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Comment Nicola Bianchi

This chapter explores the characteristics of university-industry relations (UIR) among agricultural and life science (ALS) faculty at US land grant universities (LGUs). This research question is interesting because there is a common belief that US universities are relying more and more on UIR to replace dwindling funding from the state and federal government. Despite the plausible growing importance of UIR activities, little is known about their features, their links with professors' academic output, and their consequences for academic research.

This chapter contributes to our understanding of UIR in several ways. It uses extensive survey data collected in 2005 and 2015 to explore UIR at LGUs. The sample is large, covering 946 professors in 2005 and 626 professors in 2015. Among these faculty members, 234 are surveyed in both years, allowing the analysis to have a panel component. Moreover, the survey asks detailed questions about UIR, permitting the authors to distinguish between different forms of UIR. Specifically, the chapter is able to differentiate between academic engagement (AE) and academic commercialization (AC). AE describes any form of faculty participation in shared research.

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It involves, for example, research support from industry, participation in industry presentations, and research collaborations with industry experts. AC describes any form of faculty participation in private intellectual property creation. For example, it involves the creation of patents, products, or start-ups with industrial partners.

This chapter adopts different methodologies to describe the characteristics of UIR. It compares differences in the average characteristics of faculty members participating in different types of UIR. Moreover, it creates a UIR index via principal factor analysis. Finally, it uses multivariate regressions to concurrently control for multiple drivers of UIR.

Before moving to the discussion of the main results, it should be noted that this chapter accomplishes a lot. It produces an impressively extensive analysis on UIR. It answers at least six different and important research questions on the topic. Moreover, the chapter uses newly available survey data. These data are great for many reasons. First, the sample size is big enough to obtain precise estimates. Second, this survey is designed to ask very detailed questions on UIR. As a result, the survey allows the authors to study correlations that could not be addressed by previous research on this topic. Given the importance of the data, I think that future work should put more emphasis on them. It should be clearer that the data represent a significant contribution to the literature. Moreover, future work should include more information on the survey itself, especially on the 2005 wave. In addition, any upcoming research should discuss the representativeness of the sample. It would be very informative to have a table in which the faculty members in the sample are compared to all other ALS professors at US LGUs. Ideally, the average characteristics of these two groups will be statistically similar. In addition, I think that a natural way to expand the data would be to incorporate administrative data on patent production and on publications instead of relying exclusively on self-reported output measures. The addition of these data sets would be valuable for at least two reasons. First, any self-reported variable raises questions about its reliability. Administrative or third-party data would assuage these concerns. Second, these types of administrative data would include objective measures of the quality of the academic production, which are missing from the current analysis.

Moving to the discussion on the findings, the first main result shows that between 80 and 90 percent of surveyed faculty members participate in UIR. Moreover, there is little variance across gender and academic rank. There is, however, significant variance across academic fields. The UIR rate varies from 94 percent in animal science to only 68 percent in social sciences. In future work, I would emphasize a bit more this last finding (differences across fields). Furthermore, it would be very beneficial to draw a tighter connection between the results and the hypotheses outlined in section 5.3. For example, I think it would be better to state that the differences across

fields are consistent with hypothesis 7. In addition, it would be beneficial to remind the reader that the high average participation rate is consistent with hypothesis 1.

The second main result is that AE is much more prevalent than AC. In 2005, 55 percent of faculty members participated in only AE activities, while only 3 percent participated in only AC activities. Among the remaining faculty members, 23 percent participated in both, while 19 percent did not participate in UIR at all. This result is interesting because it might speak to the nature of AC and AE activities. Is it possible that AC is, in most cases, the second or advanced phase of UIR after an initial period limited to AE activities? This could be true because most collaborations might start solely as research support. Sometimes, research activities (AE) are successful and open the path for further collaboration on commercialization (AC). This pattern could explain why AE is more widespread. Moreover, it would explain why almost nobody engages exclusively in AC activities.

The third main result shows that UIR participation fell by 3 percentage points between 2005 and 2015. Over this period, the largest shifts were away from AE/AC combined and from AC only. Instead, the participation rate in AE only increased by 7 percentage points. These results are very interesting because they partially contradict the hypothesis that states that UIR activities are on the rise. The truth is that only a subgroup of UIR, AE activities, has been increasing over the last 15 years. I think that future research could estimate the same changes in UIR using a multinomial logit model. This type of model would account for the fact that the outcomes (participation in UIR) are mutually exclusive and would produce more robust estimates.

The fourth main result shows that funding for UIR came predominantly from federal and state grants. Moreover, the importance of government grants increased over time. Possibly contrary to popular belief, patent royalties are not a substantial stream of revenues. On average, they contribute around 1 percent of revenues for faculty members participating in AC activities. These results are very interesting because they partially contradict the idea that dwindling government grants are one of the driving forces of UIR. Although it is true that state grants have been decreasing between 2005 and 2015, federal grants increased over time. It is also true that revenues from private industry have been increasing. A hypothesis is that UIR activities provide significant funding for US LGU research activities. Based on historical trends in AE and the recent push for the expansion of AC activities, along with declines in state funding levels, UIR is expected to play a significant and perhaps growing role in funding faculty research activities. These results, however, paint a more complex picture. Therefore, I think that future research should have a more nuanced discussion on how these results relate to the original hypothesis. Moreover, although the main finding is quite clear (strong reliance on federal funding), I have some doubts about other sources of funding. "Private industry" is a very general label for a funding

source. The same comment applies to "Foundations." Would it be possible to dig deeper into these sources and unpack their overall contribution into smaller subgroups? I think that doing so would help with interpretation. It would be especially important for "Private industry," considering that it is a funding source that is becoming more important over time.

The fifth main result shows a positive correlation between UIR and scholarly output. Specifically, faculty members engaged in UIR have an average academic production that is higher, compared with faculty members not engaging in UIR. Moreover, the scholarly production is the highest for professors who engage in both AE and AC. This result corroborates the hypothesis that "UIR activities are broadly synergistic with other US LGU outputs such as producing articles and training graduate students." I think that this result is fascinating because it is the first step toward addressing what might motivate professors to engage in UIR. Future research should dig deeper into these findings. First, I think that this analysis requires a multivariate regression. In fact, a regression could allow the authors to estimate the correlation between UIR and scholarly output while also controlling for other extraneous factors. Moreover, it would allow the authors to assess whether differences across UIR are statistically significant. Second, as mentioned above, adding external data on academic activity (e.g., the Web of Science Data by Thomson Reuters) would make it possible to measure the quality of the scholarly output instead of focusing only on quantity. Beyond these technical issues, I have some comments on the interpretation of these interesting results. The chapter states that these findings are consistent with the idea that there are "synergies" between UIR and academic activities. What is the true meaning of *synergies* in this context? Is *synergy* just a synonym of *correlation*, meaning that in the data, the two activities are more likely to happen together? Or does *synergy* imply an actual mechanism?

The sixth main result shows that scientific motivations to engage in UIR are more important than commercial ones. These findings are fascinating but come with some caveats. First, the motivations for UIR are self-reported. This is not necessarily a limitation of the data, because there is no other way to collect this information. However, self-reported data could be skewed toward finding that scientific motivations are more important than any other factor. There is likely a strong negative stigma attached to faculty members who identify commercial motivations as their primary driver. I think that future research should discuss this fact. Second, these results are only partially corroborating the authors' claims. Specifically, a hypothesis is that the pursuit of scientific discoveries is the primary motivation shaping US LGU faculty participation in UIR activities. I think that the results in table 5.8 do not necessarily prove this point. In other words, they do not prove that scientific motivations are the primary motivation behind UIR. These findings prove that scientific motivations are more widespread and common than commercial motivations. Third, I would emphasize how com-

mercial motivations are more common among UIR faculty. Specifically, the share of faculty members who have commercial motives is often more than 1 percentage point higher among faculty members engaging in UIR. Fourth, as I explained in the previous paragraph, this analysis should be performed using multivariate regressions.

The seventh main result shows how a UIR index, built using principal component analysis, is correlated with scientific and commercial motivations. I agree with the idea of building a UIR index, because engaging in UIR activities is likely a continuous choice, not a dichotomous one. Specifically, the chapter creates two indices: one index for AE and one for AC. The main issue is that a change in these two indices implies different comparisons. As shown in figure 5.1, an increase in the AE index compares faculty members not engaging in UIR to faculty members engaging almost exclusively in AE. Instead, an increase in the AC index compares faculty members engaging in AE to faculty members engaging in both AE and AC. These discrepancies make the interpretation of these last results a little complex.

To conclude, this chapter represents one of the most thorough explorations of UIR to date. The analysis of newly available survey data dispels some common misconceptions about UIR. Specifically, the chapter suggests that there are stark differences between AE and AC activities. As a consequence, every discussion on this topic should take into account that the various types of UIR have very different characteristics. I suggest that future research addresses the following four main issues. First, it would be beneficial to assess the representativeness of the survey data with respect to all ALS professors at US LGUs. Second, follow-up work should discuss in greater detail the complex relationship between trends in government grants (federal vs. state) and participation in UIR activities. Third, the analysis of the effects of UIR activities on scholarly output should be based on multivariate regressions in order to control for confounding factors. Moreover, future work should add third-party administrative data on academic publications and patent production (such as the Web of Science database) in order not to rely on self-reported outputs exclusively. Fourth, the UIR indexes should be redesigned to make them more comparable.