# A Multi-Regional Input-Output Analysis of the Impact of Federally-Funded Investments in Science, Research and Technology in Arizona

Jaewon Lim and Sandy Dall'erba

REAL 15-T-11 August, 2015

# A Multi-Regional Input-Output Analysis of the Impact of Federally-Funded Investments in Science, Research and Technology in Arizona

Jaewon Lim
School of Environmental and Public Affairs
University of Nevada at Las Vegas
Email: jaewon.lim@unlv.edu
4505 Maryland Parkway, Box 454030
Las Vegas, NV 89154-4030
Email: jaewon.lim@unlv.edu
Phone: 702-895-3868
Fax: 702-895-4436

Sandy Dall'erba
Dept. of Agricultural and Consumer Economics
Regional Economics Applications Laboratory
University of Illinois at Urbana-Champaign.
Email: dallerba@illinois.edu
Phone: 217-333-1810
Fax: 217-244-7088

**Abstract**. This paper uses a multi-regional input-output (MRIO) approach to highlight the spatial and social heterogeneity in the economic impact of federally-funded research and development (R&D) investments in the state of Arizona. Overall, the $ 526.9 million allocated to the state in 2010 have led to a statewide output multiplier of 2.18. However, the multiplier effects vary across the two largest metro areas (Phoenix and Tucson) and across socio-economic groups. Indeed, our calculations find returns that are between 0.23 to 0.88 point greater in Phoenix than in Tucson. The "rest of Arizona" reports an even greater gap w.r.t. Phoenix because of a lack of skilled workers and infrastructure. We also find the presence of social returns as investments in scientific innovation lead to job creation even for the labor force with just a high school degree. However, the main beneficiaries are the workers with the highest levels of education.

**Acknowledgement**: This study was supported by the National Science Foundation Grant (SMA-1158172). Any opinions, findings and conclusions or recommendations expressed in this article are those of the authors and do not necessarily reflect the views of the National Science Foundation.

## 1. Introduction

The State of Arizona has experienced a rapid population growth over the last three decades but it has not reflected in its economic development. This is because most of the jobs created have been confined to low-skilled workers in service-oriented industries. On the other hand, some places within the State boost the presence of internationally renowned high-tech companies such as Raytheon (defense electronics), Motorola (telecommunications), or Honeywell (consumer products and aerospace). This dichotomous phenomenon leads us to wonder how the State's economy could benefit from additional and eventually more diversified investments in R&D and whether it would allow the State to retain/attract a more skilled workforce.

Estimating the impact of publicly-funded R&D investments on the regional/local economy is an endeavor that has already attracted a lot of attention in the regional economics literature. For instance, Plosila (2004) offers a thorough review of state science- and technology-based economic development efforts since the late 1960's. Some of his recommendations about the ways to improve them echoes the work of Feller (1997) who advocates for a better coordination between state and federal spending in science and technology.

The difference with our current work is that we use the formal tools of input-output analysis to estimate the impact of a very specific federal program, namely the 2010 federal investments in science, research and technology in Arizona and its 15 counties. This spending is part of the 2009-2012 American Recovery and Reinvestment Act (ARRA) that devoted up to $41.5 billion (5.3% of the economic stimulus package) to such investments. To the best of our knowledge, there has not been a single study devoted to estimating their impact. In addition, the input-output literature estimating the impact of R&D and technology investment at the local level focuses mostly on the role of high-tech parks (e.g. Lim, 2010; Swenson, 2010; Clinch, 2003; Luger and Goldstein, 1991) or on the presence of a university (e.g. LeSage, 2014, Siegfreid et al., 2006; Drucker and Goldstein, 2007). Instead, this paper offers to assess the multiplier effect due to spending in the sector “Scientific research and development services” without presumptions as to whether the research is performed in the private or public sector.

In addition to measuring the impact on the output, employment and labor income across the counties of Arizona, this paper pays careful attention to the social returns generated by the 2010 federal programs. Since high-tech industries traditionally create high-wage jobs for high-skilled workers, we cannot expect everyone in Arizona will benefit from further investments in science. However, what we can expect is that some, even among the less educated, will experience a return on these investments because economic theory highlights the presence of human capital externalities and that the low-educated workers cannot be perfectly substituted with other workers (Lucas, 1988; Moretti, 2004; Ciccone and Peri, 2006).

An evidence of this type of social return appears in the IO study by Gibson *et al.* (2010) where the authors demonstrate that 30% of the newly created jobs in high-tech manufacturing sectors in 2006 in Pima county, where Tucson is located, were available for the group with ‘High School or Less Education’ while another 30% were available for the group with ‘High School and some College or Specialized Training’. Another empirical IO study (Lim *et al*., 2011) finds that the higher share of the direct jobs (46%) created in Arizona in 2009 was available for the group with ‘High School or Less Education’ and another 21% was available for the group with ‘High School and some College or Specialized Training’. For both studies, the authors use IMPLAN's occupational matrix for each economic activity. Since it is region-specific, it provides a fairly detailed level of analysis. By linking IMPLAN's occupational matrix to minimum required educational attainments, the authors quantify the impact on several population groups based on educational attainment for the related industrial sectors.

The rest of this paper is organized as follows: section 2 describes the input-output data, educational attainment data and the allocation of federal programs used for the analysis. The results, first in the frame of a single-region model and then in a multiregional IO framework, are reported and discussed in section 3. The social returns generated across groups with various educational levels are examined in this section too. Finally, section 4 summarizes the results and offers some concluding remarks.

## 2. Methodology

Like many other input-output studies, ours relies on IMPLAN, one of the most widely and commonly used analytical tools for impact analysis. More precisely, this paper relies on the newly updated IMPLAN® model (version 3) which, once it is coupled with an annually updated dataset at the regional level, enables us to estimate various types of economic impacts at different spatial scales. The key element in our work is the link between the impact results and an occupational matrix that allows us to provide a measurement of the changes in employment opportunities for a population with different levels of education.

### 2.1 The Social Accounting Matrix (SAM) of IMPLAN

This paper intends to extend previous contributions applied to Arizona (Gibson *et al.*, 2010; Lim *et al.*, 2011) by relying on the most recent IO regional data and using the true values of federal investments in science as a way to positively shock the local economy. County-level federal investments in science, research and technology are transformed into expanded sales for the related industrial sectors. This transformation enables us to analyze the impact on employment and labor income for the State as a whole and for each of the 15 counties of Arizona when treated individually. Furthermore, since we control for the trade flows across counties within the state, it is actually a multi-regional input-output (MRIO) model that we use for our calculation of the economic impact. It is well known that, by accounting for leakages and feedback effects, it provides us with a more accurate measurement of the impact on the economy than a single region model.

The SAM created in the framework of the IMPLAN® Professional package describes the regional economy within a matrix of 440 sectors that purchase and sell goods and services from and to each other. This package also identifies the transactions among four non-industrial institutions (households, government, investment and trade) allowing us to track the monetary flows in the local economy under study. We build a state-level SAM for the State of Arizona as well as two MSA-level (Metropolitan Statistical Area) SAMs. One is for Phoenix Metro (defined as Maricopa County and Pinal County) and the other is for Tucson Metro (Pima County). These models identify all the industrial sectors that compose our economy. They include the suppliers of intermediate goods and services necessary to the industrial sectors directly stimulated by federal investments for increased production. As a consequence, the regional economic impact of the federally-funded investments in Science, Research and Technology in Arizona represents the impact on the respective industrial sectors whether they are directly or indirectly associated to such investments and on the four non-industrial institutions listed above. Our developed SAM relies on the 2010 data of the State's economic structure to measure the impact of the 2010 federal investments both at the state-level and MSA-level.

SAM is used to estimate the indirect impacts, i.e. all the changes in employment and wages in all industries based on the purchases of goods and services made for the purpose of the tenant companies' operations. The magnitude of the indirect (interindustry) impacts depends on the percentage of locally produced goods and services represented in the model as the regional purchase coefficient (RPC). The more locally produced goods and services are used, the higher the local indirect impacts are. Conversely, the higher is the share of goods and services purchased outside the region, the higher the leakages will be and the less the indirect impacts will be reflected in the county's economy. Induced impacts, i.e. impacts that result from an increase in employees' spending, are estimated using the average household spending for various income groups of households generated by SAM.

In addition, SAM traces inter-institutional transfers. Transfers from industrial sectors or households to the government represent government tax revenues. In the framework of SAM, an impact analysis estimates the outputs, employment compensations, proprietors' income, other property type income, and indirect business taxes. These estimated values are used as inputs for tax revenue estimations. Utilizing the tax revenue estimation template provided by the IMPLAN® software package, the tax revenue can be estimated for the federal government and for the state & local government by aggregated items. This tax report is available for direct, indirect and induced revenues, respectively.

## 2.2 **Occupation and Educational Attainment**

Several past studies offer an estimation of the social returns of investments in high-tech sectors. For instance, the report of Clinch (2003) analyzes the impact of the (then) proposed East Baltimore Biotech Park and the UMB (University of Maryland, Baltimore) Research Park on the occupational opportunities of the lower-skilled individuals. He utilizes the Bureau of Labor Statistics Occupational Employment data that capture the share of employment in industry. He also uses an average mix of economic activities in a generic high tech/biotech research park. He finds that more than one-third of the estimated direct jobs at the two proposed parks could be available to a workforce with a fairly low educational attainment and some on-site training. More recently, Lim *et al.* (2011) estimate the occupational distribution of jobs based on a proposed University of Arizona Bioscience Park. They further extend their analysis to workers with minimum educational attainment and rely on IMPLAN’s occupational matrix for each economic activity to have the most detailed level of analysis possible. Their empirical results confirm the earlier findings by Clinch (2003) in that many of the direct, indirect and induced jobs created by the high tech research park would be available to workers with a low educational attainment.

In the current paper, we also adopt an approach based on IMPLAN’s occupational matrix but with the significant difference that it is an actual influx of federal investment that shocks the local economy. In addition, we estimate the labor income by educational attainment which enables us to compare wage per employee by educational attainment and by type of jobs (direct, indirect and induced jobs). Regional comparison of job creation/retention and of labor income by educational attainment helps us highlight the regional differences in the social returns to federal investments in science, research and technology in Arizona.

### 2.3 Allocation of federal investment across Arizona

In 2010, the Federal government invested $526.9 million in science, research, technology activities and other related industrial sectors in the State of Arizona. Around 40.5% of that amount ($213.4 million) was allocated to Phoenix Metro while Tucson Metro received 55.4% ($291.7 million). These two metro areas represent the bulk of the state's economic activity so that less than 5% remained for the rest of the state. Table 1 below displays the sectoral and spatial allocation of these investments. It indicates that more than 95% of the spending went for the industrial sector called 'Scientific research and development services'. This holds true at the state level as well as within each of the two largest metro areas. Statewide investment for the other four sectors was much smaller. It culminated at $25.7 million and was spent for the purchase of equipment and school curriculum development for STEM related activities (science, technology, engineering and mathematics).

<< Table 1 here >>

<< Figure 1 here>>

## 3. Results

Our paper quantifies the economic and tax revenue impact for each individual metro area and for the state as a whole. For the impact at the metro-level, we created a three-region MRIO structure (figure 1) whereas a single region input-output model was employed to measure the statewide impact. In addition, by linking the estimated employment and labor income impact with the occupation matrix by industry, the social returns can be measured by job creation/retention and by increased labor income for different levels of educational attainment (skill level).

### 3.1 Region-specific economic impact (***single region I-O model***)

In this section, we focus on the impact of the federal investments allocated to each of our three study areas as if they were isolated from the others. It allows us to separate the effect of new investments injected to each specific study area. Table 2 below reports the results.

<<Table 2 here>>

For each of our study area, the direct impact corresponds to the actual investments that took place in 2010, as shown in table 1. The indirect impact is driven by the purchase of inputs made by these five industries and it includes all the rounds of transaction necessary to satisfy their production. The induced impact captures all the rounds of sales that satisfy increased consumer spending due to increased income. The statewide indirect and induced effects are also measured under the structure of the single region input-output model.

When all investments allocated to the state of Arizona are accounted for, we find that the output multiplier (the ratio of 'total' to 'direct') is 2.182. It indicates that every $1,000 of direct federal investment on science, research and technology generated an additional $1,182 of output in the state. The multiplier for 'Total Value Added' is larger, at 2.423, indicating that every $1,000 of direct total value added generated an additional $1,423 of value-added in Arizona. Since comparing the two types of changes is difficult, we rely on a more straightforward index called the 'generator' that represents the total impact in $ amount per $ million of federal investment. Takasago *et al.* (2010) use it also to estimate the employment, income and value added generated in the Brazilian tourism industry. Based on this measure, the lower part of table 2 indicates that each $1 million of federal investment in Arizona generated $2,181,983 of total output sales or $1,269,787 of total value added during 2010. The estimated 'Total Value Added' serves as a potential contribution to gross regional product. In Arizona, the total estimated 'Total Value

Added' in 2010 was $669,093,063 (table 2), equivalent to 0.263% of the $247.8 billion that represented the total GSP (Gross State Product) that year. An estimated 4,070 direct jobs results from the initial investment, and leads to an additional 5,392 indirect and induced jobs, i.e. a multiplier effect of 2.3248. This can be also interpreted as roughly 18 jobs (17.96 in table 2) created or maintained for every $1 million of federal investment. The results on wage and output per employee meet our expectations. We find that the sectors that are directly impacted by the influx of federal investment provide higher average wages and output per employee than the sectors affected indirectly or through the induced effect. In terms of tax revenues, we note that the direct impact at the federal level is more than four times the state & local tax revenue. Yet, the multiplier effect of the tax revenue is more than twice larger at the state & local level than at the federal level. State and local tax revenue is mainly from the consumer spending, i.e., sales tax, captured by the induced impact.

For the two major metro areas, all the direct, indirect and induced impacts are assumed to be confined within each metro area where the federal investments take place. Interregional linkages will be added in the next section. In Phoenix, all the multipliers are above their statewide counterparts. We believe it is mainly due to the greater concentration of high-tech companies and other supporting 'business and professional services' and to the higher concentration of consumer service industries within Phoenix metro area than at the state level. As in the statewide case, we find that wage and output per employee in the sector impacted directly are greater than in those impacted indirectly or through the induced effects. Both are also greater than at the state level, reflecting once more the greater concentration of associated industrial activities in Phoenix. The total tax revenue generated for the State & Local government is approximately 46% of the federal revenue with the direct impact as the largest share.

In the second major metro area, Tucson, we find an output multiplier of 1.8911 that indicates that a $1,000 increase in investment in science, research and technology leads to an additional $891.10 of output generated in Tucson. This multiplier is much lower than in Phoenix metro and

Arizona where it is at 2.2382 and 2.1820 respectively. It indicates that the companies providing all the rounds of inputs necessary in the fabrication/delivery of the products and services financed by such investments are relatively less concentrated in Tucson than elsewhere in the state. This finding is true for all the other multipliers reported in table 2. Based on the generator measures, similar patterns are found. For instance, every $1 million federal investment in Arizona and in Phoenix metro generated approximately 18 jobs while the same investment generated only 16 jobs in Tucson metro. In terms of total value added, a $1 million investment generated only $1.08 million of total value added in Tucson metro, lagging behind Arizona and Phoenix by a large margin ($1.27 million and $1.34 million respectively). This is also noticeable in terms of expanded tax revenue. With a $1 million of investment, the state and local tax revenue increases only by $68,346, whereas the matching figure for Phoenix is 25.5% higher at $85,796. The same pattern also holds true for the federal tax case.

We also find that the regional purchasing coefficients (RPCs) of the directly impacted industrial sectors in Tucson metro are much lower than the matching coefficients in the Phoenix metro (table 3). In other words, any regional leakage from Tucson metro is largely captured by its dominant neighbor, Phoenix metro. It is particularly true for the induced effects and even more so when they are devoted to the consumer service industry. While the average wage and output per worker in the sectors directly impacted within Tucson metro are still in-between those of Phoenix metro and the whole state, the corresponding figures for the sectors impacted indirectly display a much lower average wage and output per worker compared to Phoenix metro and the State.

<<Table 3 here>>

### 3.2 Economic impact in the two metro areas (MRIO)

This section reports the economic impacts of the federal investments injected into a specific area but when the actual interregional trade flows between this area and the rest of the state are taken into account (MRIO structure). Through these linkages, ripple effects of federal investment in a specific area can be captured in the form of indirect and induced effects in other linked study areas. We decide to measure the impact for each of the three study regions first (Tucson Metro, Phoenix Metro and Rest of Arizona), and then to aggregate it at the state-level for comparison purposes with the single region model. The aggregated statewide impact appears in bold in tables 4 that focuses on investments allocated to Tucson metro and in table 5 that is devoted to investments in the Phoenix metro.

<<Table 4 here>>

In both tables the values of the direct impact are same as the ones shown in table 2 so that the direct effect is found only in the area receiving the federal investments. However, because of the interregional linkages, the indirect and induced effects are now also found in areas other than the recipient one. Furthermore, the current approach includes feedback effects to the region where the initial shock took place. As a result, we find that the multipliers are now slightly higher than in the case using single region model reported in table 2. For instance, the output multiplier has increased from 1.8911 to 1.8915 in the case of Tucson metro. It indicates that the increased output generated by the federal investment in Tucson had a positive impact on several industries (suppliers of intermediate goods and services) in other parts of Arizona (Phoenix or Rest of Arizona) through a set of backward linkages and in turn the growth of these industries (suppliers) brought in an additional positive economic impact in Tucson through their own backward linkages.

Table 4 also shows that the total impact of the ‘wage per employee’ is the highest at $52,170 in the study area (Tucson). This result is intuitive since all the direct jobs associated with the federal investments are located in this area only. Other areas have experienced new indirect and induced jobs only. Yet, we find that the overall impact of the ‘output per employee’ is still lower in Tucson than Phoenix ($117,303 vs. $129,959). This gap is mainly due to the productivity level of the indirect and induced jobs in Tucson that lags behind the level experienced elsewhere.

Furthermore, we discover through the generator that every $1 million of federal investment allocated to Tucson metro leads to 17.31 new jobs in Arizona that are decomposed as 16.13 jobs in Tucson, 0.99 jobs in Phoenix and 0.19 jobs in the rest of the state. The dominance of Tucson in the spatial distribution of the impact can be seen for most of the other factors (‘labor income’ ‘total value added’ and ‘output’). However, the relative presence of Phoenix metro increases for all the types of taxes. This result is intuitive since it hosts the state capital.

<<Table 5 here>>

Table 5 reports similar calculations but for Phoenix metro. It received $213.4 million in federal investment. We note that the multipliers for all measures are higher than in Tucson by a large margin. The statewide employment generator for the investment in Phoenix metro is 17.94, with the largest share limited to the metro area. We also find that the total statewide tax revenue – at $59.5 million- is less that the matching revenue in Tucson ($69.9 million, see table 4). The difference is only due to the larger investment that took place in Tucson metro because the standardized tax revenue generator indicates that the same amount of investment would induce a much bigger effect on the overall tax base if allocated to Phoenix. Part of the reason is the large difference in interregional leakages. Phoenix is more self-sufficient than any other region in Arizona. As a result, while a $1 million investment in Tucson metro increases the tax revenue in Phoenix by $17,106 the same investment injected in Phoenix increases the tax revenue in Tucson by $1,089 only.

As in the Tucson case, table 5 shows that the federal tax revenue is much larger (4 times) than the state & local tax revenue from the direct impact. The results also indicate that the largest share of state and local tax revenue (56.7%) comes from the consumer spending that is captured in the induced effect. This pattern reveals that the direct federal investment in science, research and technology helps state and local governments raise their tax base mainly from the consumer-focused local service industry. In the midst of the recession, we see that it is not only the local tax base that has increased, but the employment opportunities in the local service industries too. As a result, most of the sectors impacted through indirect and induced effects have hired employees with medium to low skill level and/or educational attainment. We develop further the analysis of the impact on this population in the next sub-section.

### 3.3 Social returns (by educational attainment)

Previous sections indicated that Phoenix displays the highest multiplier and generator effects. As a result, if efficiency were the major driving force when allocating federal investments, all of them should be allocated to Phoenix. However, past contributions have highlighted that public investments in human capital, have social externalities (Lucas, 1988; Moretti, 2004; Ciccone and Peri, 2006). As a result, uncovering whether groups besides workers in "Scientific research and development services" have benefited from such investments will allow us to quantify these social externalities. Here, our focus is on groups defined according to five levels of educational attainment and the impact is measured on employment, aggregate wage and wage per worker. Table 6 reports the results for Phoenix metro while table 7 focuses on Tucson metro.

Contrary to the general belief, the direct jobs generated by new investments in science, research and technology are not all for the highly educated workers. Approximately 15% of the direct jobs require no more than a high-school diploma. Furthermore, the share of this category of workers increases even further when looking at the indirect and induced jobs (64.6% and 63.5%, respectively). As a consequence, as much as 43.3% of all the new jobs are available for workers with the two lowest educational attainments ('No High School Diploma' and 'High School Only'). In contrast, 43.1% of the total new jobs require a labor force with the top two educational attainments ('Graduate Degree' and 'BS/BA Degree'). A similar pattern is found for Tucson metro.

<<Table 6 here>>

We also report the effects on aggregated wage (labor income). While the distribution of the impact by educational attainment is quite similar to employment shares, we note three important differences:

1) The share of aggregated wage available to the workers with 'No High School Diploma' is much lower than the share of employment
2) The 'High School Only' workers experience a slightly higher share of aggregate wage than that of employment and the largest gap is with induced jobs
3) The labor force with a 'BS/BA Degree' experiences a greater share of aggregate wage than that of employment mainly with indirect and induced effect.

As a result, the share of aggregate wage for the two lowest educational attainments is only 32.9%, i.e. 10.4% lower than the matching share for employment. For the top two educational attainments, the combined share of aggregated wage is 51.1%, i.e. 8.0% higher than the matching employment share. This result confirms our expectations since a low educational attainment often reflects the low skill level of employees and associated wage level.

With regards to wage per worker, we find that the highest values go to the new direct jobs, followed by the indirect and induced jobs, as expected. Surprisingly, we find that the direct jobs for the 'High School Only' workers pay approximately $2,700 more than those for the 'BS/BA Degree' workers. This pattern holds true for the workers with 'Some College or Specialized Training' as well. While it seems counter-intuitive, we believe that the difference comes from the experience workers bring with them, an element that is unfortunately not included in our primary dataset. Indeed, it could be that those with 'High School Only' or 'Some College or Specialized

Training' have a longer work history in the newly created direct employment opportunities with similar job duties, which equip them with a higher combined human capital than freshly-graduated workers with a 'BS/BA degree' but no work experience.

We also find that the labor force with 'Some College or Specialized Training' receive a wage approximately $2,000 higher than for the 'BS/BA Degree' holders for the indirect jobs and about $4,000 higher for the induced jobs. Possible explanations can be the differences in experience, as noted earlier, as well as the underemployment of college graduates in the aftermath of the recent economic recession during which most of the induced jobs were filled in low paying service industries that do not require more than low skilled workers. These findings reflect the capacity of federal investments in high technology to support the middle class by expanding its employment opportunities and offering it better-paid positions. However, it is clear that the least qualified do not benefit from such investments nearly as much: the labor force with 'No High School Diploma' gets on average wage per worker that is at least 46.2% lower than any other education level.

Based on the American Community Survey (ACS) data for 2010, we compile the wage ratios by educational attainment. By setting the average wage per worker at 100.0%, we can compare the five different levels of educational attainments under three different scenarios. First, the observed wage per worker for 25 years and older FTE workers from ACS data effectively describes the average wages differentiated by educational attainments and it is clear that education leads to a higher wage as shown in figure 2 (Observed). Secondly, we compare the wages per worker based on the required educational attainment needed for their occupation. This grouping is free from actual earning differences by education level. As shown under 'Required (Model)' in figure 2, the ratios are lower for all the educational attainments but 'Some College or Specialized Training' when compared to the observed wage. This reflects that all workers except for those with 'Some College or Specialized Training' have suffered from underemployment in Phoenix Metro in 2010.

Finally, in the third group, we use the impact results generated by IMPLAN according to four categories: Total, Direct, Indirect, and Induced effects.

<<Figure 2 here>>

Based on the actual observations from ACS data, those with graduate degree (GD) earn wages 66.1% higher than the average worker, whereas earnings for those with less than a high school level (LT HS) are at 49.4% of an average worker only. A similar pattern can be found when the minimum required educational attainments are applied to ACS data. However, the wage ratio for 'Some College or Specialized Training' workers is lower with the model (Required) than for the actual observation (Observed). This reflects that the actual wages for these three cohorts (LT HS, HSG and GD) are lower than the estimated wages defined by the minimum required educational attainment. What draws our attention is the finding that among the direct jobs the per worker wages for the 'HSG' and 'Some College' cohorts is slightly higher than those of an average worker. In fact, their per worker wage is even higher than for the 'BS/BA' workers; however, many more jobs requiring the 'BS/BA' educational level were created. For the indirect and induced jobs where a somewhat more similar number of jobs was created across educational levels, the returns on education are closer to the expected pattern.

<<Table 7 here>>

The employment impact in Tucson metro is reported in table 7 and is not much different from the previous case with Phoenix Metro. The aggregate wage share of the 'High School Only' labor force is greater than its employment shares for direct and induced jobs but the gap is not as large as it is for Phoenix metro. Instead, the aggregate wage share of the 'BS/BA Degree' holders for all types of jobs is slightly higher compared to the Phoenix case. We also find that the overall wage per worker for the 'Graduate Degree' holders is at the highest, i.e. 23.6% higher than the average for all workers and even 6.4% higher than that for the 'Graduate Degree' holder labor force (they were pretty similar in the Phoenix metro). This result is mainly due to the following two facts: first, the majority of the jobs for the 'BS/BA Degree' holders are direct jobs that offer much higher per worker wage than other types of jobs. Secondly, the earnings of the 'BS/BA Degree' holders in the indirect sectors are 30.4% higher than the average for all indirect workers. Overall, the combined share of employment of the top two educational attainment levels is 2.4% higher in Tucson than in Phoenix metro, while that of the bottom two educational attainment levels is 2.0% lower in Tucson. We believe that the latter result is mainly due to the concentration of consumer-oriented service industries in Phoenix and its associated greater multiplier effects, especially those due to induced effects. We also find that the aggregate wage share for the top two educational attainment levels is 51.1% in Phoenix, i.e. 3.7 percentage points lower than in Tucson (54.8%). The exact opposite is true for the bottom two educational attainment levels. As a consequence, the ratio of relative wage per worker indicates that the labor force with a lower education level earns a higher wage in Phoenix than in Tucson. However, this result needs to be contrasted with costs of living that are on average 2.22% higher in Phoenix. For the labor force with the two highest educational attainment levels, the average wage per worker is greater in Phoenix. However, relative to the local population, the 'BS/BA Degree' holders do slightly better in Tucson than Phoenix (123.6% vs. 118.4%).

<<Figure 3 here>>

When focusing on the per worker wage ratio in Tucson Metro (Figure 3), we find similar patterns as in Phoenix whereby education leads to higher wage both for the 'Observed (ACS)' and the 'Required (Model)' cases. With the exception of the 'LT HS' cohort, all the other educational attainment cohorts earn similar wages in the direct jobs. The gaps across educational attainments widen with the types of indirect and induced employments they generate.

## 4. Conclusion

The input-output framework is regularly used to quantify the regional economic impacts of the presence of a university and/or research park (e.g. Siegfried *et al*., 2006; Swenson, 2010). The more sophisticated studies propose a great level of details by enlarging the impact to various socio-economic groups classified by educational attainment (e.g. Gibson *et al*., 2010, Lim *et al*., 2011). In this case, the underlying idea is to verify if the groups that are not necessarily highly-educated experience some benefits from further investments in a university or research park. The current paper follows this line of thought but takes on an innovative approach in that the economic shock corresponds to actual, federally-funded, investments in science, research and technology. They took place in Arizona in 2010 in the context of the Obama administration's stimulus package.

Our calculations are performed on various spatial units within the state of Arizona. They indicate that the Phoenix Metro Area has a greater capacity to generate multiplier effects than the Tucson Metro Area. Part of the reason is that Tucson experiences greater interregional leakages than Phoenix, a metro area more than 5 times more populated yet only within a 2 hour drive. In addition, it is highly likely that its status of state capital plays in favor of Phoenix. Indeed, the allocation of new federal investments to local governments always goes through the state capital.

If we simply measure the efficiency of federal investments based on the ratio of increased tax revenue to overall investment, then the entirety of the funding should have gone to Phoenix. However, the main goal of a federal investment policy (more especially when designed under the American Reconstruction and Reinvestment Act) is to stimulate state and local economies by expanding their employment and income bases. Under this perspective, a more equal allocation across regions can be strategic to achieve both efficiency and equity. With these goals in mind, the impacts as measured by either the ratio of total value added to investment or the ratio of output sales to investment are deemed successful in our analysis. We also find that each newly created direct employment in the state and local economies has successfully retained or generated an additional 1.32 job throughout the State. As expected, Phoenix displays the greater levels of multipliers and "generator" effects due to its large inter-industry linkages and its greater concentration of consumer-oriented service industry than anywhere else in Arizona.

When we extend our analysis to various socio-economic groups classified by educational attainment, we find that the labor force with both high educational attainment (alternatively, higher skill levels) and low educational attainment (alternatively, lower skill levels) benefited from the federal investments in science, research and technology. The majority of the direct jobs requires a BS/BA degree or higher in Phoenix (67.6%) and in Tucson (67.1%). But the job creation effect is not necessarily confined to this group. Indeed, approximately 15% of the total direct jobs were available for the group with low educational attainment as well. The share increases to around 65% of total jobs when the indirect and induced employments are considered. Such investments have thus led to social returns that were not necessarily intended in the first place. Surprisingly, we find that the wage per worker for the labor with a 'High School Only' degree is higher than that for the 'BS/BA Degree' holders with induced jobs. However, this result can be partly due to differences in the workers' experience that our data do not allow us to control. Future research should therefore explore the role of professional experience by sector further and compare the returns on investments in R&D evaluated in this project with the returns of other public investments such as education, transportation or defense. Indeed, because the federal government's budget deficit is greater than ever, a clear estimation of the relative returns on public investments is essential as it could contribute to the debate about reducing, continuing or better targeting subsidies to each type of government programs. To our knowledge, such a task has never been accomplished so far but is certainly needed.

## References

Clinch R. P. (2003), The Potential Workforce Development Implications of the Development of the East Baltimore Biotech Park and the UMB Research Park, The Jacob France Institute, Economic Research. www.ubalt.edu/jfi/jfi/reports/ebmcworkforce.pdf

Ciccone A. and Peri G. (2006) Identifying Human-Capital Externalities: Theory with Applications, *Review of Economic Studies*, 73(2), 381-412.

Drucker J., Goldstein H. (2007) Assessing the Regional Economic Development Impacts of Universities: A Review of Current Approaches, *International Regional Science Review*, 30(1), 20-46.

Feller I. (1997) Federal and State Government Roles in Science and Technology, *Economic Development Quarterly*, 11(4), 283-295.

Gibson L., Kochi V., Gruener R. and Wright B. (2010) Translational Regional Science, Input/Output Analysis and Community Engagement: New Perspectives for Closing the High Tech-Community Gap, *Studies in Regional Science*, 40(1), 1-17.

Hearn J. C., Lacy T. A. and Warshaw J. B. (2014) State Research and Development Tax Credits: The Historical Emergence of a Distinctive Economic Policy Instrument, *Economic Development Quarterly*, 28(2), 166-181.

Le Sage J. (2014) The Economic Impact of Texas State University, Report prepared for Texas State University.

Lim J. (2010) Economic & Tax Revenue Impacts of the University of Arizona Science and Technology Park, *Applied Research in Economic Development*, 7(1), 50-62.

Lim J., Gibson J. and Kochi V. (2011) Planning for a High Tech/Biotech Research Park Start-up, *Regional Science Policy & Practice, 3(3),* 287-304.

Lucas R.E. (1988) On the Mechanics of Economic Development, *Journal of Monetary Economics*, 22, 3-42.

Luger M.I. and Goldstein H.A. (1991) Technology in the Garden: Research Parks and Regional

Economic Development, Edition 1, The University of North Carolina Press.

Moretti E. (2004) Human Capital Externalities in Cities, In: J.V. Henderson and Thisse J.F. (Eds.), *Handbook of Regional and Urban Economics,* 4, New York: Elsevier, 2243-2291.

Plosila W. H. (2004) State Science and Technology-based Economic Development Policy: History, Trends and Developments, and Future Directions, *Economic Development Quarterly*, 18(2), 113-126.

Siegfried J., Sanderson A., McHenry P. (2006) The Economic Impact of Colleges and Universities. Working paper, Department of Economics, Vanderbilt University.

Swenson D. (2010) The Economic Values of the ISU Research Park and its Tenants, Report prepared for the Iowa State University.

Takasago, M., Mollo M. D. L. R., Guilhoto J., and De Andrade J. (2010) The Brazilian Tourism Sector as a Source of Employment and Income Generation. Available at SSRN 1836491.

**Table 1 Sectoral and spatial allocation of 2010 investments**

| | Arizona | | Phoenix Metro | | Tucson Metro | | Rest of Arizona | |
|---|---|---|---|---|---|---|---|---|
| **Industry** | **Investment ($)** | **Share (%)** | **Investment ($)** | **Share (%)** | **Investment ($)** | **Share (%)** | **Investment ($)** | **Share (%)** |
| Architectural, engineering, and related services | 3,607,409 | 0.7 | 62,939 | 0.0 | 2,298,815 | 0.8 | 1,245,655 | 5.6 |
| Environmental and other technical consulting services | 732,618 | 0.1 | 732,618 | 0.3 | 0 | 0.0 | 0 | 0.0 |
| Scientific research and development services | 501,168,849 | 95.1 | 203,654,750 | 95.4 | 281,528,946 | 96.5 | 15,985,153 | 72.5 |
| Private elementary and secondary schools | 19,662,802 | 3.7 | 8,976,240 | 4.2 | 6,672,904 | 2.3 | 4,013,658 | 18.2 |
| Other private educational services | 1,761,495 | 0.3 | 0 | 0.0 | 1,219,495 | 0.4 | 542,000 | 2.5 |
| **Total** | **526,933,173** | **100** | **213,426,600** | **100.0** | **291,720,160** | **100.0** | **21,786,413** | **100.0** |

**Table 2 Impact within each region**

| Impact Type | Employ-ment | Labor Income ($) | Total Value Added ($) | Output ($) | Wage per Employee ($) | Output per Employee ($) | Total Tax Revenue ($) | Federal Tax Revenue ($) | State & Local Tax Revenue ($) |
|---|---|---|---|---|---|---|---|---|---|
| **Study Region** | **Direct Impact** | | | | | | | | |
| **Arizona** | 4,070 | 279,783,874 | 276,142,328 | 526,933,173 | 68,743 | 129,468 | 53,341,718 | 43,598,389 | 9,743,329 |
| **Phoenix** | 1,585 | 117,312,270 | 115,765,404 | 213,426,547 | 74,028 | 134,679 | 22,420,614 | 18,421,112 | 3,999,502 |
| **Tucson** | 2,165 | 157,665,171 | 156,231,046 | 291,720,160 | 72,838 | 134,769 | 29,694,501 | 24,310,471 | 5,384,030 |
| **Study Region** | **Indirect Impact** | | | | | | | | |
| **Arizona** | 2,130 | 91,531,684 | 152,475,412 | 239,550,743 | 42,973 | 112,465 | 29,349,055 | 19,492,782 | 9,856,273 |
| **Phoenix** | 831 | 38,466,830 | 62,821,095 | 96,954,150 | 46,290 | 116,672 | 12,043,082 | 8,107,513 | 3,935,569 |
| **Tucson** | 1,028 | 36,805,326 | 62,767,160 | 101,915,196 | 35,817 | 99,178 | 12,064,875 | 7,866,862 | 4,198,013 |
| **Study Region** | **Induced Impact** | | | | | | | | |
| **Arizona** | 3,262 | 131,506,616 | 240,475,323 | 383,275,489 | 40,315 | 117,497 | 54,811,832 | 30,505,473 | 24,306,359 |
| **Phoenix** | 1,378 | 59,294,044 | 106,402,591 | 167,301,133 | 43,026 | 121,400 | 24,009,045 | 13,633,078 | 10,375,967 |
| **Tucson** | 1,511 | 50,903,592 | 96,764,502 | 158,040,055 | 33,698 | 104,621 | 22,332,499 | 11,976,573 | 10,355,926 |
| **Study Region** | **Total Impact** | | | | | | | | |
| **Arizona** | 9,462 | 502,822,174 | 669,093,063 | 1,149,759,405 | 53,141 | 121,513 | 137,502,605 | 93,596,644 | 43,905,961 |
| **Phoenix** | 3,794 | 215,073,144 | 284,989,090 | 477,681,830 | 56,691 | 125,911 | 58,472,741 | 40,161,703 | 18,311,038 |
| **Tucson** | 4,703 | 245,374,089 | 315,762,708 | 551,675,411 | 52,176 | 117,308 | 64,091,875 | 44,153,906 | 19,937,969 |
| **Study Region** | **Multiplier (Ratio of 'Total' to 'Direct')** | | | | | | | | |
| **Arizona** | **2.3248** | **1.7972** | **2.4230** | **2.1820** | | | **2.5778** | **2.1468** | **4.5063** |
| **Phoenix** | **2.3940** | **1.8333** | **2.4618** | **2.2382** | | | **2.6080** | **2.1802** | **4.5783** |
| **Tucson** | **2.1726** | **1.5563** | **2.0211** | **1.8911** | | | **2.1584** | **1.8163** | **3.7032** |
| **Study Region** | **Generator by Study Region (per $1 million of Federal Investment)** | | | | | | | | |
| **Arizona** | **17.96** | **954,243** | **1,269,787** | **2,181,983** | | | **260,949** | **177,625** | **83,324** |
| **Phoenix** | **17.78** | **1,007,715** | **1,335,303** | **2,238,156** | | | **273,971** | **188,176** | **85,796** |
| **Tucson** | **16.12** | **841,128** | **1,082,416** | **1,891,112** | | | **219,703** | **151,357** | **68,346** |

**Table 3 Regional Purchase Coefficient (RPC) of industrial sectors with 2010 federal investments**

| Industry | Arizona | Tucson Metro | Phoenix Metro |
|---|---|---|---|
| Architectural, engineering, and related services | 75.21% | 59.38% | 79.52% |
| Environmental and other technical consulting services | 78.76% | 63.21% | 83.07% |
| Scientific research and development services | 72.19% | 59.45% | 74.83% |
| Private elementary and secondary schools | 76.78% | 70.52% | 77.02% |
| Other private educational services | 72.75% | 58.92% | 75.46% |

*Source: IMPLAN data for 2010*

**Table 4 Economic impact of Federal Investment in Tucson Metro (*MRIO Model*)**

| Impact Type | Employ -ment | Labor Income ($) | Total Value Added ($) | Output ($) | Wage per Employee ($) | Output per Employee ($) | Total Tax Revenue ($) | Federal Tax Revenue ($) | State & Local Tax Revenue ($) |
|---|---|---|---|---|---|---|---|---|---|
| | **Direct Impact** | | | | | | | | |
| **Tucson** | 2,165 | 157,665,171 | 156,231,046 | 291,720,160 | 72,825 | 134,744 | 29,694,501 | 24,310,471 | 5,384,030 |
| **Phoenix** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **R .of AZ** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **AZ** | **2,165** | **157,665,171** | **156,231,046** | **291,720,160** | **72,839** | **134,771** | **29,694,501** | **24,310,471** | **5,384,030** |
| | **Indirect Impact** | | | | | | | | |
| **Tucson** | 1,028 | 36,837,404 | 62,830,106 | 102,033,915 | 35,834 | 99,255 | 12,078,501 | 7,874,530 | 4,203,971 |
| **Phoenix** | 142 | 7,381,856 | 11,830,822 | 18,865,889 | 51,985 | 132,858 | 2,364,673 | 1,564,620 | 800,053 |
| **R .of AZ** | 35 | 1,331,475 | 2,145,760 | 3,797,152 | 38,042 | 108,490 | 462,592 | 278,485 | 184,107 |
| **AZ** | **1,205** | **45,550,735** | **76,806,688** | **124,696,956** | **37,801** | **103,483** | **14,905,766** | **9,717,635** | **5,188,131** |
| | **Induced Impact** | | | | | | | | |
| **Tucson** | 1,511 | 50,903,592 | 96,764,502 | 158,040,055 | 33,689 | 104,593 | 22,349,934 | 11,986,003 | 10,363,931 |
| **Phoenix** | 148 | 6,844,079 | 11,807,515 | 18,822,114 | 46,244 | 127,176 | 2,625,351 | 1,535,966 | 1,089,385 |
| **R .of AZ** | 20 | 688,478 | 1,358,971 | 2,301,661 | 34,424 | 115,083 | 311,118 | 165,549 | 145,569 |
| **AZ** | **1,679** | **58,436,149** | **109,930,988** | **179,163,830** | **34,804** | **106,709** | **25,286,403** | **13,687,518** | **11,598,885** |
| | **Total Impact** | | | | | | | | |
| **Tucson** | 4,704 | 245,406,167 | 315,825,654 | 551,794,130 | 52,170 | 117,303 | 64,122,936 | 44,171,004 | 19,951,932 |
| **Phoenix** | 290 | 14,225,935 | 23,638,337 | 37,688,003 | 49,055 | 129,959 | 4,990,024 | 3,100,586 | 1,889,438 |
| **R .of AZ** | 55 | 2,019,953 | 3,504,731 | 6,098,813 | 36,726 | 110,888 | 773,710 | 444,034 | 329,676 |
| **AZ** | **5,049** | **261,652,055** | **342,968,722** | **595,580,946** | **51,823** | **117,960** | **69,886,670** | **47,715,624** | **22,171,046** |
| | **Multiplier (Ratio of 'Total' to 'Direct')** | | | | | | | | |
| **Tucson** | 2.1727 | 1.5565 | 2.0215 | 1.8915 | | | 2.1594 | 1.8170 | 3.7058 |
| **AZ** | **2.3321** | **1.6595** | **2.1953** | **2.0416** | | | **2.3535** | **1.9628** | **4.1179** |
| | **Generator by Study Region (per $1 million of Federal Investment)** | | | | | | | | |
| **Tucson** | 16.13 | 841,238 | 1,082,632 | 1,891,519 | | | 219,810 | 151,416 | 68,394 |
| **Phoenix** | 0.99 | 48,766 | 81,031 | 129,192 | | | 17,106 | 10,629 | 6,477 |
| **R .of AZ** | 0.19 | 6,924 | 12,014 | 20,906 | | | 2,652 | 1,522 | 1,130 |
| **AZ** | **17.31** | **896,928** | **1,175,677** | **2,041,617** | | | **239,568** | **163,566** | **76,001** |

**Table 5 Economic impact of Federal Investment in Phoenix Metro (*MRIO Model*)**

| Impact Type | Employ -ment | Labor Income ($) | Total Value Added ($) | Output ($) | Wage per Employee ($) | Output per Employee ($) | Total Tax Revenue ($) | Federal Tax Revenue ($) | State & Local Tax Revenue ($) |
|---|---|---|---|---|---|---|---|---|---|
| | **Direct Impact** | | | | | | | | |
| **Phoenix** | 1,585 | 117,312,270 | 115,765,404 | 213,426,547 | 74,028 | 134,679 | 22,420,614 | 18,421,112 | 3,999,502 |
| **Tucson** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **R .of AZ** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **AZ** | **1,585** | **117,312,270** | **115,765,404** | **213,426,547** | **74,028** | **134,679** | **22,420,614** | **18,421,112** | **3,999,502** |
| | **Indirect Impact** | | | | | | | | |
| **Phoenix** | 832 | 38,518,548 | 62,907,569 | 97,098,907 | 46,302 | 116,719 | 12,061,766 | 8,118,895 | 3,942,871 |
| **Tucson** | 7 | 329,835 | 574,529 | 1,202,080 | 49,975 | 182,133 | 122,355 | 73,279 | 49,076 |
| **R .of AZ** | 8 | 257,847 | 495,572 | 1,048,149 | 31,833 | 129,401 | 462,592 | 278,485 | 184,107 |
| **AZ** | **847** | **39,106,230** | **63,977,670** | **99,349,136** | **46,192** | **117,351** | **12,646,713** | **8,470,659** | **4,176,054** |
| | **Induced Impact** | | | | | | | | |
| **Phoenix** | 1,380 | 59,362,750 | 106,520,129 | 167,490,557 | 43,032 | 121,414 | 24,035,156 | 13,648,417 | 10,386,739 |
| **Tucson** | 6 | 254,651 | 481,112 | 889,425 | 39,789 | 138,973 | 110,109 | 59,857 | 50,252 |
| **R .of AZ** | 11 | 346,710 | 714,009 | 1,313,523 | 31,519 | 119,411 | 311,118 | 165,549 | 145,569 |
| **AZ** | **1,397** | **59,964,111** | **107,715,250** | **169,693,505** | **42,927** | **121,479** | **24,456,383** | **13,873,823** | **10,582,560** |
| | **Total Impact** | | | | | | | | |
| **Phoenix** | 3,796 | 215,193,568 | 285,193,102 | 478,016,011 | 56,688 | 125,923 | 58,517,536 | 40,188,424 | 18,329,112 |
| **Tucson** | 13 | 584,486 | 1,055,641 | 2,091,505 | 44,960 | 160,885 | 232,464 | 133,136 | 99,328 |
| **R .of AZ** | 19 | 604,557 | 1,209,581 | 2,361,672 | 31,652 | 123,648 | 773,710 | 444,034 | 329,676 |
| **AZ** | **3,828** | **216,382,611** | **287,458,324** | **482,469,188** | **56,523** | **126,030** | **59,523,710** | **40,765,594** | **18,758,116** |
| | **Multiplier (Ratio of 'Total' to 'Direct')** | | | | | | | | |
| **Phoenix** | 2.3955 | 1.8344 | 2.4635 | 2.2397 | | | 2.6100 | 2.1817 | 4.5828 |
| **AZ** | **2.4157** | **1.8445** | **2.4831** | **2.2606** | | | **2.6549** | **2.2130** | **4.6901** |
| | **Generator by Study Region (per $1 million of Federal Investment)** | | | | | | | | |
| **Phoenix** | 17.79 | 1,008,279 | 1,336,259 | 2,239,721 | | | 274,181 | 188,301 | 85,880 |
| **Tucson** | 0.06 | 2,739 | 4,946 | 9,800 | | | 1,089 | 624 | 465 |
| **R .of AZ** | 0.09 | 2,833 | 5,667 | 11,066 | | | 3,625 | 2,081 | 1,545 |
| **AZ** | **17.94** | **1,013,850** | **1,346,872** | **2,260,587** | | | **278,896** | **191,005** | **87,890** |

## Table 6 Employment and wage effects by educational attainment (Phoenix Metro)

| Minimum Required Educational Attainment for Occupation | Graduate Degree | | BS/BA Degree | | Some College or Specialized Training | | High School Only | | No High School Diploma | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Type** | **Direct Impact** | | | | | | | | | |
| **Employment** | 46 | 2.9% | 1,025 | 64.7% | 281 | 17.7% | 192 | 12.1% | 41 | 2.6% |
| **Total Wage ($)** | 3,549,197 | 3.0% | 75,538,737 | 64.4% | 21,480,178 | 18.3% | 14,671,370 | 12.5% | 2,072,795 | 1.8% |
| **Wage per Worker ($)** | **76,502** | 103.3% | 73,726 | 99.6% | 76,465 | 103.3% | 76,407 | 103.2% | 50,870 | 68.7% |
| **Type** | **Indirect Impact** | | | | | | | | | |
| **Employment** | 18 | 2.1% | 197 | 23.6% | 80 | 9.7% | 314 | 37.8% | 223 | 26.8% |
| **Total Wage ($)** | 1,176,893 | 3.1% | 11,143,716 | 28.9% | 4,706,809 | 12.2% | 14,802,330 | 38.4% | 6,688,799 | 17.4% |
| **Wage per Worker ($)** | **66,479** | 143.6% | 56,694 | 122.4% | 58,537 | 126.4% | 47,091 | 101.7% | 30,005 | 64.8% |
| **Type** | **Induced Impact** | | | | | | | | | |
| **Employment** | 79 | 5.7% | 272 | 19.7% | 152 | 11.0% | 409 | 29.7% | 467 | 33.8% |
| **Total Wage ($)** | 4,929,909 | 8.3% | 13,556,840 | 22.8% | 8,201,218 | 13.8% | 19,171,490 | 32.3% | 13,503,293 | 22.7% |
| **Wage per Worker ($)** | **62,486** | 145.2% | 49,789 | 115.7% | 53,952 | 125.4% | 46,818 | 108.8% | 28,925 | 67.2% |
| **Type** | **Total Impact** | | | | | | | | | |
| **Employment** | 143 | 3.8% | 1,493 | 39.3% | 513 | 13.5% | 916 | 24.1% | 731 | 19.2% |
| **Total Wage ($)** | 9,655,999 | 4.5% | 100,239,293 | 46.6% | 34,388,205 | 16.0% | 48,645,191 | 22.6% | 22,264,887 | 10.3% |
| **Wage per Worker ($)** | **67,528** | 119.1% | 67,120 | 118.4% | 66,990 | 118.2% | 53,116 | 93.7% | 30,479 | 53.8% |

## Table 7 Employment and wage effects by educational attainment (Tucson Metro)

| Minimum Required Educational Attainment for Occupation | Graduate Degree | | BS/BA Degree | | Some College or Specialized Training | | High School Only | | No High School Diploma | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Type** | **Direct Impact** | | | | | | | | | |
| **Employment** | 67 | 3.1% | 1,385 | 64.0% | 397 | 18.3% | 268 | 12.4% | 47 | 2.2% |
| **Total Wage ($)** | 4,887,617 | 3.1% | 101,010,336 | 64.1% | 29,552,328 | 18.7% | 19,961,922 | 12.7% | 2,252,975 | 1.4% |
| **Wage per Worker ($)** | 72,946 | 100.1% | 72,906 | 100.1% | 74,473 | 102.2% | **74,498** | 102.3% | 47,626 | 65.4% |
| **Type** | **Indirect Impact** | | | | | | | | | |
| **Employment** | 22 | 2.1% | 236 | 23.0% | 98 | 9.6% | 375 | 36.4% | 297 | 28.9% |
| **Total Wage ($)** | 1,036,078 | 2.8% | 11,055,485 | 30.0% | 4,295,599 | 11.7% | 13,156,946 | 35.7% | 7,293,297 | 19.8% |
| **Wage per Worker ($)** | **47,702** | 133.1% | 46,750 | 130.4% | 43,724 | 122.0% | 35,131 | 98.0% | 24,588 | 68.6% |
| **Type** | **Induced Impact** | | | | | | | | | |
| **Employment** | 88 | 5.9% | 294 | 19.4% | 173 | 11.5% | 422 | 27.9% | 533 | 35.3% |
| **Total Wage ($)** | 4,911,069 | 9.6% | 11,540,268 | 22.7% | 7,460,780 | 14.6% | 14,441,506 | 28.3% | 12,589,149 | 24.7% |
| **Wage per Worker ($)** | **55,535** | 164.7% | 39,283 | 116.5% | 43,017 | 127.6% | 34,256 | 101.6% | 23,602 | 70.0% |
| **Type** | **Total Impact** | | | | | | | | | |
| **Employment** | 177 | 3.8% | 1,916 | 40.7% | 668 | 14.2% | 1,064 | 22.6% | 877 | 18.7% |
| **Total Wage ($)** | 10,834,763 | 4.4% | 123,606,089 | 50.4% | 41,308,707 | 16.8% | 47,560,374 | 19.4% | 22,135,421 | 9.0% |
| **Wage per Worker ($)** | 61,160 | 117.2% | **64,521** | 123.6% | 61,793 | 118.4% | 44,698 | 85.6% | 25,231 | 48.3% |

**Figure 1. Three Study Region for the MRIO model**

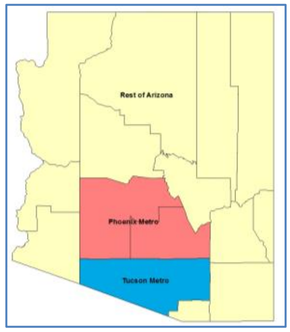


**Figure 2. Per Worker Wage Ratio Comparison by Educational Attainment in Phoenix Metro**

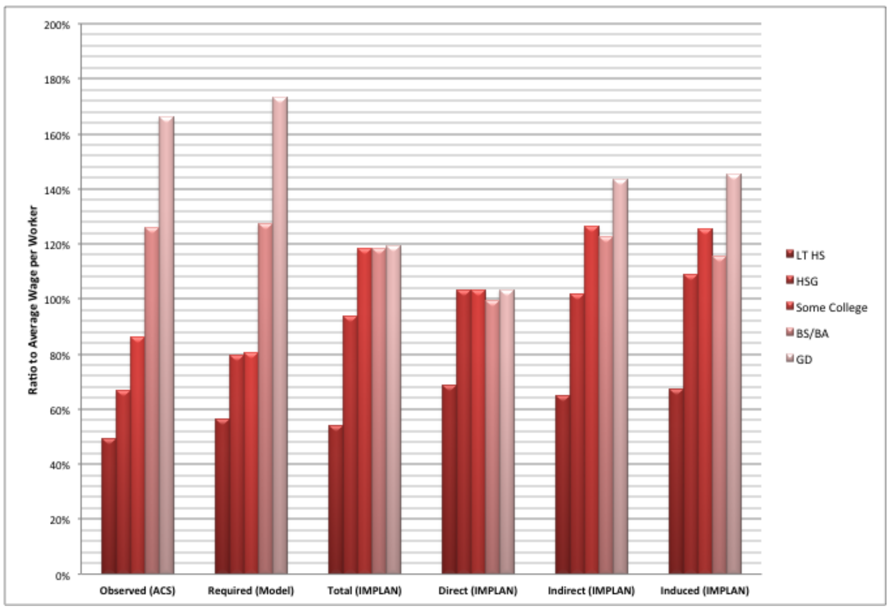


**Figure 3. Per Worker Wage Ratio Comparison by Educational Attainment in Tucson Metro**