Supplemental Appendix

A.1: Additional Background on National Data for A-MI Construction

The national advanced manufacturing index is constructed using metrics from four separate categories: innovation, talent, business climate, and productivity. Each category received an equal weighting (25 percent).

Following Crossman (2020),[1] our final selection of indicators was based on four rules:

1. Face Validity – the metrics should measure some aspect of the nature, efficiency, or enhancement of the production process inputs or attributes of its outputs.
2. Uni-dimensionality – the metrics should be narrow enough to measure a single dimension.
3. Specificity – the metrics must be granular enough to capture the desired objective.
4. Variance – the metrics should have sufficient variability to differentiate industries along a spectrum.

We subjectively evaluated the candidate indicators according to the first three rules. For the fourth, we used visual inspection of box plots.

Below we provide more details on the metrics used for each category.

Innovation (25 percent)

Much precedent exists for research and development (R&D) as a measure of innovation. We used a log transformation to achieve a distribution with fewer outliers.

- Research & Development: log (R&D costs / employment), an often-used proxy measure for industry innovation

These data enabled a metric for R&D per employee by industry.

Talent (25 percent)

Again, there is precedent for STEM share as a measure of talent, and average annual wages is strong correlated with educational attainment. Each was equally weighted.

- STEM share: STEM employment / employment; a measure of the quality/talent of labor input
- Average annual wages: log (average annual wage), a measure of the quality/talent of the labor input

For determining the percentage of STEM employees in each NAICS code, we began by identifying STEM occupations using the Department of Labor's Employment and Training Association's O*NET resource. Then we used the Bureau of Labor Statistics Industry-Occupation matrices for a crosswalk to 4-digit NAICS manufacturing industry. A log transformation of the average wage reduced the influence of outliers and achieved a more normal distribution.

[1] Crossman, Ashley. "How to Construct an Index for Research." ThoughtCo, Aug. 27, 2020, thoughtco.com/index-for-research-3026543.

Business Climate (25 percent)

Any manufacturing industry with large export volume, by definition, is competitive globally. It follows that this competitive position exists at least partially because of a favorable regulatory and tax climate. Regulatory policy, tax reform, and trade policy were all sub-recommendations of the business climate in the AMP report. Due to data availability, we focus on a metric related to trade policy (export volume) as our measure of business climate.

Export volume: log (export value / employment); a measure of the business climate.

Data for export volume by industry came from USA Trade Online. Again, we used a log transformation to reduce the influence of outliers and achieve a more normal distribution.

Productivity (25 percent)

The purpose of seeking manufacturing industry advancement is to maximize productivity over a set of inputs. Therefore, productivity measures comprise one-quarter of our A-M index – 5 percent for each measure below. These definitions were taken largely from the BLS Productivity Glossary.[2]

- Capital productivity: output / capital cost; the efficiency at which capital inputs are utilized in producing output of goods and services, measured as output produced per unit of capital inputs.[3]
- Capital intensity: capital input / hours worked; the ratio of the amount of capital input used relative to the amount of labor hours used to produce output. Increases in the capital-to-hours ratio reflect increases in the intensity of capital used in the production process.
- Dispersion index: the dispersion index is an experimental measure of within-industry productivity. For an individual industry, it is the log of the productivity ratio of an establishment in the 75th percentile divided by that of an establishment in the 25th percentile; log ($prod_{75th}$ / $prod_{25th}$). This measures the difference in productivity between the more productive firms versus less productive firms in a given industry. One hypothesis is that an increase in new industry entrants following a period of innovation creates more dispersion in productivity. We consider high dispersion indicative of rising productivity or advancement.
- Labor cost share: labor cost / sum of input costs; the portion of the total costs to produce output that can be attributed to the cost of labor. Since more labor (and less capital) are generally considered to be inefficient; we use the negative of this measure.
- Labor productivity: output / hours worked; the efficiency at which labor hours are utilized in producing output of goods and services, measured as output per hour of labor.

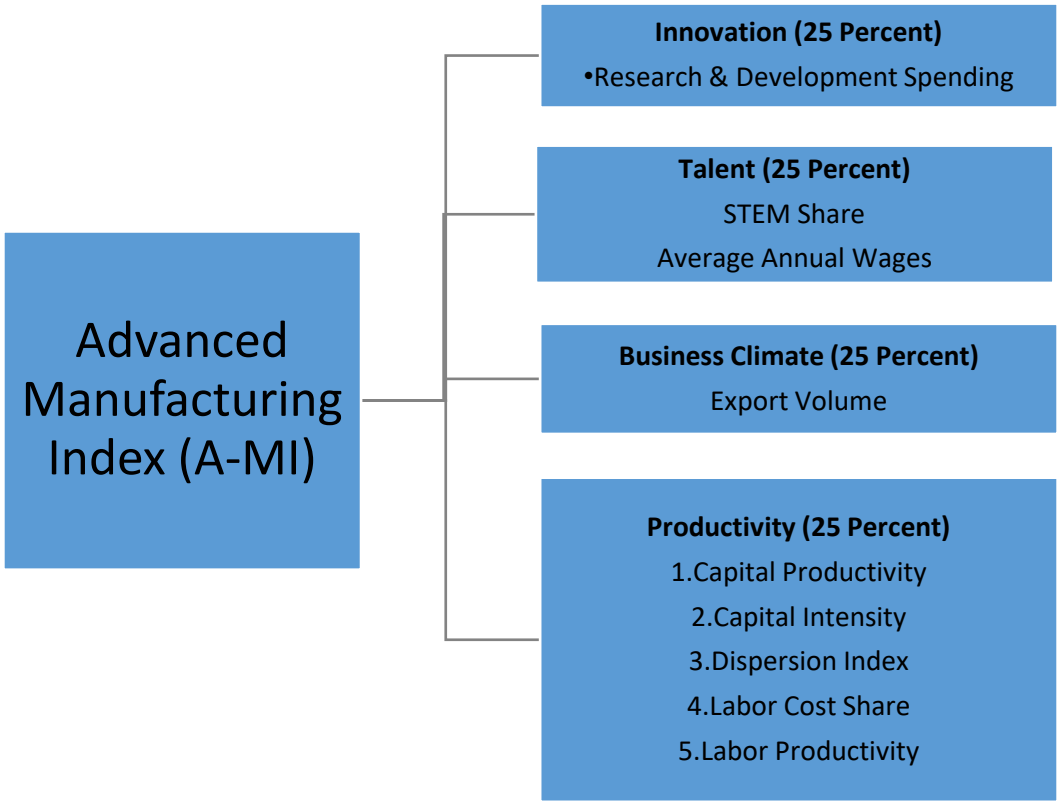
Figure A.1 provides a visual overview of our method for using these industry-specific indicators to construct our index of advanced manufacturing. To summarize, we convert the indicators to index

[2] https://www.bls.gov/mfp/optglossary.htm.

[3] *Capital input,* also known as capital services, is the flow of the services derived from physical assets (equipment, structures, inventories, and land) and intellectual property used to produce output.

values and combine them within each of the four major categories. We then combine those category-specific index values into an aggregate index, weighting each category equally (at 25 percent).

Figure A.1: A-MI Construction



A.2: Additional Background on County Data for RI Construction

Innovation (33.3 percent)

Innovation is measured using three separate metrics:

- Patent technology diffusion - a calculation that measures the degree to which a technology spreads and is adopted. It is based on a region's volume of patents and the technology classes of those patents. Patents are first classified according to twelve technology categories, recognizing that some categories (e.g., medical devices and medical technology) are cited more widely across diverse fields. A diffusion index is then calculated for each category. The number of citations is separately counted for each patent, and individual scores are assigned on the basis of how that number deviates from the mean number of citations among patents in the region. The final patent technology diffusion indicator value is a function of both the technology category and the relative number of citations.
- University-based knowledge spillovers - the amount of university R&D spending in engineering, geosciences, life sciences, math and computer science, and physical science at universities within a 50-mile radius. Adjusted for distance to university.
- Latent innovation - estimates the complexity and uniqueness of an industry in a region. The operating principle is that uniqueness and complexity are indicators of specialization and innovation. We use the Latent Innovation Index measure created by Goetz and Han (2020).[4] This measure uses spatial proximity to innovative industries on the premise that industries interact and influence each other.

These three measures were weighted equally.

Talent (33.3 percent)

Talent is measured using three different indicators:

- Technology-based knowledge occupation clusters - the percent of total employment that is in occupations which apply high-level technology (e.g., scientists and engineers).[5]
- Associate degree attainment - the percent of the population age 25 and older with an associate degree.
- Average prime working-age population growth - the five-year-average annual growth rate for the population age 25 to 44.

All three were equally weighted.

Business Climate (33.3 percent)

We expect traditional climate measures such as tax policy and regulatory environment to be roughly consistent throughout the state, so lack of variation made these poor measures. However, the dynamism occurring as firms enter, grow, shrink, or exit the economy can differentiate counties and

[4] Goetz, S. J., & Han, Y. (2020). Latent innovation in local economies. Research Policy, 49(2), 103909.
[5] This measure is a substitution for the preferred STEM degree counterpart which exhibited insufficient variation across counties.

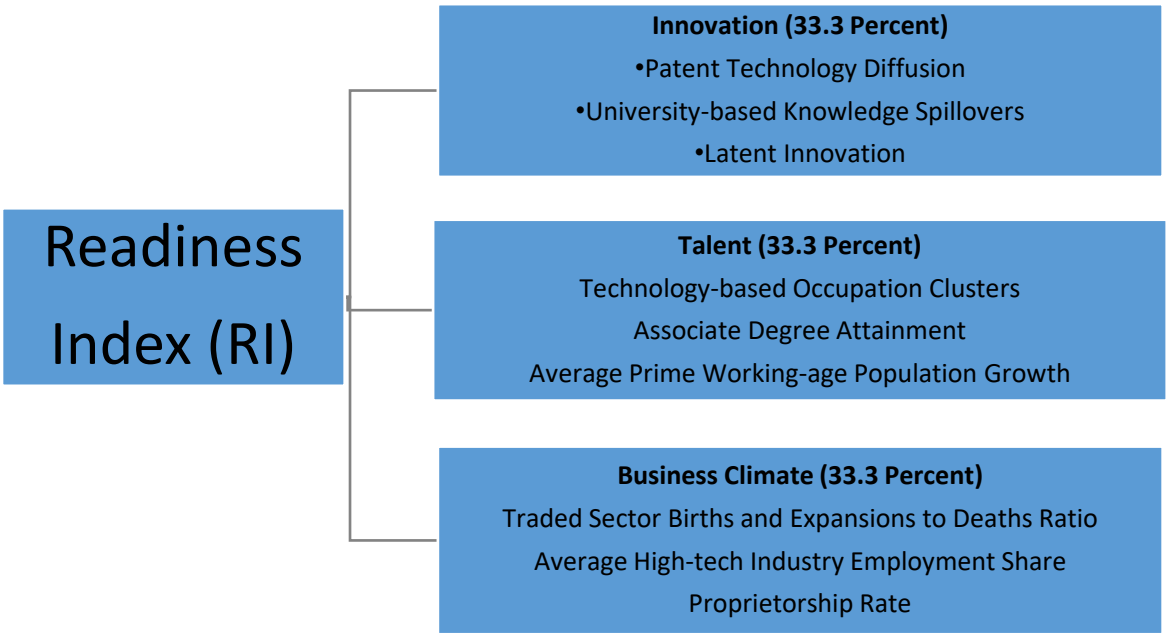
provide a measure of the local business climate. Therefore, our definition of business climate includes direct and indirect measures of the local operating environment.

The first indicator captures an aspect of a firm's location decision. Industries that serve a population outside the region and are not resource dependent have the freedom to choose a favorable (local) business climate. The last two measures reflect co-location and entrepreneurial optimism for high-tech industry. A recent study (Liang 2020) showed a significant beneficial effect for high-tech industry attributed to regional economic co-evolution.[6] The study captured the extent to which firms aspire to co-locate for synergy and other aspects of a favorable business environment. Moreover, larger values of the last two indicators implicitly suggest existing regulatory and tax conditions that, at a minimum, are not so burdensome to change the location decision. The three were equally weighted.

- Traded sector births and expansions to deaths ratio - measures which new businesses serve "export" markets, i.e., sell to those outside of the region rather than serving the local population.
- Average high-tech industry employment share - the percentage of total employment that is in high-tech industries.
- Proprietorship rate - the number of nonfarm businesses divided by the total number of workers.

[6] Liang, L., Wang, Z. B., Luo, D., Wei, Y., & Sun, J. (2020). Synergy effects and it's influencing factors of China's high technological innovation and regional economy. Plos one, 15(5), e0231335.

Figure A2. Readiness Index Construction



A.3: Additional Background on County Data for PI Construction

Innovation (30 percent)

Some measure of patent activity is used in both location-based indices because it is an accepted indicator of innovation.

- Change in the average patenting rate - the ten-year change in average patents per 1,000 workers.

Talent (30 percent)

Significant increases in earnings, the most comprehensive and a market-based measure of talent, reflect a talent pool that is deepening.

- Change in annual wage and salary earnings per worker - the five-year change in annual wage and salary earnings per worker.

Business Climate (30 percent)

Increases here signal a local climate conducive to high-tech industry growth and entrepreneurial optimism, as well as a tax and regulatory environment that does not constrain either.

- Change in share of high-tech industry employment - the five-year change in the percentage of total employment from high-tech industries.
- Change in proprietorship rate – the five-year change in the proprietorship rate.

Productivity (10 percent)

Gross Domestic Product (GDP) per worker is the ultimate measure of productivity.

- Change in Gross Domestic Product - the five-year change in current-dollar GDP per worker.

Figure A3. Progress Index Construction

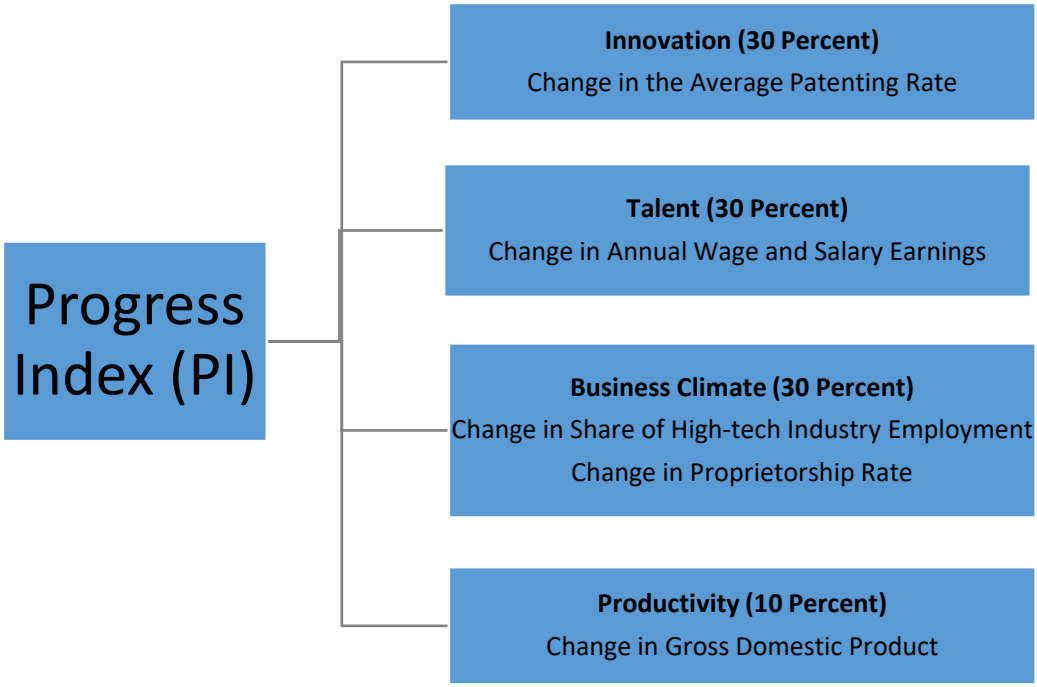


Table A.1 State Indices and Ranks for All Manufacturing Industries

State	Employment Index	Wage Index	Employment Rank	Wage Rank	State	Employment Index	Wage Index	Employment Rank	Wage Rank
Indiana	74.4	88.6	1	1	Oregon	43.1	43.5	26	27
Wisconsin	70.7	77.9	2	2	Idaho	39.1	44.2	27	26
Alabama	67	73.2	3	4	Connecticut	39	38.8	28	30
Iowa	63.8	74.8	4	3	South Dakota	38.9	41.8	29	29
South Carolina	61.5	71.3	5	5	Oklahoma	37.8	42.7	30	28
North Carolina	60.4	61.8	6	8	Utah	36.9	35.9	31	32
Mississippi	59.8	70.9	7	6	California	35.6	34.8	32	33
Tennessee	**56.5**	**61.2**	**8**	**9**	Massachusetts	34	30.6	33	35
Kentucky	56.3	66.2	9	7	West Virginia	33.5	38.4	34	31
Arkansas	55.2	58.7	10	12	Texas	32.4	34.3	35	34
Ohio	53.6	60.3	11	10	Virginia	31.4	29.9	36	36
Rhode Island	51.5	50.4	12	17	Washington	29.4	25.7	37	38
Vermont	50.9	51.5	13	14	New Jersey	28.8	27.2	38	37
Michigan	50.5	57.8	14	13	Colorado	24.6	22.8	39	40
Minnesota	49.1	48.3	15	20	North Dakota	23.8	23.4	40	39
Georgia	48.3	50.7	16	16	New York	23	17.7	41	46
Maine	47.3	51	17	15	Montana	21.9	22.8	42	41
New Hampshire	47.2	47	18	22	Delaware	21.5	22.7	43	42
Kansas	47	50.3	19	18	Arizona	21.5	22.2	44	43
Alaska	46.5	46.9	20	23	Florida	20.2	21.1	45	45
Louisiana	46.3	59.8	21	11	Wyoming	19.8	22.1	46	44
Missouri	45	47.6	22	21	Maryland	17	16.4	47	47
Illinois	44.3	45.5	23	24	Nevada	14.5	15.6	48	48
Pennsylvania	44	44.3	24	25	New Mexico	14.1	13.3	49	49
Nebraska	43.8	48.5	25	19	Hawaii	10.5	8.9	50	50