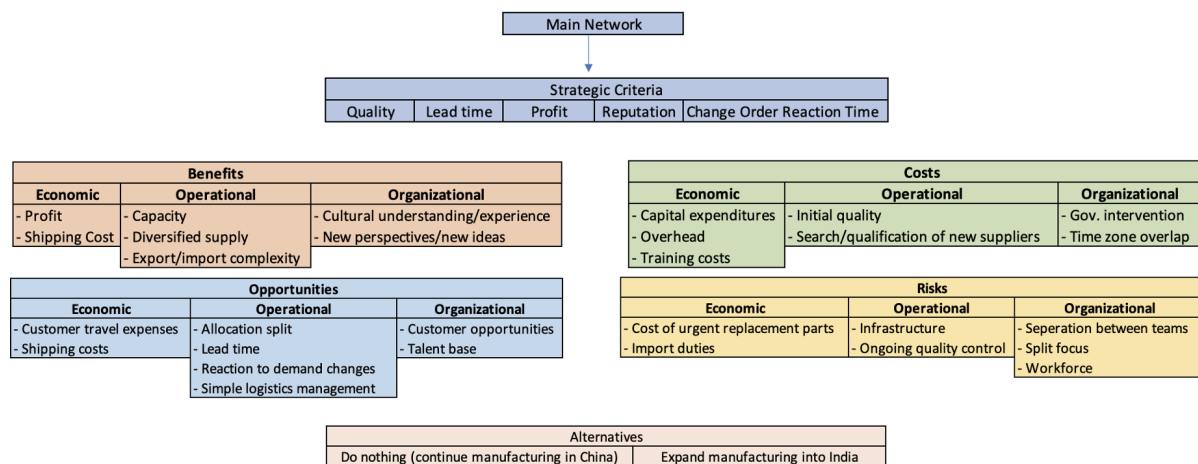


## International Manufacturing China vs India

This final project focuses on a company called BCI Engineering. BCI Engineering is primarily a contract manufacturer and supply chain management company. It was established in 2006 and has its headquarters in Pittsburgh, PA. BCI has offices and manufacturing operations located all around the world, including China, Malaysia, Hong Kong, Mexico, and Italy. BCI's primary business is manufacturing steel components for solar racking systems. Currently, the majority of the manufacturing of these components occurs in China. The delivery locations for the products have historically been primarily in the United States, but BCI is now seeing increasing demand in India.

As a result of the increasing demand in India, the high-level management at BCI is being faced with a decision: should they expand their contract manufacturing business into India to better serve the increased demand in India or should they remain in China? This is the question we will be using the SuperDecisions software to analyze. In order to simplify the analysis, we used two alternatives: Do nothing (continue manufacturing in China) or Expand manufacturing into India. Once the background, decision, and alternatives were understood, we began to build out our BOCR model.

To begin, we brainstormed strategic criteria that represented BCI's interests and came up with control criteria for each BOCR section. We then continued brainstorming bottom level factors for each section. Ultimately, we ended up with the following model structure:

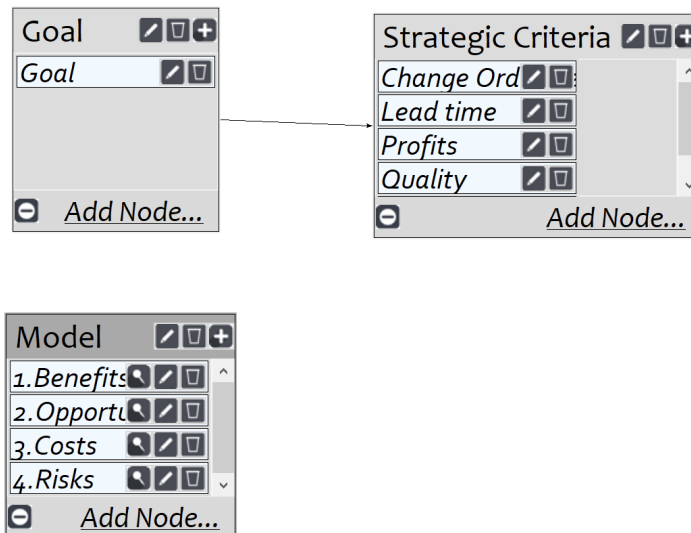


As a contract manufacturer, BCI is often focused on quality and lead time, since those directly impact our customer relationships. As any business, BCI needs to consider profits in order to keep the business healthy. Right now, profits are very important since BCI is looking to use current manufacturing profits to expand other business segments. For BCI in particular, reputation is extremely important. BCI receives the majority of its new contract manufacturing

sales leads through word of mouth from existing customers, and their reputation is what often wins them new business. Change order reaction time is also something that BCI prioritizes in order to best serve its customers. Often there are last minute order changes and being able to react quickly to fill a changed order is important.

When looking at the control criteria and bottom-level factors, we removed BCI's specific agenda from our mind and built the model in a way that would be applicable for any business in the same industry looking at the same decision. We used economic, operational, and organizational categories as our control criteria for each BOCR section and identified 2-4 bottom level criteria for each control criteria category.

Once we had settled on the model structure, we began building out the model in the SuperDecisions software. Here is a picture of the main network in our SuperDecisions model:

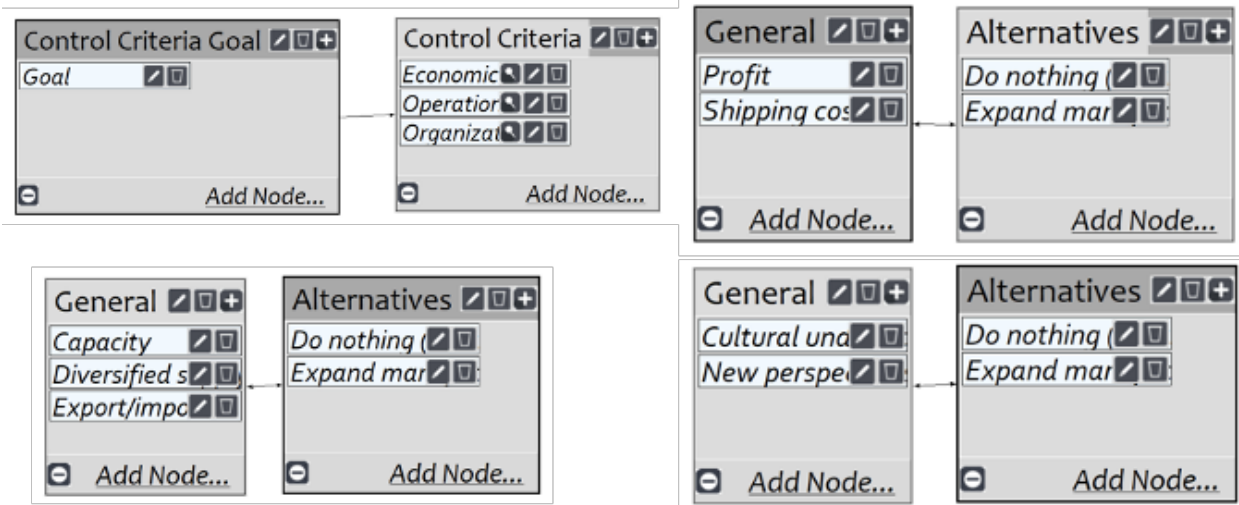


You will note that there are no connections between the goal cluster and the Model cluster, since as we mentioned earlier, the BOCR models are not related to BCI's specific strategic criteria. Rather, later we will relate those two things together via a ratings model.

Once the strategic criteria were entered into the model, we were able to pairwise compare them based on BCI's priorities. These are the weights that resulted, which are in line with BCI's current priorities:

Strategic Criteria	Weights
Change Order Reaction Time	4.0%
Lead time	18.7%
Profits	32.8%
Quality	11.6%
Reputation	32.8%

Next, we built out the Benefits section of the model, which can be seen below:



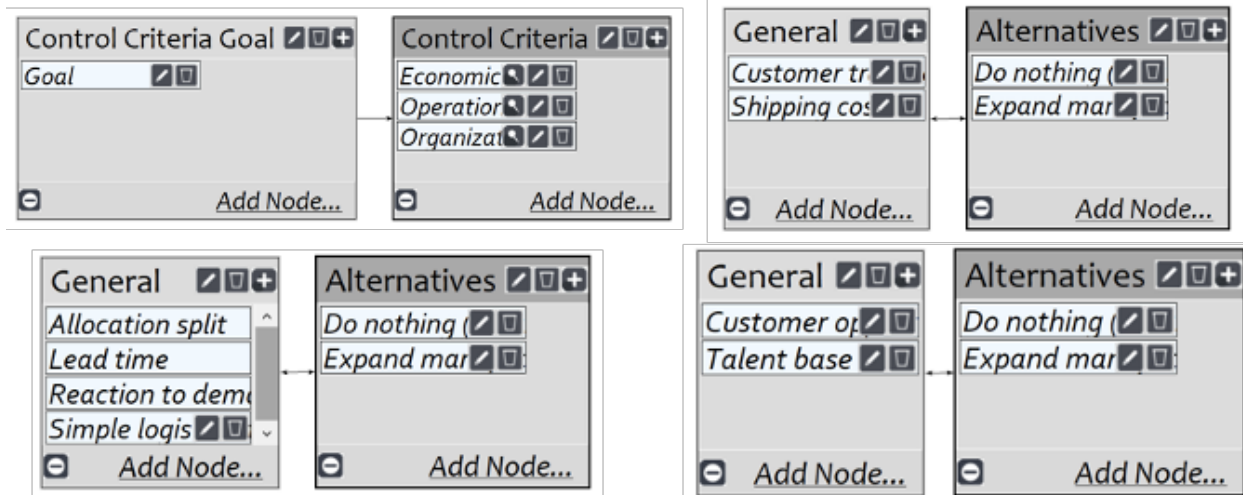
1. Economic
  - a. Profit - The financial gain for the company.
  - b. Shipping Cost - The total cost for the company to get the product to the customer. This would be more expensive if shipping from country to country.
2. Operational:
  - a. Capacity - Quantity of items or orders that the company can fulfill
  - b. Diversified Supply Chain - The ability to produce products in multiple locations. For example, if one gets shut down due to external circumstances, the company's risk is reduced by having another facility.
  - c. Exporting/Importing Complexities - The difficulty of dealing with exports and imports. The risk and expenses of dealing products in and out of a country.
3. Organizational
  - a. Foundational Ideas and process improvements due to new perspectives - the ability to produce new ideas and improvements due to the cultural differences of a location
  - b. Existing cultural understanding and experience - tribal knowledge of current workforce

After building out the benefits section, we were able to synthesize the section and saw the following results:

Benefits				
Decision	Economic	Operational	Organizational	Total
Do nothing (continue manufacturing in China)	0.46	0.46	0.09	0.19
Expand manufacturing into India	0.14	0.13	0.53	0.81

The overall Benefits synthesis gives a clear decision to expand manufacturing into India. The decision is heavily favored in the Economic and Operational perspective. While organizationally the decision gets edged out, it is overall favored as the Economic and Operational benefits are prioritized. It makes sense as expanding is expected to lead to higher profits and increased customer demand.

Here you can see the Opportunities section of our model:



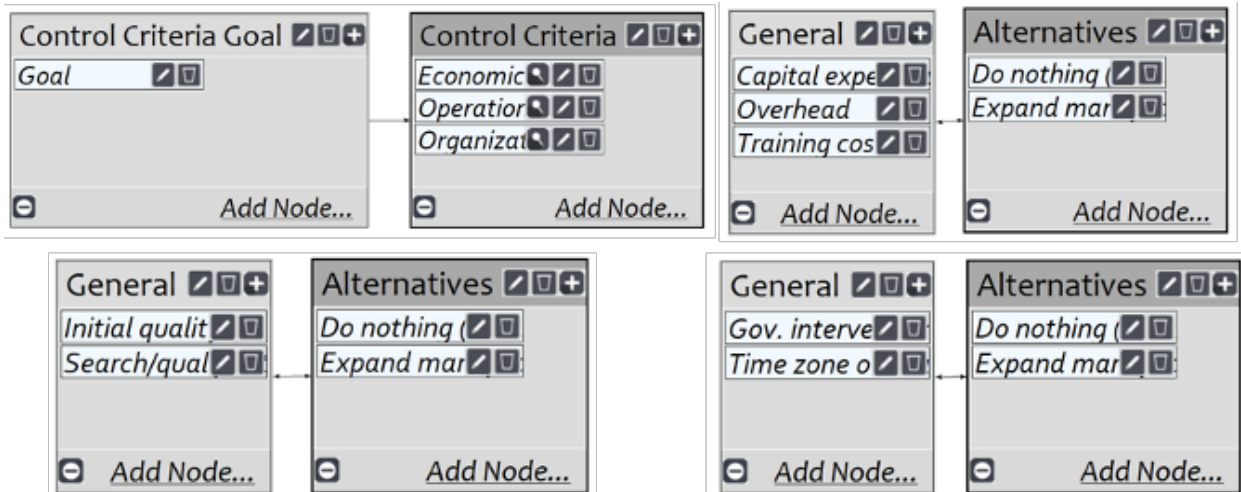
1. Economic
  - a. Shipping Costs - Expense of getting product to customers. Being logistically closer to customers decreases these costs
  - b. Customer travel expense for factory inspections - cost to travel to facilities
2. Operational
  - a. Lead Times - Time it takes to produce customer demand
  - b. Ability to react to demand changes - changing customer orders during the manufacturing process
  - c. Logistics Management - Do you have to import/export goods?
  - d. Allocate Production - Can the company allocate production to another facility?
3. Organizational
  - a. Capturing more customer demand due to regional presence - increase in customer demand due to regional presence and shorter lead times
  - b. Talent base - Expansion increases the ability to bring in new talent from different areas

The Opportunities sections synthesizes yielded the following results:

Opportunities				
Decision	Economic	Operational	Organizational	Total
Do nothing (continue manufacturing in China)	0.11	0.12	0.14	0.11
Expand manufacturing into India	0.89	0.88	0.86	0.89

Within Opportunities, the decision to expand into India is clear. In every aspect, the decision to expand heavily beats out for the company to do nothing. The ability to reduce costs while capturing more customer demand heavily influences these results.

We built out the Cost section of our model as shown below:



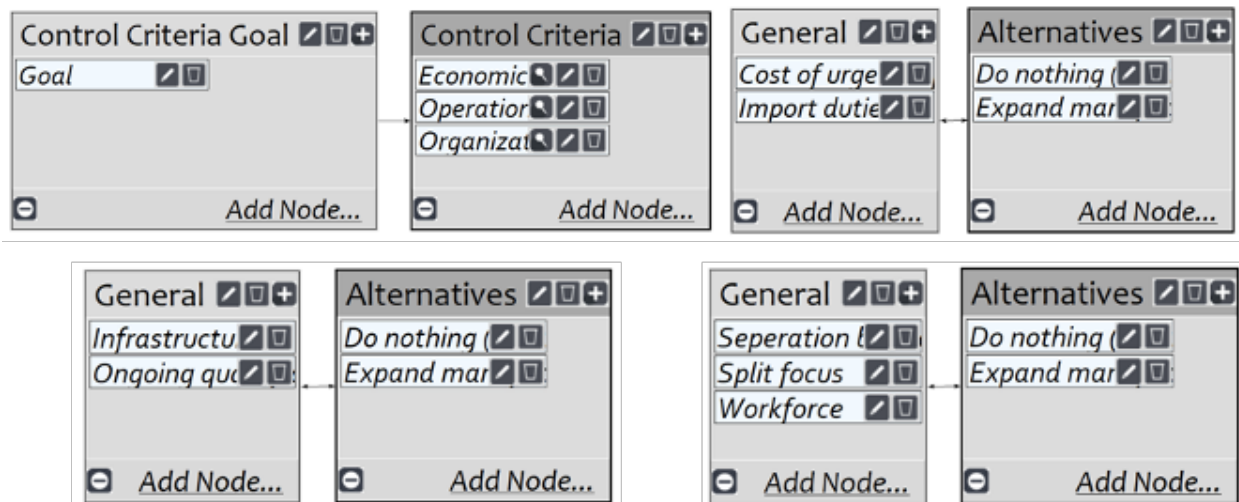
1. Economic
  - a. Capital Expenditures -cost to acquiring or maintaining a fixed asset.
  - b. Overhead - cost of operating a business and staff.
  - c. Training costs - cost of learning curve and to train employees
2. Operational
  - a. Initial Quality - Products are complicated and require high skill level to manufacture
  - b. Search and qualification process of new suppliers - process of bringing in new suppliers to fulfill customer demand
3. Organizational
  - a. Government Intervention - Obstacles a country's government presents when looking to operate within a country. Some involve corruption and hard barriers to entry.
  - b. Time Zone - Differences in time with location can present hurdles

Once built out and pairwise compared, the Cost section yielded the following results:

Costs				
Decision	Economic	Operational	Organizational	Total
Do nothing (continue manufacturing in China)	0.71	0.21	0.08	0.16
Expand manufacturing into India	0.10	0.12	0.47	0.84

In the cost synthesis, economic and operational costs dominate in favor of the decision to expand. While organizationally it does edge out the decision to do nothing, the other two categories are much more of a priority. Leading to the decision to expand to be heavily favored. It will certainly cost a lot for the company to expand, something that must be weighed in a decision like this.

The last section of the model was Risks and can be seen below:



1. Economic
  - a. Increase of import duties - Staying in one location can result in an increase of import costs
  - b. Cost of urgent replacement parts - only having one location causes express shipments for replacement parts
2. Operational
  - a. Infrastructure - different locations may lack infrastructure to successfully operate
  - b. Ongoing Production Quality Control - different locations may not follow existing standard of quality
3. Organizational
  - a. Ability to hire high skilled workers - are residents of possible new locations taken by higher paying industries?
  - b. Separated Employee teams - Impacts of working with cross-regional teams
  - c. Split Focus

The Risks synthesis showed the following results:

Risks				
Decision	Economic	Operational	Organizational	Total
Do nothing (continue manufacturing in China)	0.57	0.33	0.10	
Expand manufacturing into India	0.89	0.16	0.16	0.57
	0.11	0.84	0.84	0.43



There is a lot of economic risk for the company to do nothing. The possibility of increasing import costs heavily influenced this result. While the decision to expand provides a lot of risk operationally and organizationally, the priority of the economic category resulted in doing nothing being riskier.

Once we had built out the rest of the model, we came back to the top level in order to connect the strategic criteria to the rest of the BOCR model. In order to do that, we created a rankings model with the Benefits, Opportunities, Costs, and Risks as the alternatives and the strategic criteria as the criteria to rate. Once this was created, we used the winning alternative in each BOCR section as the basis for how we rated each alternative in the various categories seen below:





Alternatives	Priorities	Totals	Change Order R... (0.0396)	Lead time (0.1874)	Profits (0.3283)	Quality (0.1163)	Reputation (0.3283)
1.Benefits	0.2677	0.5018	Fast	Fast	B: 85%-92%	Med	C:70%-84%
2.Opportunities	0.2677	0.5018	Fast	Fast	B: 85%-92%	Med	C:70%-84%
3.Costs	0.2677	0.5018	Fast	Fast	B: 85%-92%	Med	C:70%-84%
4.Risks	0.1968	0.3689	Slow	Slow	C:70%-84%	Hi	B: 85%-92%

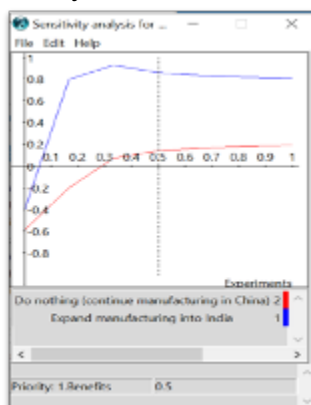
Once the entire model was completed, we were able to synthesize the overall results. We looked at both short-term and long-term. Here you can see the short-term results, which we produced via multiplicative synthesis:

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Main Network: Final Project.sdmod: formulaic: ratings				
Name	Graphic	Ideals	Normals	Raw
Do nothing (continue manufacturing in China)		0.126994	0.112684	0.251277
Expand manufacturing into India		1.000000	0.887316	1.978646

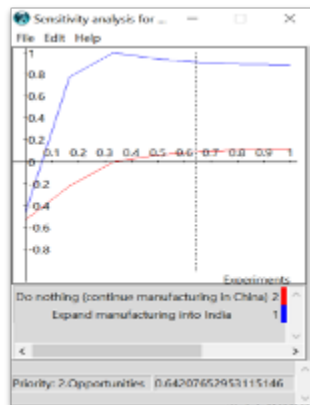
In the short-term, expanding manufacturing into India is very favorable  
Here you can see the long-term results, which were generated through additive synthesis:

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Main Network: Final Project.sdmod: formulaic: ratings				
Name	Graphic	Ideals	Normals	Raw
Do nothing (continue manufacturing in China)		-0.483939	-0.326118	-0.080548
Expand manufacturing into India		1.000000	0.673882	0.166442

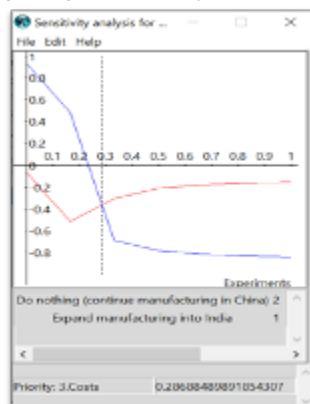
In the long-term, expanding manufacturing into India is favorable.  
Once we had our results, we did a sensitivity analysis on each of the BOCR sections. Here you can see the results:



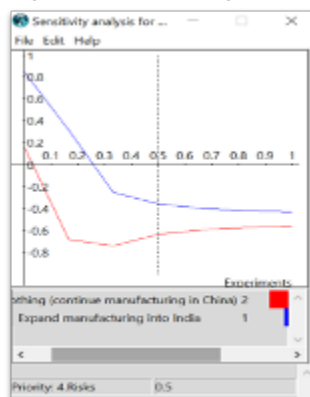
In terms of benefits, the best option has always been to expand. It will increase profits, capacity and workforce diversity, while decreasing shipping costs, exports/imports and risk of COVID shutdown impacts.



Expanding into India dominated in the long-term opportunities. Expanding will decrease shipping costs, lead times and allow the company to react faster to customer demand. All while giving the ability to capture more customer demand.



It will certainly cost the company quite a bit to expand into another country. Up front, the company will need to pay for a facility, train new employees and find new suppliers in the region. Expanding will cost the company a lot but is accounted for in the decision to expand.



A small change in prioritization within the risk category would lead to a change in the overall result. In the chart there is a shift from .3-1 where the two lines come closer. With a small



change, there is certainly a chance the result would be different. Expanding will ultimately be risky.

Overall, when we look at all of the results we generated from our model, it is clear that expanding manufacturing into India is the best option for BCI Engineering at this point in time, based on their increased demand in India. Both the short-term and long-term results showed expanding manufacturing as the strong winner, and even the majority of the BOCR results also showed expanding manufacturing as the winning alternative. Based on BCI's current situation, we would suggest that the upper-level management seriously consider the results of this report and look at expanding their manufacturing.