright assignments in Mexico, Ecuador, Colombia and the Dominican Republic. Romeu has a doctorate in Statistics/O.R., is a C. Stat Fellow of the Royal Statistical Society, a Member of the American Statistical Society and of the American Society for Quality. He is Past ASQ Regional Director, and holds Reliability and Quality ASQ Certifications.