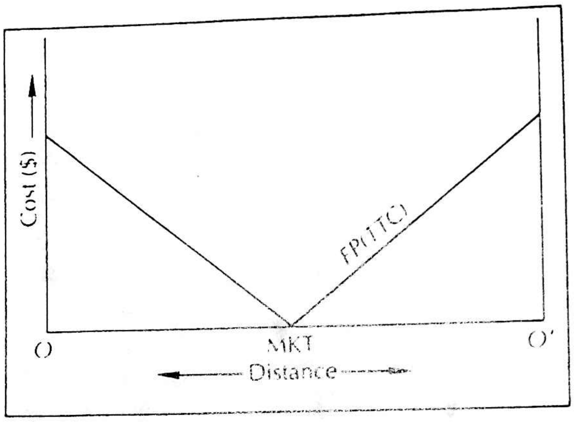
The Simple Weberian Model: Assembly Costs

1 Ubiquities Only

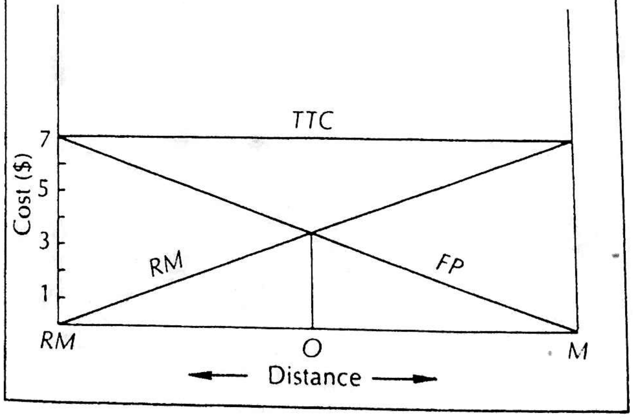
Only *localized* raw materials attract production. Ubiquities merely add to the pull of the market. In all cases, we assume the existence of a single market point. Ubiquitous raw materials occur everywhere so the cost of their assembly is always zero. Only finished products costs are important and they are reduced to zero with a location at the market point. This is illustrated by Figure 1. Raw material costs (*RM*) are the line *O–O′*. Finished product distribution costs rise steadily away from the market. The cost line *FP* also marks total transportation costs which are minimized at the market.

Figure 1 Weber's model: ubiquities only.



Localized, pure raw materials Figure 2 illustrates costs, given one pure localized raw material and a single market. The material is localized at *RM* and the market is at *M*. The line *RM* gives the assembly costs which increase as a function of distance from the source of the localized raw material. Similarly, the line *FP* gives the distribution costs for the finished product. Total transportation costs (*TTC*) is the sum of *RM* and *FP*. At *RM*, *TTC* = \$7 (*RM* = \$0, *FP* = \$7, *TTC* = \$7). At O, *RM* = \$3.50, *FP* = \$3.50, so that *TTC* = \$7. Total transportation costs are exactly \$7 everywhere along a straight line between mine and market, so that manufacturing can locate anywhere along this line and minimize costs.

FIGURE 2 Weber's model: one pure, localized raw material.



One pure raw material plus ubiquities This case is graphed in Figure 3. The assembly costs for the localized raw material *(RM)* are minimized at *RM*. Ubiquitous assembly costs are zero everywhere and finished product distribution costs are minimized at *M*. Ubiquitous raw materials, once processed, add to the weight of the finished product so that total transportation costs *(TTC)* are minimized at the market *(M)*. In other words, this location avoids the necessity of moving the ubiquitous material in its processed form. The optimum location is at *M*.

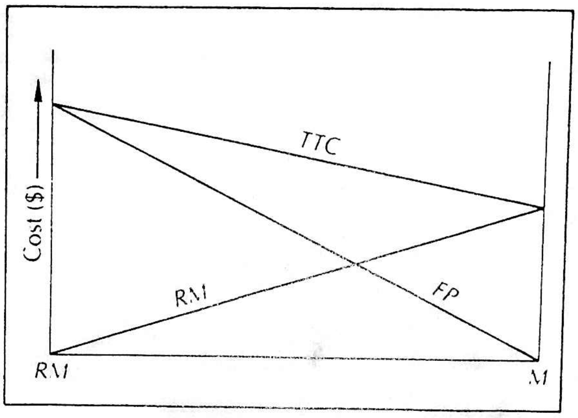


FIGURE 3 Weber's model: one pure, localized raw material plus ubiquities.

Several pure, localized raw materials Figure 4 shows the solution for two pure, localized raw materials, but the outcome is the same for more than two. Once again, the single market is at *M*; one pure raw material is localized at RM_1, and the other is localized at RM_2. The transportation cost for each raw material is given by the lines RM_1 and RM_2. It is assumed in Figure 4 that equal amounts of each raw material are used and that transport costs are $1 per ton-kilometer. Consider a location at RM_1; RM_1 = $0, RM_2 = $6 (one ton moved six kilometers), and a finished product which weighs *two* tons (both raw materials are pure). It costs $6 to ship the finished product back to *M* (two tons shipped three kilometers @ $1 per ton-km = $6) so that total transportation costs *(TTC)* at RM_1 equal $12. The same total transportation costs are also true of a location at RM_2. At *M*, however, total transportation costs equal $6 (one ton of RM_1 moved three kilometers + one ton of RM_2 moved

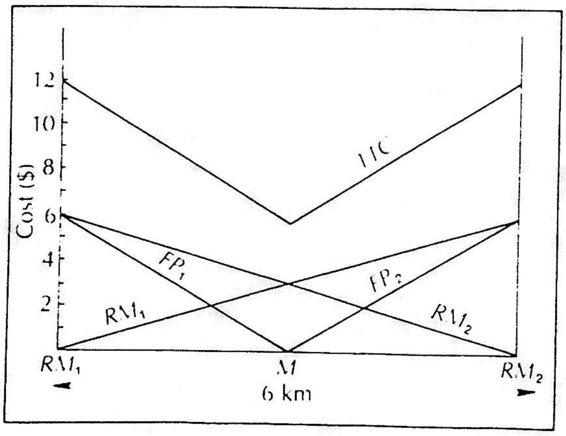


FIGURE 4 Weber's model: two pure, localized raw materials.

three kilometers @ $1 per ton-kilometer = $6). Total transportation costs are minimized at the market. Such a location eliminates the need to "back-haul" a raw material.

Several pure, localized raw materials plus ubiquities This case is illustrated in Figure 5. Remember that ubiquities always add to the pull of the market. In Figure 5 we assume that equal parts of RM_1, RM_2, and the ubiquitous raw material are used so that the finished product weighs three tons (assuming an input of one ton each of the raw materials). Finished product distribution costs at RM_1 and RM_2 are now \$9. Localized raw material costs (RM_2) equal \$6 and finished product distribution costs (FP_2) equal \$9 (three tons moved three km) and total transportation costs equal \$15 at RM_1 or RM_2 while they equal only \$6 at *M*. The pull of the market is considerably strengthened by the addition of ubiquitous raw materials.

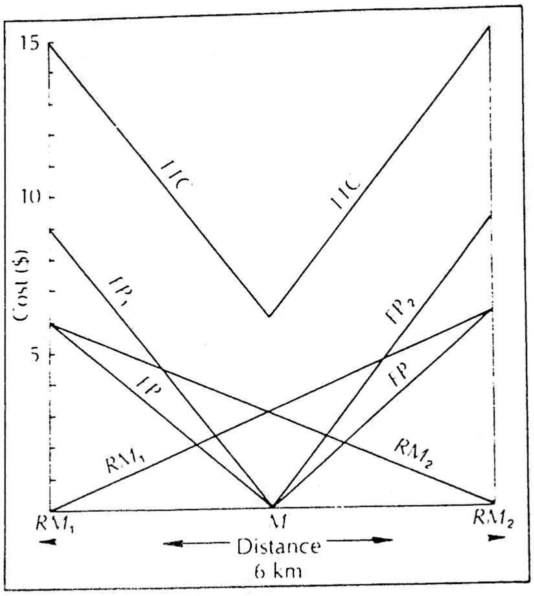


FIGURE 5 Weber's model: several pure, localized raw materials plus ubiquities.

2 Weight-Losing Raw Materials

Weight-losing raw materials have a material index greater than 1. We now consider several cases involving localized raw materials which lose weight in processing.

One localized, weight-losing raw material Figure 6 illustrates this particular situation. Assume that the raw material (located at *RM*) loses one-half its weight in processing ($MI = 2$). Each unit of the raw material shipped to the market (*M*) costs \$10 (line *RM*), but each unit of the finished product shipped from the mine

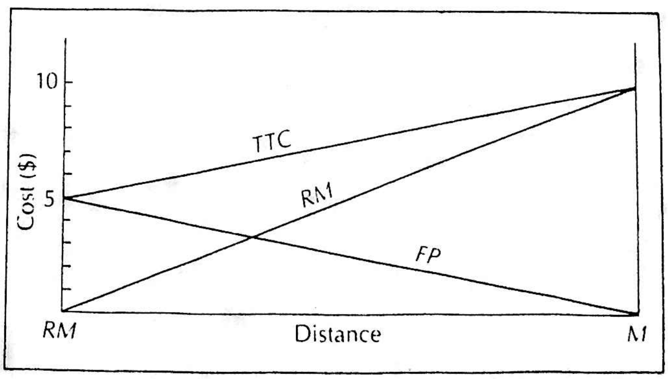


FIGURE 6 Weber's model: one localized, weight-losing raw material.

costs only \$5. Total transportation costs (*TTC*) are minimized at the raw material source.

One localized, weight-losing raw material plus ubiquities The solution to this case depends upon the ratio of weight lost through processing to the weight of the ubiquitous material. Two extreme cases are illustrated in Figure 7A and 7B. In Figure 7A, the weight-losing raw material is a fuel and all of its weight is lost in the manufacturing process. Assume that one ton of fuel (localized at *RM*) and 1000 kilograms of the ubiquitous raw material are required to produce 1000 kilograms of the finished product. Total transportation costs are minimized at the source. Figure 7B illustrates a weight-losing raw material with a material index of 2 (one-half its weight is lost in processing), but let us assume that the ratio of ubiquitous raw material to localized raw material (after processing) is 3:1. Two tons of the localized raw material plus three tons of the ubiquitous raw material are processed into a finished product weighing four tons. At *RM*, total transportation costs are $4 (weight of the finished product), but at *M*, total transportation costs are $2 (weight of the localized raw material required for one unit of the finished product). Total transportation costs are minimized at the market *(M)*. This last ratio typifies commercial brewing. Barley and hops are the localized raw materials and they lose weight in processing, but the major ingredient by weight (water) is ubiquitous. Brewers tend to be market rather than raw material oriented.

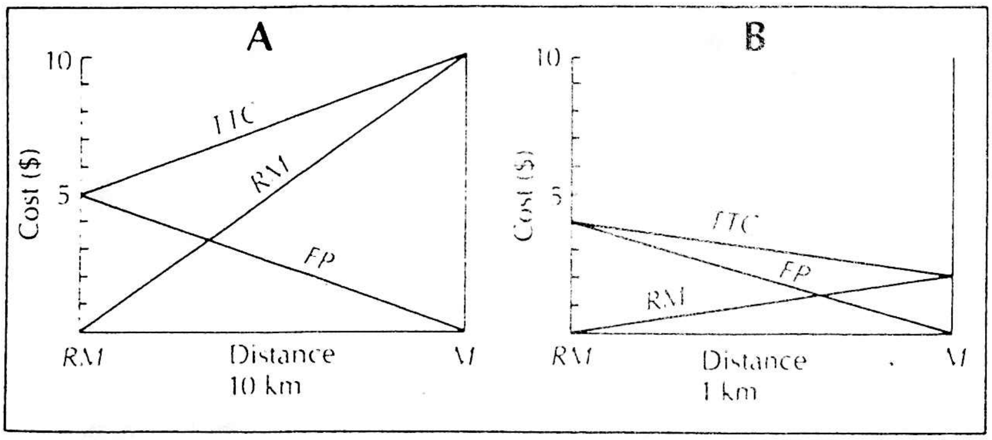
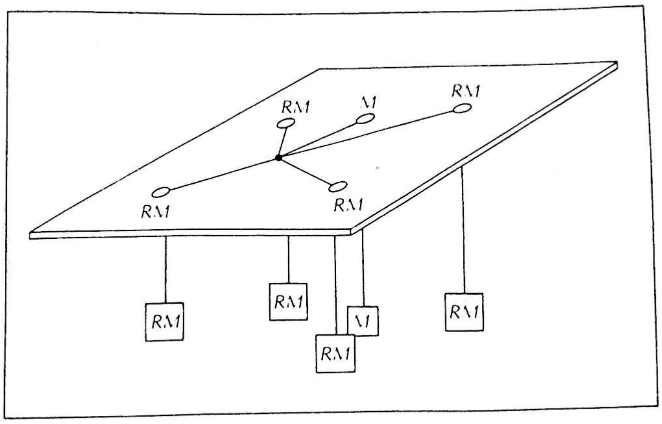


FIGURE 7 Weber's model: one localized, weight-losing raw ma rial plus ubiquities (A) optimum location at raw material source; optimum location at market.

Several localized, weight-losing raw materials The solution becomes more complex when several weight-losing raw materials are considered. Several mathematical solutions are possible, but a simple mechanical analogue known as the "Varignon frame" simplifies the problem. The localized raw material sites are pinpointed on a map mounted on a board (Figure 8). Holes have been drilled in the board at each site. A pulley (to reduce friction) is located at each hole. Each raw material is simulated by a weight proportional to the total weight of the raw material required to produce one unit of the finished product. Cords are run from the weights through the pulleys (raw material sites) and tied together into a single knot. When the weights are released, the final location of the knot will be the optimum location.

FIGURE 8 The Varignon frame.



Finished product distribution costs are simulated by a weight (equal to finished product weight) running through a hole and pulley at the market point *(M)*. Ubiquitous raw materials can be simulated by adding to this weight.

This type of Weberian analysis of single firms has often been applied to the steel industry, which processes several weight-losing raw materials

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Solutions to Weber's locational problems

Material Classes	**Location**
Ubiquities Only	Market
Localized and Pure	
One Pure	Anywhere Between Source of Raw Material and Market
One Pure and Ubiquities	Market
More Than One Pure	Market
More Than One Pure and Ubiquities	Market
Localized and Weight-Losing (Gross)	
One Weight-Losing	Source
One Weight-Losing and Ubiquities	Source or Market Depending on Relative Size of Input
More Than One Weight-Losing	Indeterminate (Mathematical Solution)
More Than One Weight-Losing and Ubiquities	Indeterminate (Mathematical Solution)