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92 years of economic insights for Indiana

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Lean manufacturing: The production employment and wages connection

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The manufacturing sector of the economy is increasingly characterized by complexity and rapid change. The inherent volatility of manufacturing is often the source of workforce apprehension, which produces a reluctance to adapt to the changing environment.

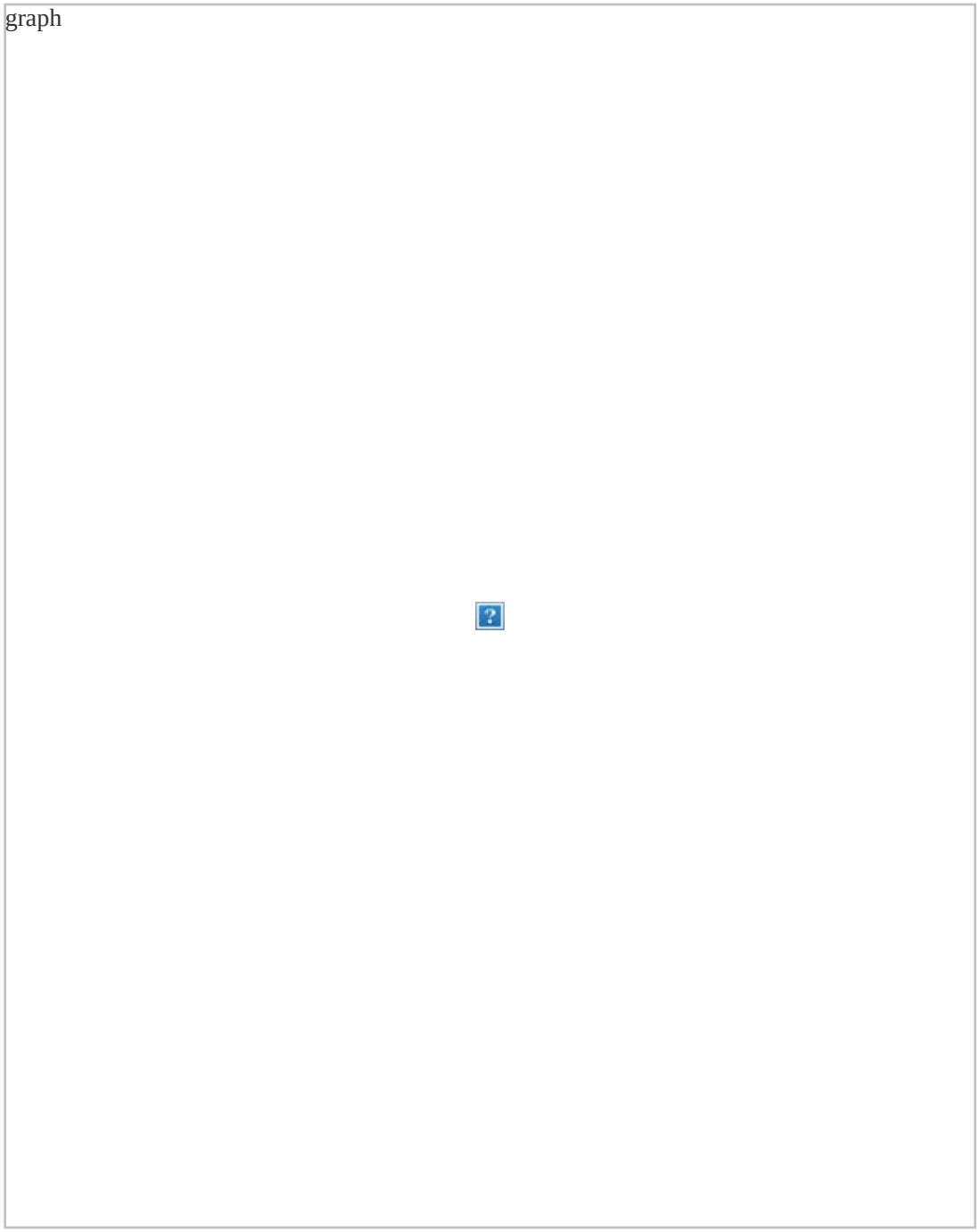
To make (or manufacture) things, it costs money – facilities, materials and labor are just three of the many "inputs" necessary – and it makes sense to add as much value to a product as possible. Lean manufacturing has long been one of the ways to add value by improving the processes involved in the making of the product and eliminate waste.

Purdue University's Manufacturing Extension Partnership has a Lean Office that provides training and consulting on building a "lean enterprise."

Workplace efficiency initiatives can sometimes be misinterpreted as attempts to disrupt the workplace or undermine the social contract between the employer and employees. Within this context, the workforce can resist the adoption of lean manufacturing or other manufacturing efficiency programs. The lack of direct research to counteract this viewpoint only re-enforces its legitimacy. This article is a step towards understanding the relationship between value-adding (or lean) manufacturing and employment and wages.

This analysis is in the same line as well-established research in the area of efficiency wage hypothesis. Efficiency wage hypothesis (EWH) research examines the potential for wage premiums over market-clearing wages to attract better talent. The goal is to acquire better talent that produces productivity gains and reductions in turnover costs in excess of the increased wages.[1] This analysis differs in that it does not assess the performance impacts of wage premiums of individual companies, but rather uses statewide wage averages. Using statewide averages, we examine the directional link between productivity and market-clearing wages, rather than the premium wages of individual actors within industry.

Figure 1: Comparison of value added per hour



Source: U.S. Census Bureau, Annual Survey of Manufactures

(Editor's note: **Table 2** is for readers who want to see the statistical results of the number crunch. Others may want to skip this part).

Table 1: Production by the numbers

		Value Added Per Hour of Work		Average Wage Per Hour		
	In order by highest value added per hour	Indiana	U.S	Indiana	U.S	

	Manufacturing	$149.99	$151.50	$22.28	$22.15
Top 5	325 Chemicals	$796.16	$432.60	$27.49	$29.08
	324 Petroleum and coal products	$732.75	$646.41	$41.53	$38.32
	312 Beverage and tobacco products	$375.36	$534.62	$25.11	$26.91
	334 Computers/electronic products	$211.17	$240.47	$22.22	$26.29
	331 Primary metals	$168.37	$138.32	$31.00	$25.99
	311 Food	$162.91	$123.10	$19.31	$17.65
	339 Miscellaneous	$162.03	$158.97	$20.02	$19.52
	336 Transportation equipment	$126.99	$157.19	$23.23	$26.82
	333 Machinery	$126.73	$146.77	$21.83	$23.39
	322 Paper	$107.39	$155.49	$21.71	$25.44
	327 Nonmetallic minerals	$98.35	$113.58	$22.22	$21.53
	332 Fabricated metals	$96.74	$91.41	$20.29	$21.29
	335 Electrical equipment/components	$92.69	$135.27	$20.23	$21.39
Bottom 5	326 Plastics and rubber	$77.12	$94.51	$17.55	$18.75
	337 Furniture	$75.61	$73.97	$17.15	$17.05
	323 Printing	$73.02	$82.03	$19.42	$20.29
	321 Wood products	$56.64	$69.25	$17.23	$17.25
	314 Textile product mills	$43.07	$65.48	$13.06	$15.15

Source: U.S. Census Bureau, Annual Survey of Manufactures

Our sources include data from the U.S. Census Bureau's Annual Survey of Manufactures (ASM). It includes statewide, industry-level data for the 50 states and the District of Columbia beginning in 1998 through 2013.[2] These data include total number of employees, total number of production employees, total wages for production employees, total production hours for production employees, value added by the company, and capital expenditures by the company. Calculated variables were also added. Summary statistics are provided in **Table 2** .

Table 2: Summary statistics

Variable	Number of Observations	Mean	Standa
Total employees	13,767	1,551.5	
Production employees	13,728	10,957.0	
Total wages for production employees	13,698	365,000,000	
Total hours for production employees	13,748	20,900,000	
Production employee wages per hour (1)	13,587	17.27	
Wage per production employee (2)	13,569	31,993	
Value added	13,428	2,320,000,000	
Value added per production hour (3)	13,310	118.0	
Capital expenditures	12,313	154,000,000	
Capital expenditures per production employees (4)	12,168	14,812.0	
Ratio of total employees to production employees (5)	13,620	1.4	

(1) Calculated as: Total Wages for Production Employees / Total Hours for Production Employees
(2) Calculated as: Total Wages for Production Employees / Production Employees
(3) Calculated as: Value Added / Total Hours for Production Employees
(4) Calculated as: Capital Expenditures / Production Employees
(5) Calculated as: Total Employees / Production Employees
Source: Authors' calculations, using U.S. Census Bureau Annual Survey of Manufactures data

The analysis used an ordinary least squares (OLS) model. Yearly binaries were created to account for yearly influences, such as the general economic climate and inflation. State binaries were created to account for state-specific influences and cost of living differences. Industry binaries were created to designate the type of manufacturing and account for the differing wage scales that exist in manufacturing due to job variation. The manufacturing designations are based on three-digit North American Industry Classification System (NAICS) codes. This analysis assumes that different manufacturing jobs require differing levels of employee skill. The more skills required for specific jobs or sectors within manufacturing, the higher the wage.[3]

This article attempts to determine the impact of lean manufacturing on employment and wages. Lean refers to "manufacturing that focuses on reducing or eliminating waste in all facets of the system."[4] The study uses value added per

production employee hour as a proxy for lean.

> *A*s a manufacturer becomes lean, it should increase the value added it provides per production employee per hour.

Gross value added per employee has been used in prior studies.[5] The variable, value added per production employee, is used as explanatory in this analysis.

Investment was a possible explanatory variable since capital investment can influence the level of value added in the manufacturing process. The ratio of total employees to production employees was also added as an explanatory variable. This variable ascertains the influence of differing employee structures.

The non-binary data was transformed to natural log form to help account for exponential effects and to aid in the interpretation of the data. As both the independent and explanatory variables of note are in natural log form, the magnitudes of the result coefficients will be elasticities. Increases in value added per employee hour (or becoming lean) have a lingering effect on wages (existence of autocorrelation). A lagged term was added to the model in order to accommodate this influence. The lagged variable is the value added per production employee term.

The results establish a strong correlation between value added and wages. Higher levels of worker productivity coincide with higher worker wages. The results of the non-binary variables are provided in **Table 3**. (Download the appendix for the full results.) The value added and its lag are both highly significant and positive in all four models.

Table 3: Regression results (non-binary variables)

	1		
	Production employees		Tota
Adjusted R-square	0.747		
	Coefficient	Standard error	C
Value added per production employee	0.161	0.031*	
Value added per production employee lagged (one year)	0.320	0.031*	
Capital expenditures per production employees	0.250	0.012*	
Ratio of total employees to production employees	-0.641	0.059*	

* Statistically significant at the 1 percent level.
Source: Authors' calculations, using U.S. Census Bureau Annual Survey of Manufactures data

Higher levels of value-added production are positively correlated with more production employees, more total hours for production employees, higher production employee wages per hour and higher total wages per production employee. Increasing the value added per employee is correlated with increasing levels of production employment and higher production wages. However, this study lacks the explanatory variables necessary to claim a causal link, so the focus is correlation.

The capital expenditure per production employee variable is highly significant and positive in all four models. Capital expenditures are positively correlated with more production employees, more total hours for production employees, higher production employee wages per hours and higher total wages per production employee.

Efforts in lean manufacturing are often coupled with capital expenditures. These capital expenditures, rather than diminishing the need for workers, are correlated with increasing levels of production employment and higher production wages.

The ratio of total employees to production employees is highly significant and negative in all four models. Manufacturing companies that are increasingly top

heavy are correlated with fewer production employees, fewer total hours for production employees, lower production employee wages per hour and lower total wages per production employee.

The results generally suggest a positive relationship between lean manufacturing and its impact on worker welfare. Value-added enhancement is associated with higher levels of production employment and wages.

However, the advances in employment and wage growth are less than proportional to the increase in value added. A 1 percent increase in value added only results in a 0.16 percent increase in production employment, a 0.13 percent increase in total hours for production employees, a 0.14 percent increase in production employee wages per hour and a 0.11 percent increase in total production employee wages. This indicates that a smaller portion of the benefits of value-added enhancement activities are allocated to production employees.

This information is important for policy planning in the areas of business development and education. Economic developers should focus on bringing high value-added manufacturing to the state if they want long-term increases in wage and employment growth. A state with low-skill manufacturing will likely languish with slow wage growth and lower rates of employment growth. If a state wishes to bring in higher value-added manufacturing, they will also need a workforce with the required skills, so having adequate educational services to provide for this demand is important.

Notes

1. J.E. Stiglitz, “The Efficiency Wage Hypothesis, Surplus Labour, and the Distribution of Income in L.D.C.s,” *Oxford Economic Papers* 28, no. 2 (1976): 185–207.
2. U.S. Census Bureau Annual Survey of Manufactures data obtained from STATS Indiana (www.stats.indiana.edu/asm/) on November 12, 2015.
3. S. Snell and J. Dean, “Integrated Manufacturing and Human Resource Management: A Human Capital Perspective,” *Academy of Management Journal* 35, no. 3 (1992): 467-504.

4. “APICS Operations Management Body of Knowledge Framework, Third Edition.” APICS Magazine, 2015, www.apics.org/industry-content-research/publications/ombok/apics-ombok-framework-table-of-contents/apics-ombok-framework-3.11.
5. T. Kochan, R. Lansbury, and J. P. MacDuffie, *After Lean Production: Evolving Employment Practices in the World Auto Industry* (Ithaca: Cornell University Press, 1997).

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Innovation 2.0 – What's in your wallet?

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Is your region innovative? How does your economic landscape compare to your peers?

The new Innovation Index 2.0 can help answer

those and many other questions. The II 2.0 is a web resource that can give economic development practitioners and other regional leadership the ability to assess their economic strengths and challenges, in addition to their capacity for innovation.

> “*I*nnovation is the specific instrument of entrepreneurship. The act that endows resources with a new capacity to create wealth.”
> –Peter Drucker

The new II 2.0 is more comprehensive than the earlier innovation index. II 2.0 expands on the previous index by adding more than 50 new measures. Like the first version, these data are all at the county level and can be aggregated to a regional level based on the user's needs. These measures reflect contemporary research on understanding and measuring innovation. For example, II 2.0 includes measures that take into account regional knowledge spillovers, technology diffusion and foreign direct investment.

Both the II 2.0 and economic development related web tools that are available on StatsAmerica.com were developed and built by the Indiana University Business Research Center with funding from EDA.

> "*T*he secret of change is to focus all of your energy, not on fighting the old, but on building the new."–Socrates

The Innovation Index 2.0 provides a set of analytic tools and data that can help regional leaders reach a strong consensus on their region's strategic direction. Data and analysis can inform stakeholders' collective action toward a common vision and can guide complex decision-making at a regional-level by identifying region's capabilities, shortfalls and potential.

Data-driven regional development strategies require data and not all regions' economic development commissions or business associations can afford data and analysis from data vendors. The IBRC, thanks to the EDA, provides these data and resources at no cost to the user.

The tool is engineered for drilling down into detailed data as well as cross-regional analysis. Users can focus on a single area (Overview) or a multi-area comparison (Comparisons). A nationwide mapping widget allows you to see

every county or region in a heat map style – even allowing the user to select a county or region as the "comparison point," against which all other counties are then measured.

The user can compare a county or region side-by-side with other, similar geographic units, and capture the data in a spreadsheet or pdf. The index values and ranks can be downloaded by county, MSA and Economic Development District.

The headline index is calculated from five major index categories (three based on innovation inputs and two based on innovation outputs). The structure and the calculation of the index is hierarchical, or built up pyramid-like, from a large foundation of data to the single headline index. The "headline" index—the one, high-level summary index—is comprised of five major categorical indexes organized thematically. Those five major indexes are built up from several core indexes that are built up from several measures that are also organized thematically along more precisely defined concepts. Those measures are directly tied to the raw data, most of which can be accessed on the StatsAmerica.com website.

Indexes present complex data simply, somewhat like a dashboard gauge. Understanding what the dashboard is showing was the main focus of the webinar on February 2, 2017. In this webinar, we showed how to compare a country/metro/EDD against other benchmark or peer regions that share similar characteristics. The Map Tool can be used to view, spatially, each one of the Innovation metrics, such as STEM, prime working age population, per capita income or business incubators spillover effects.

For more details on how the II 2.0 was built and how to use and understand it, please refer to the report which is available at:

http://www.statsamerica.org/ii2/reports/Driving-Regional-Innovation.pdf

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Reflections on the Carrier deal

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November 24, 2016 wasn't a typical Thanksgiving Day in Indiana news. The then-president-elect tweeted about making progress on keeping jobs in Indiana that Carrier had announced earlier in the year were leaving the state.

On Tuesday, November 29, President-elect Trump and Governor Pence announced that on December 1, they would unveil the deal that would result in keeping some 1,000 jobs in Indiana.

> *C*arrier – was it a good deal?

Then the phone started ringing. Broad outlines of the negotiation were reported and state-based reporters wanted to know "if it was a good deal for Indiana."

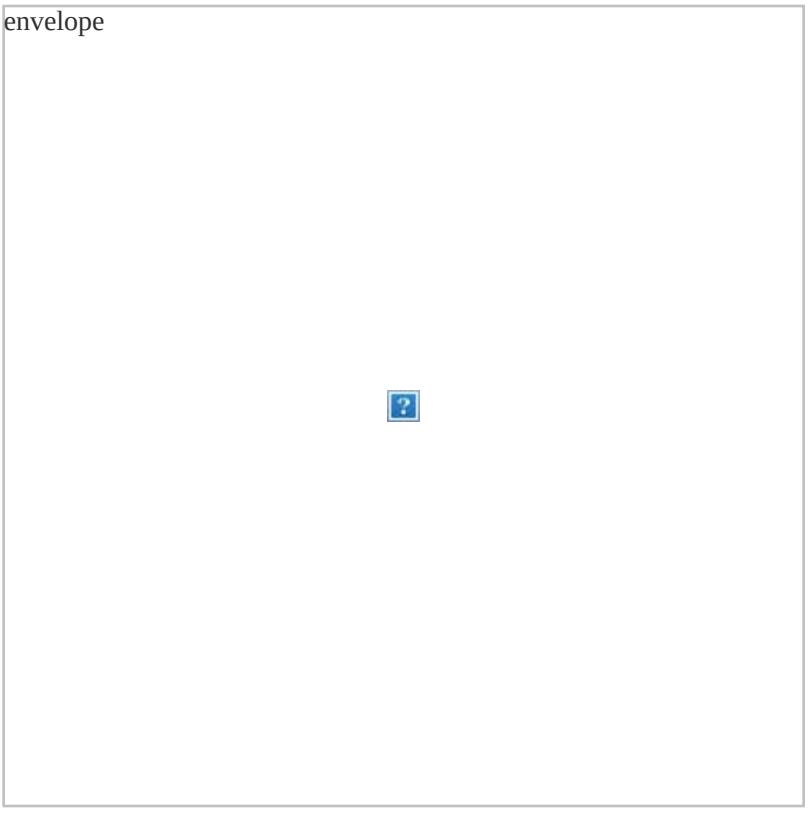
What they didn't ask, perhaps wisely, is if the deal made sense and was a good economic idea. The chattering class had plenty to say about that, so one's contribution on those particular questions would have been marginal at best.

Esteemed conservative economists like John Cochrane and Tyler Cowen were resolutely against the action, considering it crony capitalism where firms make money off the government. The deal represented baby steps to a dysfunctional economy like France or, worse, Venezuela. On the opposite end of the political spectrum, the likes of former Treasury Secretary Larry Summers and former Enron advisor Paul Krugman likened it to a government protection racket and presages of a scary economic and political future.[1]

The Electoral College had not yet met and both the right-wing Never Trumpers and the left-wing Clinton apparatchiks were still in high dudgeon.

The hand wringing and contempt for the deal was well expressed across the political divide. (Perhaps Trump would pull the country together after all!) Left-leaning radio news program guests and call-in listeners were suddenly discovering the wisdom of the government not picking winners and losers. They definitely did not approve of Trump winning a deal at tax payer expense.

Which brings us back to the question of the reporters: Was it a good deal? To me, that question translated into this: What do the numbers say? Or better still, what is the cost-benefit? I had an envelope handy so I went to work.



These sorts of calculations require several assumptions and are done quickly. The annual cost to the state was reported at that time to be

about $1 million a year for ten years and the number of jobs to be saved was 1,000. Assuming each job is full-time with no overtime hours, that is about 1,960 hours per job per year, or about $0.51 an hour cost to the state. Does the state extract any financial benefits? State income taxes run at 3.3%. My initial guess for the wage rate was $27 an hour which yields state income tax revenue per hour of about $0.89.

> *I*f one pays 51¢ and gets 89¢ back, that is a pretty good deal.

If one pays 51 cents and gets 89 cents back, that is a pretty good deal. So good in fact, that even if one overestimated the hourly wage by a third – that would be $18 an hour – the math still works, although not as favorably. Taxpayers are not footing the bill.

Were those workers made redundant, they would qualify for several state and federal displaced worker programs, at a cost to the tax payer.

Like any good journalist working on a deadline, the reporter called several economists, even those from rival universities. Turns out, when I provided the reporter my quick and dirty, back-of-the-envelope calculations, she said they basically matched the results of another economist at a rival state-supported university to the north and west of me that will go unnamed because they poached one of our best economic analysts. (Not that I'm bitter.)
He must have used the same envelope.

Based on this one dimension – Indiana's costs and benefits – it was a good deal.

About a week later, Mike Kwatinetz, commenting in *Fortune*, made an even

stronger case.[2] Mr. Kwatinetz not only included Indiana taxes in his cost-benefit analysis, he included the other taxes and contributions that a "Carrier job saved" provides the federal government: Social Security, Medicare and income taxes. His estimates, based on an average hourly wage of $20 an hour, totaled $12,300 per year, or $6.27 an hour. Kwatinetz, a venture capitalist and self-proclaimed non-supporter of Trump, put the cost-benefit ratio at 1 to 14.

And Kwatinetz was not as comprehensive as he could have been. There are government support programs like Trade Adjustment Assistance that workers can avail themselves of, not to mention unemployment benefits.

Many may say this is a false calculation. A redundant Carrier worker will find employment elsewhere. Yet, that worker will have a tough time finding work as remunerable. A worker may be able to find a job in the appliance department at Home Depot or Lowe's for $18 an hour, in which case, the net is slightly in the state's favor to have the Carrier job disappear and be replaced by the appliance sales associate. (Home Depot: $18 times 0.033 ≈ $0.60 an hour in state revenue, versus $0.90 minus $0.50 ≈ $0.40 an hour net state revenue with the Carrier deal.) But there are at least two problems with the last calculation and its attendant assumptions. One, workers who are "made" to work in production don't tend to migrate to other industries easily. In a study reported in these pages recently, the IBRC found that a majority of workers who had lost their jobs in transportation equipment manufacturing (TEM) or primary metal manufacturing (PMM) from 2002 to 2014 just vanished from the official employment records. They could have become self-employed, moved, retired, passed away or become grand-daddy daycare, but they were not working in a traditional, tax-paying sense. Those who did lose their jobs and took advantage of education and re-training benefits – a troubling small share of those who were displaced – went

back to work in TEM and PMM because that is where the higher wages are.

The second problem is that the hourly wage base was wrong. One didn't have time to double-check his assumptions about hourly wages when using the first envelope. The average hourly wage for Indiana workers in industry NAICS 333415 – Air-conditioning and warm air heating equipment and commercial and industrial refrigeration equipment manufacturing (yes, that is the complete industry title) – was $30.82 in 2015, according to the Bureau of Labor Statistics. This is a full $10 an hour greater than what Kwatinetz assumed. Given what we know about human behavior – how workers find new employment – and given more realistic assumptions about costs and benefits, the Carrier deal looks better and better.

Those familiar with measuring the benefits of securing a new greenfield investment from out of state or the costs of closing a large facility will, by now, have asked the following question: What is, or would have been, the total economic impact of losing 800 Carrier jobs?[3] The IBRC routinely conducts such economic impacts analyses (EIA). But we rarely do those analyses for free – it requires more than an envelope – and our EIA staffer was overburdened anyway. But the issue of total economic impact is important because any large economic event like a new plant or a plant closure or dramatic scaling back has ripple effects. The plant sources inputs and services from around the region and those firms stand to gain or lose when an anchor production facility is added to, or removed from, the economic landscape. In short, those 800 Carrier jobs may support another 400 full-time jobs across a spectrum of occupations in the region, along with all the attendant state and federal taxes and contributions associated with those additional jobs. There are several companies that have developed sophisticated EIA software and done EIA studies for clients, among them, EMSI,

IMPLAN and REMI. These firms help answer the question: what is the total expected economic impact of losing those 800 jobs?

This, in a roundabout way, brings us to the last chapter of my Carrier story. When I presented my quick and dirty analysis of the Carrier deal to a room full of business economists, no one challenged me about the political economy of the deal, whether it was a baby step to Mafiosos picking industry winners and losers. Rather, at the end of the Q&A, a gentleman in the back of the room stood up, said he was with REMI and that they had run their models on the deal.

He said he agreed with my conclusions.

Φ The views and comments expressed are the author's and do not necessarily reflect the views of the IBRC, the KSoB or IU. No parasites were harmed in the writing of this article, at least none that the author knows on a first name-basis.

Epilogue

It turns out that the Indiana Economic Development Corporation approved the Carrier deal on March 28, 2017. (www.insideindianabusiness.com/story/35016839/iedc-approves-incentives-for-carrier) The terms of the deal became more clear. The total value of the incentives were materially less than originally bandied about: $7 million in contrast to $10 million. The number of jobs settled at 800. The duration – ten years – remained the same.

This enhanced the cost-benefit ratio to approximately $1 in cost to $2 in benefit. This C-B ratio doesn't include any of the other contributions and costs that Mike Kwatinetz used in his analysis to get his 1 to 14 ratio. It also doesn't include the social costs of people losing their jobs, and often the attendant hopelessness of

being out of work.

One wonders how we can save more.

Notes

1. Tim Worstall , “Donald Trump's Carrier Jobs Deal - Baby Steps To Killing The US Economy”, *Forbes*, https://www.forbes.com/sites/timworstall/2016/12/04/donald-trumps-carrier-jobs-deal-baby-steps-to-killing-the-us-economy/#17274ee6496f ,December 4, 2016.
2. Mike Kwatinetz, "Trump’s Carrier Deal Could Generate Big Returns For The U.S. Government" , *Fortune,* ,http://fortune.com/2016/12/13/trumps-carrier-deal/
3. Danielle Paquette, "He ‘lied his a– off’: Carrier union leader on Trump’s big deal", *Washington Post*, The alert reader will note the change in the number of jobs from 1000 to 800. Shortly after the announcement, there was a big dustup about the exact number of jobs. The union leader Chuck Jones, president of United Steelworkers 1999 who represents the Carrier workers, getting into a verbal fist fight with President Elect Trump. The number of saved jobs appears to have settled around 800. The lower jobs number doesn’t materially change the cost-benefit equation. https://www.washingtonpost.com/news/wonk/wp/2016/12/06/he-got-up-there-and-lied-his-a-off-carrier-union-leader-on-trumps-big-deal/?utm_term=.d0cff315612b

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