Differing factor prices within urban areas, particularly land prices, result in capital-land ratios exemplified by high-rise apartments and single family dwellings. The variation in the intensity of residential land use that occurs in cities can be estimated using the properties of production functions. The elasticity of substitution between land and capital, $\sigma$, shows the relationship between intensity of use and variations in land values.

The objectives of this study are to estimate the value of $\sigma$ between land and capital, and to study its implications on recent plot ratio controls for residential sites, for condominium housing, in Singapore. The value of $\sigma$ for residential sites in Singapore may be unitary, constant or variable.

This study is interesting because there is little direct empirical testing of production functions in the context of housing. A relationship between intensity of use and land values is often posited but not elaborated in detail. This is important in the context of Singapore where intensity of use is highly regulated. Land use planners may be imposing their values through plot ratio controls. It will also explore the feasibility of increasing the intensity of use to meet increasing housing demands as the population expands.

The approach is based on the Constant Elasticity of Substitution (CES) and Variable Elasticity of Substitution (VES) production functions. The method of estimation is the linear regression model which requires data on the site area, land price, total capital cost and the total value of a completed development. This study uses data from the Urban Redevelopment Authority (URA) Sale of Sites programme. There were 25 residential land sales in 1996 and 1997. The land price is the highest bid by the housing
producers at each URA land tender. The 25 residential sites used in this study are located in different locations outside the CBD. They vary in their land prices and maximum permissible intensity of use. The lands have similar lease conditions and the land sales took place in 1996 and 1997 when the market prices were relatively stable. These facilitate the author in estimating the value of $\alpha$. The Gross Development Value (GDV), the total value of a completed development on a site, has been estimated by the author using the market comparison approach based on sales of comparable units in completed residential developments. Under the assumption of competitive factor markets, a profit maximising housing producer earns normal profits. Hence, the total amount of capital employed on a site is the difference between the GDV and the land price.

The findings indicate that the production functions have a constant elasticity of substitution of 0.79 and a variable elasticity of substitution of between 0.17 to 0.80. These findings refute the simplifying assumption of a Cobb-Douglas production function which implies a unitary $\alpha$. The results imply that recent plot ratio controls for residential sites, for condominium housing, in Singapore are still highly dependent on land values rather than just a general application of government housing density policy.

Keywords: Elasticity of Substitution, Neoclassical Production Function, Housing density.