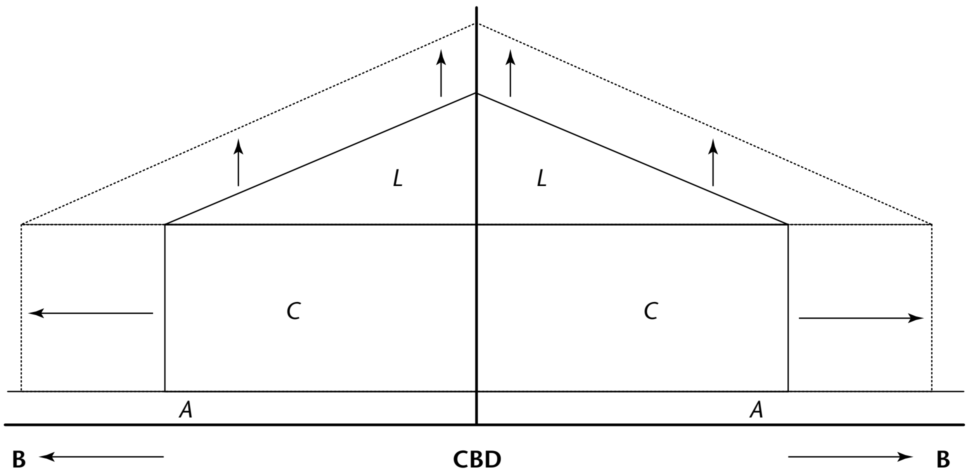
**Exhibit 4-4**
Effect of Population Growth with Density and Transport Cost Constant




and hence the radius, must expand. In particular, for every percent increase in population, the area must increase by an equal percent (for constant density), and the radius must increase by about half that percent.[10] The housing rent at the new periphery must equal the construction cost rent plus the agricultural rent, based on the same arguments as before, which have not changed. Likewise, the rent gradient as we move in from the new periphery must still be the same \$500 per mile (because transport cost and density are the same as before), again based on the same equilibrium argument. So this means that population increase, holding density and other prices constant, must increase rents all over Circlopolis. This is depicted in Exhibit 4-4.

We can summarize the analysis up to now in an important principle:

> Principle 1:
> *Other things being equal, larger cities will have higher average location rents.*

This basic principle, derived from such a simple model of urban form and land values, is no doubt a major reason that land prices, rents, and housing costs are so much higher in the nation's largest cities, such as New York, Chicago, Los Angeles, and San Francisco. (For example, in 1990 the median house price in San Francisco was \$258,000, while in Cincinnati it was \$71,000.)

Perhaps this size principle seems intuitively obvious. But the monocentric city model allows you to deepen your understanding of why larger cities have higher rents. In particular, notice what caused the higher rents when we considered the growth in population in Circlopolis. In our simple model, we were holding density constant. Therefore, land rents (per acre of land) would tend to be higher in larger cities, even if such cities were no denser than smaller cities. This suggests that if larger cities are to keep rents per housing unit at the same level as those in smaller cities, then some

[10] If the area of the circle increases by $p$ percent (that is, $AREA_{NEW}/AREA_{OLD} = 1 + p$), then

$$\frac{RADIUS_{NEW}}{RADIUS_{OLD}} = \frac{\sqrt{AREA_{NEW}/\pi}}{\sqrt{AREA_{OLD}/\pi}} = \sqrt{1+p} \approx 1 + p/2$$

for relatively small values of $p$. For example, if $p = 10\%$, then the more exact value of $\sqrt{1.1} - 1$ is 4.9%.