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Employment Effects of Offshore Oil and Gas Regulations

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Abstract

The estimation of the employment effects of offshore safety and environmental regulation is often highly speculative and based on questionable assumptions. Nevertheless, it is still highly publicized and used as a basis for policy statements in support or, or in opposition to, proposed regulations. Much more reliable estimates of such employment effects can be made, however, based on fundamental principles of microeconomic analysis. This paper demonstrates this by developing a microeconomic model explaining the effects of offshore regulations on employment, assuming the standard profit-maximization behavior of firms. The paper finds that the most relevant and reliable measures of employment effects are: reductions in employment from operations that are terminated because of the new regulation, increases in employment because of additional labor needed to meet the new requirements, and increases in employment in equipment manufacturing when the regulation calls for the expanded use of certain equipment. The costs related to these contractions or expansions of employment can often be gleaned from information in the benefit-cost analysis that was required to accompany the proposed regulation by the regulatory agency involved. For example, the daily costs of offshore rigs and the costs of equipment can be translated to increases in employment.

Keywords: Offshore, Oil, Gas, Regulation, Employment, Microeconomics

JEL Codes: J23, D20, Q48, L51

Note: The views expressed in this paper reflect the views of the authors alone, and they do not necessarily reflect the views of any organizations to which they belong.

1. Introduction

The U.S. government has continued to establish regulations to secure human safety and environmental protection in offshore oil and gas operations on the U.S. Continental Shelf, especially in the aftermath of the 2010 Deepwater Horizon tragedy in the Gulf of Mexico.¹ In response to the Deepwater Horizon tragedy, the Bureau of Safety and Environmental Enforcement (BSEE) of the Department of the Interior (DOI) in 2016 issued a final rule known as the Well Control Rule which required “more stringent design requirements and operational procedures for critical well control equipment” (BSEE, 2016a). The *Wall Street Journal* described it as “the third and biggest set of rules the Interior Department has issued in response to the Deepwater Horizon explosion” (Harder, 2015). Also, in 2016, DOI established new regulations for Exploratory Drilling in U.S. Arctic Waters (BSEE, 2016b). These regulations were preceded by regulatory impact analyses (DOI, 2016a; DOI, 2016b) in accordance with government requirements for the determination of new regulations (EPA, 2016). These analyses compared the costs and benefits of the regulations and found that the benefits exceeded the costs, justifying these rules. The effects of the regulations on employment were not analyzed in these regulatory impact analyses primarily because employment effects would not be considered costs or benefits of the regulations and because those effects would be impossible to determine based on available data.²

Because the regulations would require more labor, this would imply a positive effect on employment. On the other hand, in response to previously proposed regulations, which would have been substantially costlier, arguments had been made by some industry groups that there could be declines in employment due to a constriction of operations because of the regulations (Snow, 2016). While the topic of this supposed adverse effect on employment has drawn significant public attention, there has been no detailed micro-economic analysis to provide the basis for estimating the effect. The paper uses basic micro-economic foundations to illustrate various partial equilibrium impacts of regulation on employment and then uses a case study to illustrate how it can be applied.

2. Background of the Analysis of Employment Effects

Several regional models have been developed to estimate the employment effects such as the RIMS II (by the Bureau of Economic Analysis); IMPLAN (the IMPLAN Group, LLC); and REMI (by Regional Economic Models, Inc). These models are useful when correctly applied but may have severe limitations when they are not correctly applied. That is, if the underlying assumptions surrounding their application do not correctly capture the true circumstances under which the economic change is occurring, especially if crowding out effects are present, the multiplier effect may be limited (Stanley, 2010; Sloboda & Yao, 2008).

For the study of the employment effects of offshore oil and gas regulations, one problem is the regional multiplier models. More specifically, there is no separate NAICS code for offshore oil and gas extraction. As a result, the industry code under NAICS would be NAICS 21111 (crude oil and natural gas extraction), which is mainly land-based operations, not sea operations.

As a result, multiplier models can only be used to analyze offshore employment through the questionable assumption that all oil and gas extractions, via land or sea, would exhibit the

¹ For comprehensive background on the tragedy, see the Report to the President (National Commission, 2011).

² Many rule-makings often do not analyze the impacts of these regulation on employment. However, if there are concerns about the impacts on employment such as the Occupational Exposure to Respirable Crystalline Silica as finalized by the Department of Labor, an employment analysis was conducted as requested by special interest groups and trade organizations.

same effects because of a regulation. As regional models, however, these models calculate effects based on county data and on the proximity of various businesses to each other - all on land. There are no ocean sectors in these models. To utilize the models, an analyst must use counties near the coast where offshore workers are believed to live when not living at sea.

As an example, suppose that an onshore industrial plant were shut down in a parish in Louisiana, putting 500 people out of work, and the effects of that closure were analyzed by a regional model to estimate the additional unemployment in the region that would occur. The model would make use of apparent economic interdependencies that exist and would consider that those 500 workers would no longer make purchases in the area (e.g., buying lunch at a local diner). The model will measure the secondary effects on the local economy resulting in greater unemployment. However, compare this scenario to the closing of a large offshore platform (or group of interconnected platforms) where staff may live typically for two weeks at a time. The food eaten on the platform is already prepared by the same staff who would be laid off as well when the platform was closed. Offshore platforms are much more self-contained or vertically integrated economic entities, which combine other industries (e.g., room and board for the workers on the platform, transportation costs to get them there, etc.). For these combinations of industrial activities based on NAICS codes, the offshore regional multiplier effects are much smaller. They must be substantially smaller because the interaction between the different related industries is already subsumed within the offshore industry itself.

The same concern is applicable to the use of multiplier models for any economic analysis of the effects of changes in offshore operations, whether involving the effects of regulations or of new investment policies. For example, Considine (2014) examined drilling and extraction in California using the IMPLAN model. The analysis estimated indirect and induced effects on employment per \$1 million spent in drilling expenditures and per \$1 million spent on oil and gas production. Moreover, it applied these IMPLAN parameters, which had been based on expenditures and observed effects pertaining to *onshore* activities to forecast the effects of investment in *offshore* activities. This was performed without any apparent consideration of the fundamental differences between the onshore and offshore operations, which will surely lead to different multiplier effects as just described.

In estimating the employment effects of offshore oil and gas regulations, the first problem is estimating what initially occurs as a result of the new regulation. If that estimated initial direct effect is inaccurate, then any estimation of the secondary effects or ripple effects would not be correct. Some industry groups could make the initial assertion that the new expensive regulations will force many of their operations to close because those operations will no longer be profitable (Quest, 2015; Wood, 2016). If these hypothetical closures of offshore operations are entered into a regional multiplier model, the model may generate predictions of high unemployment through the secondary effects and thus predict adverse economic consequences on the national economy. Such assessments have generally not accounted for the positive effect of the regulations on employment because the regulation imposes costs to begin with, and additional labor, capital, and material will be needed to meet the requirements of the new regulation.

3. A General Analytical Model

Let us examine the effects of the regulation in terms of a simple microeconomic model:

$$Y = Y(K, L, M)$$
$$Z = rK + wL + qM$$

where Y is output (of the industry in question) and Z is the cost of production; K is physical capital (as a flow of capital services used per year) which would include the use of all equipment, physical structures (including platforms and pipelines), and vessels; L is labor; and M is materials purchased. The parameters r , w , and q are the costs per unit of each of these factor inputs (with w being the annual compensation and L the number of full-time equivalent workers per year in thousands).

If P is the equilibrium price (e.g., the market price of crude oil), then we would expect the firm to produce at a level until marginal cost equals the equilibrium price and the marginal value product of each factor input equals the price of each factor input:

$$\frac{dZ}{dY} = P; \quad \frac{\partial Y}{\partial K} = \frac{r}{P}; \quad \frac{\partial Y}{\partial L} = \frac{w}{P}; \quad \frac{\partial Y}{\partial M} = \frac{q}{P}$$

This creates a solvable system of these four equations and four unknowns (Y, K, L, M), assuming the known (observed) parameters P, r, w , and q .

Let us now define Y' as new production after a regulation and

$$Y' = Y'(K, L, M) = Y(AK, BL, CM)$$

where A, B , and C are parameters that change because of the regulation and are normalized to 1 in the absence of a regulation. For example, if the regulation doubles the amount of physical capital equipment that is needed to produce the same level of output, then $A = 0.5$ (as the first direct effect) (i.e., we now must utilize twice as much capital in production to produce the same output we produced before the regulation).

Since B (as well as A and C) are assumed constant, we have:

$$\frac{\partial Y'}{\partial L} = B \frac{\partial Y}{\partial L} .$$

In other words, the marginal product of labor proportionally declines with B . For example, if B is 0.8 because a 25% increase in labor is needed by the regulation for the same level of output (since $0.8 \times 1.25 = 1$), then the marginal productivity of labor is 20% lower than it was before with regard only to the industry output (e.g., oil and gas production), leaving out the added product of additional safety and environmental protection, which is assumed to have value to society but does not enter into the profit-based decisions of the firm.

The firm then solves for L such that

$$\frac{\partial Y'}{\partial L} = B \frac{w}{P} .$$

This also assumes that w is exogenous, or at least “sticky” in the short term, which may be a competitive wage for someone like a petroleum engineer and determined by a much larger market (such as the market for petroleum engineers both offshore and onshore).

Assuming diminishing marginal productivity (i.e., $\partial^2 Y' / \partial L^2 < 0$), this implies that L will be higher as the value of B decreases, demonstrating the basic principle that more labor will be used for the firm to meet the additional labor requirements required by the regulation.

As an example, consider the initial production function below, which has labor as the only input:

$$Y = -\frac{1}{3}(BL)^3 + 10(BL)^2$$

In the case prior to the regulation, we have:

$$B = 1 \rightarrow Y = -\frac{1}{3}(L)^3 + 10(L)^2 \rightarrow \text{marginal productivity } \frac{dY}{dL} = -L^2 + 20L$$

which reaches a maximum of 100 (units of output) when $L = 10$ (or 10,000 employees). To continue the illustration, let $w/P = 60$. The firm will then want to increase L (to increase profits) for as long as $\frac{dY}{dL} > \frac{w}{P}$, so we solve for L in the following equation (for the value of L that is greater than 10):

$$60 = -L^2 + 20L \rightarrow L = 16.325 \text{ (or 16,325 employees).}$$

Now consider the case after the regulation where $B = 0.8$. We then have:

$$Y = -\frac{1}{3}(0.8L)^3 + 10(0.8L)^2 \rightarrow \frac{dY}{dL} = 0.8(-0.64L^2 + 16L)$$

which reaches a maximum of 80 when $L = 12.5$. Using the same market condition of $w/P = 60$, we then have:

$$60 = 0.8(-0.64L^2 + 16L) \rightarrow L = 18.750 \text{ (or 18,750 employees).}$$

From this example and as shown in Figure 1, employment rises by 2,425 new employees which can be attributed to the new regulation. Capital and materials were omitted as inputs, but adding them in will not change the findings because they will fall out when a partial derivative is taken with respect to labor.

In this example, the regulation clearly reduces the profitability of the firms' operations, which might best be understood in the sense that after the regulation, the firm is now producing "two products" in a broad sense: (1) the oil and gas it was producing before, and (2) the increased safety and environmental protection that results from the regulation. Productivity is lost for the firm in the sense of it continuing to be paid only for the first product while now providing the second product for "free" relative to the situation it faced before. The additional safety and environmental regulations benefit the industry in several ways. These include reducing the risk to industry of possible moratoriums on offshore operations if a major disaster were to occur, aiding the industry in better public relations for implementing improved safety and environmental standards, improving worker morale from reduced safety risk (Rundmo, 1995), and diminishing the risk of liability in the event of safety hazards (Bennear, 2015), among others. In this sense, all of industry's continued profitability from offshore operations relies on its adherence to safety and environmental regulations.

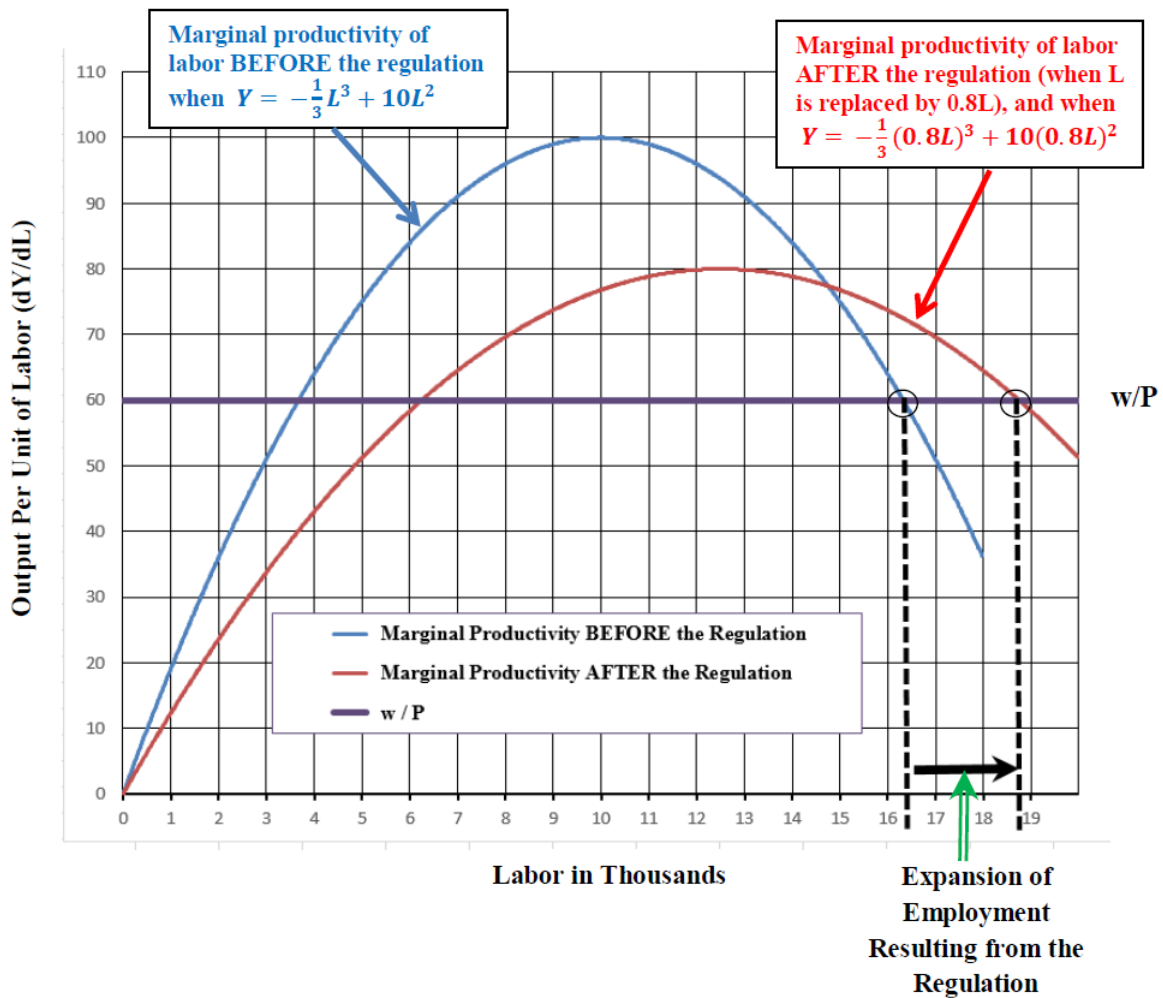


Figure 1. Example of How a New Regulation Could Lead to Increased Employment, Using the Sample Production Function $Y = 10L^2 - L^3/3$

4. Identifying the Effects on Labor from Benefit-Cost Analyses of Offshore Regulations

To summarize the discussion, regulations will affect employment by:

- (1) increasing labor devoted to implementing the new regulations,
- (2) expanding labor through increased construction of new facilities and the manufacturing of new equipment as well as the potential spillover effects from these, and,
- (3) possible declines in labor if some operations are terminated or downsized due to a loss in profitability.

In benefit-cost (BC) analyses of the offshore regulations, additional costs are generally identified for each provision of the regulation under the following three categories: (1) direct labor requirements, (2) services provided by offshore rigs, or the opportunity costs of those rigs being taken offline, and (3) physical capital requirements. In the BC analysis, only the cost of the provision and whether the cost can be monetized are relevant, while estimated employment effects serve primarily as inputs to the cost estimation.

In the case of direct employment effects, the cost of a provision that involves labor typically requires an estimate of hours needed to meet the provision, and the labor category of the worker who performs the task. Offshore rigs are usually the largest contributor to regulatory costs because of the labor provided and because offshore rigs are quite expensive to operate. When preparing a regulatory impact analysis, a cost figure of \$1 million *per day* is often used for some types of rigs. The number of additional rig-days required to meet a regulation (in terms of the opportunity costs of the rig) often serves as the numeraire in such an analysis where only the cost itself (e.g., \$1 million per day) is counted in the analysis. However, direct and indirect labor in the use of rigs to meet regulatory requirements can be estimated in terms of the direct labor devoted to employment on a rig plus the substantial amount of labor employed to produce rigs.

To appreciate the magnitude of what offshore operations entail, in terms of both capital and labor, Figure 2 shows a modern drillship—the “Pacific Khamsin.” It is 228 meters in length and 42 meters wide and was built in 2013 by Samsung in South Korea. It is designed with an ability to operate in a water depth of 12,000 feet (2.3 miles) and has a maximum drilling depth of 40,000 feet (7.6 miles) (Pacific Drilling, 2016a). The Pacific Khamsin can accommodate 200 workers (Pacific Drilling, 2016b). The cost of operating the ship *per day* is approximately \$750,000 (Goodridge, 2015).



Figure 2. Illustration of a Modern Drillship: Pacific Khamsin

Suppose a drillship (e.g., the Pacific Khamsin) has a crew of 200, costs \$500 million to build, and has a useful life of 30 years or loses about \$17 million in value each year. To be more precise, suppose the ship runs routine tests on certain equipment that it would perform independently of the new regulation. In this sense, only part of the use of the ship should be associated with (or caused by) the regulation if it is performing other functions simultaneously. That proportion itself may easily be ambiguous since there will be staff on the ship (e.g., the ship’s cook) who could be apportioned to either activity. For example, suppose that only 10 people are actively working on an activity associated with the new regulation, 70 people are working on maintaining the ship’s safe status (as an ocean vessel) in various ways, 20 people are working directly on a simultaneous activity, and 100 are temporarily idle while waiting to perform other functions when the ship moves to other locations. Depending on one’s analytical framework under such a hypothetical situation, the proportion of the ship’s time attributable to meeting the new requirements could be as low as 0.05 (if only the 10 people are counted), 0.33 (attributing 1/3 of the work, based on 10 out of 30 performing active work on specific, non-routine work), 0.5 (simply recognizing the ship is performing two functions simultaneously and attributing 50 percent of the time to each), or 1.0 (assuming that whatever is being done

simultaneously could have been done simultaneously with other functions at a later date and for this reason should not be considered in the calculation).

Similarly, another source of ambiguity exists in determining how much travel time is needed for the rig to go to the location where the regulatory work is to be performed. If the trip is entirely independent and unrelated to any other trips, then all the travel time could be attributed to the new regulation. At the other extreme, if the travel is precisely on route to another location that the ship will travel to next regardless of the regulation, then it could be argued that none of the ship's travel time should be attributed to the new regulation. One can now envision the general case where the trips course is a *triangle* in its travelling to the location needed to comply with the new regulation and then to its next destination, and its travel time attributable to the regulation could be based on that triangle.

Given all ambiguities, the best any BC analysis could do is to generate very rough estimates of the time used by rigs to meet the requirements based on best judgment. Compounding this uncertainty is the uncertainty regarding the cost per day of the rig itself, which depends greatly on the type of rig. It cannot be assumed that the lowest-cost rigs would be used in meeting a regulatory requirement since those lowest-cost rigs may not be available in the area at the time they are needed due to scheduling conflicts with other activities.

5. Estimation of Full-Time Equivalent (FTE) Employment Levels

Various conventions apply for estimating the number of hours a full-time worker performs per year, where these hours would also include paid time off (e.g., for holidays, annual leave, sick leave, and administrative leave). Sometimes, the number used is 2,080 (for 40 hours per week for 52 weeks per year), or one might more generally estimate 2,087 (accounting for another 1.25/7 days more than 52 weeks assuming 365.25 days per year). However, offshore employment works differently in the sense that offshore workers do not work 40-hour weeks. They typically work 12-hour shifts daily (rather than 8-hour shifts), and they typically work under a “seven-on, seven-off” or “14-on, 14-off” schedule. The former entails seven days of continual work (at 12 hours per day) followed by 7 days off, and the latter entails 14 days of continued work (also at 12 hours per day) followed by 14 days off. Like their counterparts who work regular 40-hour per week schedules, offshore workers are entitled to additional days off for holidays, annual leave, sick leave, etc. Overall, their work hours are quite similar to regular working hours in terms of their total amounts of labor and leisure time per year, reflecting the tendency for the relative amounts of labor and leisure to remain fairly consistent across different occupations within any society (Constant & Otterbach, 2011).

A typical FTE employee works 160 hours over four weeks, or 5.71 hours per day, while any existing a crew member works 12 hours per day, implying that the conversion factor (C) between the number of average daily crew members (N) and FTEs is $12/5.71 = 2.1$. Thus, if a rig has a daily crew of N , the number of FTEs *per day* = $2.1 N / 365.25$ or $(0.05749)N$.

A depreciation in the value of the rig by \$17 million per year would imply a daily rate of depreciation of about \$46,000. Therefore, this opportunity cost per day implies that \$46,000 more should be spent on the production of new rigs per day to compensate for this loss in the value of the physical asset as the rigs to continue to perform functions at the same rate as they would have performed prior to the regulation. If, for example, labor costs account for 50% of the costs of building new rigs, then there is a labor cost of \$46,000/2 needed to replace this value. If the average compensation of labor used to produce rigs is, say, \$100,000 per year (including all benefits), then the number of FTEs generated from this effect would be $(46,000/2)/100,000$ or

approximately 0.23 FTEs. Adding the two effects, resulting in 1.23 FTEs, would imply (in this hypothetical example) that 1.23 full-time jobs for one year would be created for *each day* that the drilling rig would be used to meet a regulatory requirement. Formalizing this framework, we have:

$$L = \frac{CN}{365.25} + \frac{PK}{AS}$$

where:

L ≡ Employment in (annual) FTEs from one day's use of an offshore rig

C ≡ Conversion factor for FTEs per average crew-member day (as above, e.g., 2.1)

N ≡ Average number of employees on Drilling Rig on any given day when it is operating

K ≡ Initial Value of a Newly Built Rig

A ≡ Expected Life of a rig in *days* (= expected life in years x 365.25)

P ≡ Proportion of a rig's production cost that is salaries (0 < P < 1)

S ≡ Average (annual) salary *per year* of a worker who builds rigs.

6. Types of Rigs Utilized in Meeting Offshore Regulations and Their Costs

There are three general types of mobile offshore drilling units (MODUs) that are often used to meet the requirements of offshore environmental and safety regulations: jackup rigs, semi-submersible drilling rigs, and drillships. Figure 3 provides an illustration of these rigs in terms of their outward appearance and how they penetrate through the ocean and then the ground below it to explore for and extract oil and gas. These types of rigs vary in the size of their crews and in the depth of the water in which they operate.

Platform rigs (which are not MODUs) are also used extensively to develop wells after exploration and are subject to a variety of regulations as well. Figure 4 provides an example of a platform rig – the “Mad Dog spar” in the Gulf of Mexico. As one might suspect, the deeper the water, the larger the drilling rig required, and the larger the crew needed to operate the larger vessel. Table 1 shows approximate staffing levels that are found on these rigs and their equivalent annual FTEs per day of operation, though the actual levels will surely vary among rigs within the same category.

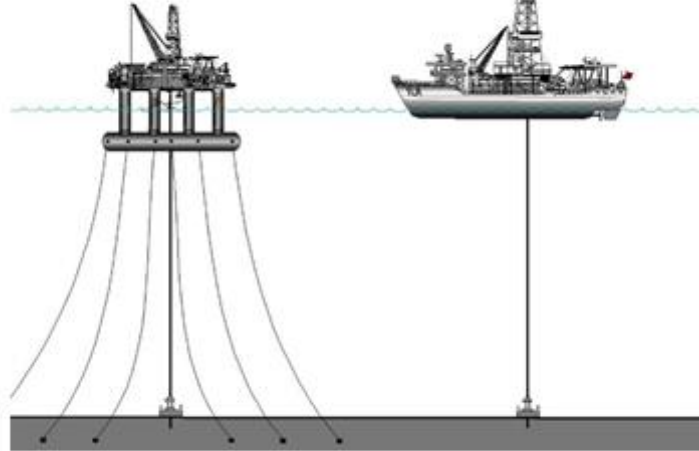
Different rigs are often involved in two different stages of offshore operations: exploration and development. Exploration, as the name implies, first involves finding oil and gas reserves by drilling initial wells. Once an initial well is drilled, and it is resolved that there are worthwhile resources in that location, then the well is capped and left untouched, and the rig that performed the exploration leaves the area. The development stage then ensues, involving another rig—typically a semi-submersible—to develop the well further for the extraction of oil and gas. Once that well is fully developed, the production stage begins, which does not involve a rig, in which the oil and gas are finally extracted. The production stage also involves an infrastructure that includes pipes which may extend across hundreds of miles along the ocean floor to bring oil and gas to refineries. However, in areas of the ocean that are too remote for this method of operations on the U.S. Continental Shelf (where U.S. offshore regulations apply).

It is the exploration stage of offshore operations that pose, by far, the greatest risks to safety and the environment, particularly because of the absence of information about the circumstances the drillers are facing when drilling into new areas. The Deepwater Horizon transport, the oil and gas may be loaded onto tankers. Only the former case applies to offshore incident occurred during this stage when the drillship encountered a much higher upward

Jackup



Semi-submersible



Drillship



Figure 3. Illustration of the Three Types of Mobil Offshore Drilling Units (MODUs)
Sources (from left to right): United States Coast Guard, <http://tinyurl.com/j2q8gcw> and Wikicommons, <http://tinyurl.com/zewml9v> (both in the public domain).



Figure 4. Example of a Platform Rig: The Mad Dog Spar in Deep Water in the Gulf of Mexico

Source: Cndn Bacon at English Wikipedia, Accessed April 7, 2016: <http://tinyurl.com/h873o6z> (permission granted under the terms of the GNU Free Documentation License, Version 1.2).

Table 1. Staffing Capacity (and FTEs Per Day) on Different Types of MODUs

Type of Rig	Measure of Employment	Type of Staff				Total Staffing Capacity
		Supervisory	Specialized	Regular Crew	Maximum New Hires	
Jackups and Platform Rigs*	Crew	10	15	30	75	130
	FTEs Per Day	0.06	0.09	0.17	0.43	0.75
Semi-Submersibles	Crew	21	25	34	70	150
	FTEs Per Day	0.12	0.14	0.20	0.40	0.86
Drillships	Crew	24	29	37	110	200
	FTEs Per Day	0.14	0.17	0.21	0.63	1.15

Source of Staffing Levels: Triepke (2016) (FTEs per day were developed by the author based on the conversion factor of 0.005749 derived above.). The source did not include platform rigs, which are added to the table based on their similarity in crew levels with jackups. For example, the Mad Dog spar, shown in Figure 4, has quarters for a crew of 126 (Offshore Technology, 2016). Compliant platforms (guyed tower, tension-leg, and spars) are included here under platform rigs.

pressure from the well than had been anticipated, leading to a “blowout” and “loss of well control” which destroyed the ship, caused 11 fatalities, and spilled nearly 5 million barrels of oil into the sea before the well could be successfully capped.

Luk (2014) provided the following summary of the general costs associated with the use of offshore rigs:

The offshore drilling industry talks in per-day unit terms. ...oil companies can choose from ... jackups that are fixed to the seabed to massive drillships that can drill in the harshest environments To simplify ... take the latest 7th-generation drillship. Operating costs run at around \$200k/day. These are expenses like salaries, contractors, transportation, materials and energy costs. ... Annual maintenance capital expenditures ("capex") runs around \$14k/day or \$5 million per year. The ship gets pretty battered by the sea, so you need to replace broken equipment continuously ... Then every five years there is a more in-depth inspection and review, and this could cost ... \$50 million. This averages out to \$22k/day. ... the original cost of the ship ... can be ... from \$600 {million} to close to \$1 billion. These rigs usually last 30-35 years, which works out to a per-day cost of \$59k ... Current day rates ... are running around \$550k/day. This is the cost ... to rent the ship ... typically ... for years at a time. The \$550k/day covers the operating costs, maintenance capex, survey costs and provides a return on capital on the original build costs of the ship.

There is often ambiguity in the literature in the use of the term “operating costs” where, in some contexts, it refers only to the types of expenses described as “operating costs” in the above quotation. In other contexts, it refers to what offshore operators (the large oil companies such as Shell) must pay drilling companies for rental and use of their rigs. As an example, the

following quotation is from the initial regulatory impact analysis of a “Well-Control” rule proposed in BSEE (2015, p. 14) about blowout preventers (BOP):

Some requirements in the proposed rule affect rig operations. To monetize the impacts of these requirements, we estimated the daily rig operating costs for affected rigs. Based on input from BSEE and industry subject matter experts, we assumed that subsea BOP rigs have a daily rig operating cost of \$1 million and surface BOP rigs have a daily rig operating cost of \$200,000. We recognize that these figures can fluctuate and thus have chosen estimates that reflect the average daily rig operating costs for those with surface and subsea BOPs.

In this case, a distinction is being made between rigs that utilize “surface BOPs” – blowout preventers that exist above the water on the topside deck of floating rigs or platform rigs – and “subsea BOPs” that lie on the ocean floor, typically requiring the use of semisubmersibles and drillships. As further mentioned in their report, BSEE based these estimated costs on consultation with experts from BSEE and from a sister agency within the Department of the Interior—the Bureau of Ocean Energy Management (BOEM). They also relied on data from listings of rig day rates provided by Rigzone Data Services.

7. The Need for, and Reality of, Rough Estimates of Employment Effects

The sources of uncertainty abound in any effort to estimate the employment effects of any offshore regulation (i.e., to estimate the employment that would be created from the new efforts by offshore operators and their contractors to meet the new regulation). The first uncertainty lies at both the engineering and logistics level. That is, when facing a new regulation, offshore operators may well need to conduct an advanced study of how they plan to meet the regulation based on the technology involved and the resources they have available. It would be difficult enough for the offshore firm itself to perform this analysis, even given its high level of expertise in the field and the detailed information it possesses regarding its capabilities and resources. For example, it might be theoretically possible for some of the required work to be performed by a relatively cheaper drillship than those that are truly available at the time needed, and so the firm may realize that a more expensive drillship (with a larger crew to hire) may be the only option available. However, only the firm would know this, or at least be capable of researching it to know it. Thus, it would not be possible for any regulatory agency to develop such details in its own analysis of the effects of the regulation when the firms being affected themselves may not have those details known or available at the time the regulation takes effect.

Such limitations for the regulatory agency regarding available information and analytical resources, nevertheless, do not prevent the agency from being able to develop meaningful and policy relevant BC analyses of proposed offshore regulations. Rather, these limitations imply that rough estimates will need to be made based on the information that is available and based on reasonably reliable and defensible assumptions. From this perspective, the following guidelines could be considered in the study of the employment effects of offshore regulations:

(1) Demonstrated Effects. All assumed effects should be supported by verifiable empirical evidence as has been the standard requirement for all policy-oriented economic research (Anderson and Kichkha, 2016). As a case in point, no assertions should be made that a regulation is expected to increase operator’s cost by a certain percent without demonstrating how that percent was derived.

(2) Avoidance of Multiplier Models for Estimating Effects on Offshore Employment. Multiplier models rely on NAICS-based data primarily from the Census Bureau’s surveys of

businesses. Because no NAICS code exists for offshore industries, the use of these models for this application would essentially rely on the counterfactual assumptions that offshore industrial activities take place onshore in counties of Texas and Louisiana, and that the multiplier effects that exist on land apply equally to offshore operations.

(3) Downsizing from the Closing of Operations. While multiplier effects should not be estimated for the reasons outlined above, the direct losses of employment due to the closing of operations can be estimated if reliable assumptions could be made regarding which offshore operations would be expected to close because of the new regulation and how many jobs would be lost as a result.

(4) Employment Increases from Additional Daily Use of Rigs. Rough estimates may be made of employment created from the additional use of rigs to meet new offshore regulatory requirements.

(5) Increases from the Labor Requirements of Regulations. These estimates should be readily available to the regulatory agency as they are necessary for the agency's preparation of the BC analysis of the proposed regulation. That is, to estimate various costs associated with the regulation, the BC analysis would most likely have needed to estimate the hours spent by industry personnel to perform the work required under the regulation before multiplying those hours by an estimated compensation rate to arrive at an estimated labor cost. Employment created by the regulation could then be estimated as simply the sum of those hours, converted to full-time equivalent (FTE) employees.

(6) Greater Employment in the Manufacture of Newly Required Equipment. When new regulations require the purchase of new equipment in offshore operations, rough estimates could be made of the corresponding increase in labor that would result in the manufacturing sector (if it is likely that the equipment will be produced in the United States).

Regarding the loss of jobs from closings (item #3 above), depending on who performs the study, the findings could be highly speculative given that estimates of such job losses are anything but policy neutral.

Estimates of employment created from rig use, as discussed above, is highly problematic due to the wide diversity of rigs that might be used and the uncertainty of which rigs might be used to meet certain requirements. Earlier in this paper, it was demonstrated that the one-day use of a large, fully staffed, state-of-the-art drillship could translate to roughly 1.15 FTEs per year. (See Table 1.) This is a ballpark figure that is believed to be a reasonable estimate. In the example provided above, the figure could be increased when accounting for the depreciation of the ship and thus accounting for the additional employment that would be created in the long run in building more ships to replace the old ones. On the other hand, most rigs are built overseas, and if the focus is only on U.S. employment, the additional FTE's per day to replace the depreciated physical capital may not be warranted in the calculation.³

The 1.15 FTEs per rig-day, however, assumes a fully staffed, large drillship and further assumes that the entire staff should be attributed to the work that the regulation requires on each rig-day as opposed to any other work that might be performed on the ship simultaneously. In this regard, the 1.15 FTE per day may be an upper bound on the employment created by each rig-day for any rig (large or small).

³ Of course, in a broader sense, regarding the global economy, employment created overseas then spills over to employment in the United States through increased demand for U.S. exports, though this would be taking the analysis further than the scope of the paper and further than most analyses would go to estimate the employment effects of a regulation.

At the other extreme, as shown in Table 1, jackup rigs typically have a staffing capacity of 130 in contrast to 200 in a drillship. However, this 130 includes a maximum of 75 new hires, without which the staff would be 55. Assuming that there will most likely be at least some new hires, perhaps at least 5, a lower-bound estimate of the staff on a jackup could be approximately 60, and if the rig is performing work to meet the requirements of a regulation, it is most likely that at least 10 workers might be attributed to the work (including proportions of staff time devoted to functions on the ship that are necessary in order to enable the work to be performed). Consequently, if a fully engaged rig of 200 workers accounts for 1.15 FTE per rig day, one might estimate the lower bound of a jackup rig, engaging about 10 workers to perform work in compliance with a new regulation, to account for approximately 0.06 FTEs. To place these estimates in an easier context, one might say that for any 100 rig-days, the employment created per year might range from 6 to 115 jobs, depending on the circumstances.

One approach that analysts could adopt for pinpointing an estimate within this range is to convene a panel of experts on offshore operations who may first understand that the range of 5 to 115 reflects the range between (1) a jackup with 10 employees working on meeting the regulatory requirements while others perform other activities, and (2) a drillship with a full staff of 200, which is not performing any other simultaneous activities that it would perform otherwise in the absence of the regulatory requirements. Suppose, for example, that such a panel, when considering this range, arrived at an average estimate of 40 new FTEs created per 100 rig-days associated with the new regulation. Further suppose that a new regulation is expected to require 5 rig-days for each of 300 wells per year (above and beyond the rig days that would be devoted to other activities), implying a total of 1,500 rig-days per year attributable to the regulation. It then follows that, in this example, the regulation will lead to a rise in employment of 600 ($40 \times 1,500/100$) jobs per year.

With regard to estimating jobs created from the purchase of new equipment, it may be useful in this case to examine the data on the industry “Oil and gas field machinery and equipment manufacturing” (NAICS Code 333132).⁴ For this industry, Census Bureau data for 2014 reports a total number of employees of 53,723 and a “total value of shipments and receipts for services” of 25.850 billion (Bureau of the Census, 2016). These statistics imply a mere 2 employees per \$1 million in shipments and receipts.⁵ The reason for this low number is not that average employee compensation is anywhere near \$500,000 per annum, of course. The costs faced by the industry include a great deal of costs for physical capital (facilities and equipment); indeed, it takes equipment to produce equipment as well as substantial materials costs. In addition, the industry pays for contractual services which require the labor of contractors who are not included as the industry’s “employees.” It is then easy to conclude that the generation of 2 FTE’s for every additional \$1 million in sales is a gross underestimate of the employment created. The problem with finding the more accurate number is two-fold: (1) data are not readily available that could facilitate an estimate of additional employment associated with contractors and services hired by the industry, and (2) such estimates will enter us into the realm of multiplier effects, which would be defensible in this case but inconsistent with not using multiplier effects for offshore activities (for the reasons mentioned above). Regarding the latter

⁴ There is certainly no contradiction here in the use of this NAICS-defined industry to understand the employment effects of the increased manufacture of the equipment used in offshore operations. First, the analysis here is not examining multiplier effects, and this is indeed the industry that should be examined in this case. The *manufacture* of offshore equipment is a production process that takes place on land, by the same firms, and likely in the same exact locations where equipment for onshore operations is also manufactured.

⁵ It is 1.998 to be precise when the statistics are carried out to the full number of significant figures provided by the Census Bureau.

issue, by not including such multiplier effects, the estimated increase in employment is clearly defined as only a “direct effect” and as a lower-bound, “conservative” estimate of the employment increase.

As an example, suppose it is estimated that a new regulation will require the purchase of 300 units of a certain kind of equipment per year that industry would not otherwise purchase without the regulation at a cost of \$100,000 per unit. This implies an additional equipment expenditure of \$30 million per year, creating 60 new jobs per year in the manufacturing sector.

Estimates of employment created or lost from a proposed regulation is a secondary factor in the determination of whether the regulation is worthwhile for society; the primary factor is the extent to which the benefits of the regulation (both pecuniary and intangible) exceed the costs. If the benefits do outweigh the costs, then only a substantive, net decrease in employment would cast a shadow on the regulation that would otherwise be considered preferable based on the BC findings. The situation is not symmetric. That is, if the costs of a proposed regulation outweigh the benefits, then a substantial net increase in employment, attributable to the proposed regulation, would not counterbalance the finding that costs exceeded benefits. Put differently, regulation may be discouraged if it promotes unemployment, but regulation would *not* be an *instrument to create employment*.

8. Estimates of the Employment Effects of the Well-Control Rule

The 2016 Well Control Rule provides a case in point for studying the employment effects of offshore regulations. In its regulatory economic analysis of the rule, BSEE estimated the cost of each major component of the rule in which costs were determined based on:

- (1) Hours of Labor (to meet the requirements of the regulation)
- (2) Use of Small Rigs (in terms of days)
- (3) Use of Large Rigs (in terms of days)
- (4) Costs of Equipment, and
- (5) Costs of Equipment and Labor Combined (if the only available data combined the two)

Table 2 summarizes these costs by topic area. (See DOI 2016a for detailed explanations of the meaning of each topic area.)

One factor that was not considered, because information is not available that would allow for such estimates, is that the new regulation, by reducing the risks of accidents, also reduces the risks of unemployment that might occur because of those accidents. Such job losses might occur through direct curtailment of certain offshore activities, along with the ripple effects of the lost revenue from those activities (Walden, 2013). While these effects could not be estimated, they suggest that the regulations may tend to have a greater positive effect on employment than what we have measured here.

Because of the totals of these estimates, and on the analysis presented above in this paper, Table 3 generates lower-bound and upper-bound estimates of the increase in employment that would occur because of the rule in the absence of an industry contraction. In the table, conversion from thousands of hours to FTEs were simply based on there being approximately 2,000 working hours per FTE. The conversion factors for FTEs per rig day were based on Table 1, where the lower bound for small rigs assumes zero new hires for jackup and platform rigs and the upper bound for small rigs assumes maximum new hires for semi-submersibles. For large rigs, the lower bound assumes no new hires on semisubmersibles, and the upper bound assumes

Table 2. Requirements of Each Major Category of Provisions of the Well Control Rule, in Terms of Labor, Equipment Costs, and Use of Drilling Rigs, Over a 10-Year Period

Topic Area in the Well-Control Regulation	Hours of Labor in thousands (separate from rig days)*	Small Rigs Days in Use	Large Rigs Days in Use	Costs of Equipment (millions of 2015 \$)	Costs of Labor and Equipment Combined (millions of 2015 \$)
(a) Info. in description of well drilling design criteria	3.200	0.00	0.00	\$0.000	\$0.000
(b) Additional information in the drilling prognosis	0.800	0.00	0.00	\$0.000	\$0.000
(c) Prohibition of a liner as conductor casing	0.000	30.00	0.00	\$1.950	\$0.000
(d) Additional capping stack testing requirements	0.000	0.00	0.00	\$2.262	\$0.000
(e) Additional information in the Application for Permit to Modify (APM) for installed packers*	1.300	0.00	0.00	\$0.000	\$0.000
(f) Info. in APM for pulled and reinstalled packers	5.050	0.00	0.00	\$0.000	\$0.000
(g) Rig movement reporting	0.900	0.00	0.00	\$0.000	\$0.000
(h) and (i) Information on MODUs, including liftboats	46.600	0.00	0.00	\$0.000	\$0.000
(j) Monitoring of well operations with a subsea BOP	0.000	0.00	0.00	\$0.000	\$40.500
(k) Documentation and certification requirements for BOP systems and system components	0.300	0.00	0.00	\$17.800	\$0.000
(l) Additional info. in Application for Permit to Drill or to Modify, or other submittals	6.400	0.00	0.00	\$0.000	\$0.000
(m) Submission of a Mechanical Integrity Assessment Report by a BSEE approved certification body	12.450	0.00	0.00	\$48.000	\$0.000
(n) New surface BOP requirements	0.000	0.00	0.00	\$2.500	\$0.000
(o) New subsea BOP system requirements	0.000	0.00	0.00	\$50.000	\$0.000
(p) New surface accumulator system requirements	2.160	0.00	0.00	\$2.250	\$0.000
(q) Two-pin chart recorders	0.004	0.00	0.00	\$0.090	\$0.000
(r) Use water to test surface BOP system	1.200	0.00	0.00	\$0.000	\$0.000
(s) Alternating BOP control station function testing	0.000	250.00	200.00	\$0.000	\$0.000
(t) ROV intervention function testing	0.000	0.00	1.39	\$0.000	\$0.000
(u) Autoshear, deadman, and EDS system function testing on subsea BOPs	0.000	0.00	50.00	\$0.010	\$0.000
(v) Approval for well control equipment not covered in Subpart G	2.965	0.00	0.00	\$0.000	\$0.000
(w) Breakdown and inspection of BOP systems	0.000	0.00	0.00	\$0.000	\$43.000
(x) Record-keeping for real-time monitoring	0.600	0.00	0.00	\$0.000	\$0.000
(y) Industry familiarization with the new rule	0.260	0.00	0.00	\$0.000	\$0.000
(z) BSEE-approved verification org. applications	4.760	0.00	0.00	\$0.000	\$0.000
TOTAL	88.948	280.00	251.39	124.862	83.500

Source: DOI. 2016a.

*Includes employment by both industry workers and (as a very small share) employment by government officials in some cases to process and review information and documents provided by industry.

Table 3. Estimated Increase in Employment from the Well-Control Rule in the Absence of an Industry Contraction

	Hours of Labor in thousands	Small Rigs Days in Use	Large Rigs Days in Use	Costs of Equipment (millions of 2015 \$)	Labor and Equip. Costs Combined (millions of 2015 \$)	Total Annual FTEs over Ten-Year Period	FTEs Per Year
Estimates from Regulatory Impact Analysis (Table 2)	88.948	280.00	251.39	124.862	83.500		
Conversion Factor to Estimate FTEs - Lower Bound	0.500	0.32	0.46	2.000	2.000		
Conversion Factor to Estimate FTEs - Upper Bound	0.500	0.86	1.15	2.000	5.556		
Lower Bound FTEs Estimate	44	90	116	250	167	666	67
Upper Bound FTEs Estimate	44	241	289	250	464	1,288	129

maximum new hires on drillships (where the parameter values were also based on Table 1). The lower bound conversion from equipment costs to FTEs was based on the conservative estimate only 2 FTEs per million dollars of cost, and the upper bound estimate assumed it was all labor costs, implying 5.556 FTEs per million dollars based on an average compensation of mid-level industry engineers of \$180,000 per annum (which includes benefits).

From Table 3, the annual FTEs that would be created each year by the Well Control Rule would range from 67 to 129. While these limits vary by a factor of two, it nevertheless allows us to conclude that the Well Control Rule, as its first, direct effect, will *increase employment by approximately 100 jobs per year*. Of course, if there is a reduction of offshore operations because of the rule, this increase in employment will be counter-balanced by declines in employment from the closing down of some operations. However, unless and until such closures of operations become evident, one might argue that, consistent with microeconomic theory (as presented at the beginning of this paper), offshore regulation should be understood as increasing employment on offshore operations, though only slightly.

9. Conclusions

The estimation of the employment effects of offshore safety and environmental regulation is complex in certain respects, and more often than not, could benefit from additional data that unfortunately are not available. Nevertheless, such estimation, to be valid, must rely on fundamental principles of microeconomic analysis. Reliance instead on initial, unverifiable assumptions regarding proportional cost-markups, followed by the simple application of regional multiplier software, has questionable validity for several reasons, as had been explained in this paper. The most relevant employment effects—those that are most reliable, and less subject to the analyst’s choice of often-arbitrary assumptions—are the direct effects that can be said to be caused as an immediate consequence of the new regulation. These direct effects include: reductions in employment from operations that are terminated because of the new regulation, increases in employment in offshore operations because additional labor is needed to meet the

new requirements, and increases in employment in the equipment manufacturing sector when the regulation calls for the expanded use of certain types of equipment by offshore operators.

The costs related to these expansions of employment can generally be gleaned from information that should already be available in the benefit-cost analysis that accompanied the proposed regulation. That BC analysis will have costs attributable to actions required by offshore workers (and determined by hours of work), costs based on the use of rigs, i.e., the rig-days needed to comply with the regulation, and the costs of new equipment to be purchased by offshore operators. As shown in this paper, both the daily costs of rigs and the costs of equipment can be translated to increases in employment.

If the additional, indirect spillover effects are still desired, then the net effects on employment may be cautiously magnified using a legitimate multiplier that is based on research about the offshore industry itself. However, if the direct employment effects alone demonstrate that there is a net increase in employment as a result of the regulation, then it follows that after the multiplier there can only be an even larger net increase in employment, and so one may choose to forego the multiplier analysis when there are already findings, on the basis of direct effects alone, that the regulation is cost-beneficial and employment enhancing.

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⁶ In accordance with the classification of citations in this paper, based on Payson (2019), the Essential Citations were BSEE 2016a and DOI 2016a, and the relevant citations were Luk 2014 and Snow 2016.

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