ESTIMATING THE DETERMINANTS OF LAND CONVERSION

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This study estimates the determinants of land conversion using an empirical model based on Hardie (for publication), Alig and Healy (1987), and Brueckner and Fansler (1982). The study proposes a land-use conversion model which assumes that an increase in built-up area will increase land conversion. Changes in the determinants in built-up area are therefore assumed to affect the incidence of land-use conversion. The determinants tested in this study were population, income, house value, lot size and agricultural rent. The results show that land conversion increases with increased income and population and is not affected by changes in house value, lot size or agricultural income. This means that policies that would increase agricultural rent or the cost of residential construction would not deter expansion of built-up area as long as income and population are increasing.

The conversion of farmland into built-up area is a historical phenomenon commonly associated with economic modernization. In recent years, land conversion has become a socio-political issue because land conversion often conflicts with the land acquisition and distribution goals of the Comprehensive Agrarian Reform Program (CARP). Other negative effects of land conversion are a cause for concern. Land conversion results in the loss of agricultural output and of the positive externalities associated with farming and wide-open spaces. It also results in the inefficiencies associated with urban sprawl.

Recent assessments have been made of land conversion in various countries. Firman (1997) and Nasoetien (1995) studied land-use and land conversion in Indonesia. Kitamura and Kobayashi (1993) cite problems associated with land conversion in India, Bangladesh, Sri Lanka and the Philippines. Hellig (1997) cites the anthropogenic factors leading to land-use change in China. In the Philippines, studies have been made by Sermano (1994) and Gordoncillo (1998).

Mori (1998) and Hanayama (1986) describe the phenomenon of land conversion in Japan. The concern over land conversion in the United States has prompted some groups to set up the American Farmland Trust. This group advocates farmland preservation policies. Various papers commissioned by the Trust review existing farmland conversion policies. (Gehl and Libby 1997; Gehl and Paulson 1997; Gordon 1998; Paulson 1997a; Paulson 1997b)

Several authors have approached this problem by trying to estimate the determinants of land conversion. Some authors estimate the determinants of farmland conversion directly, while others estimate the determinants of urban land-use. The land conversion studies include Kline and Alig (1999), Lockeretz (1989) and del Castillo (undated). Studies that measure the determinants of urban land-use directly include Hardie, et al. (for publication), Brueckner and Fansler (1982), Alig and Healy (1987), and Verburg, et al. (1999).

This study estimates the determinants of land conversion by estimating the determinants of built-up area. The framework of this study presupposes that there are three types of land-use as illustrated in Figure 1.

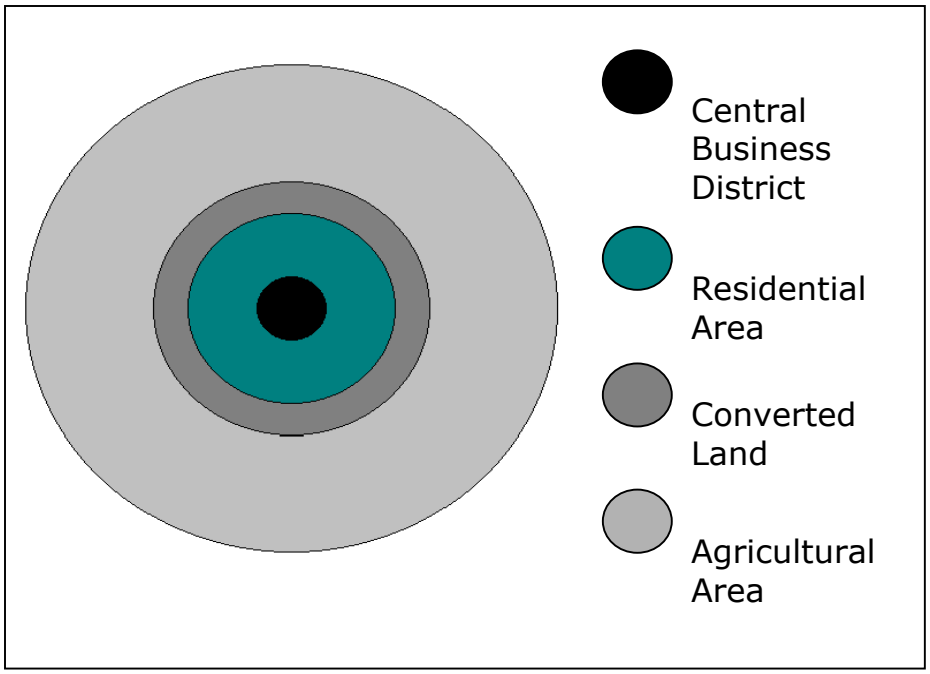
The following assumptions are made:

1. All residents work at the Central Business District.
2. Urban areas outside the Central Business District are used exclusively for residential purposes.
3. Agricultural areas are suitable for conversion into urban areas.

4. Residents earn the same income.
5. Residents own the same size of residential lots and all residential development is horizontal.

Land conversion is defined as the act or process of changing the current use of a piece of agricultural land into urban land-use. Land conversion occurs because of the increase in spatial sizes of cities.

Figure 1
Land Conversion in the Land-Use Model

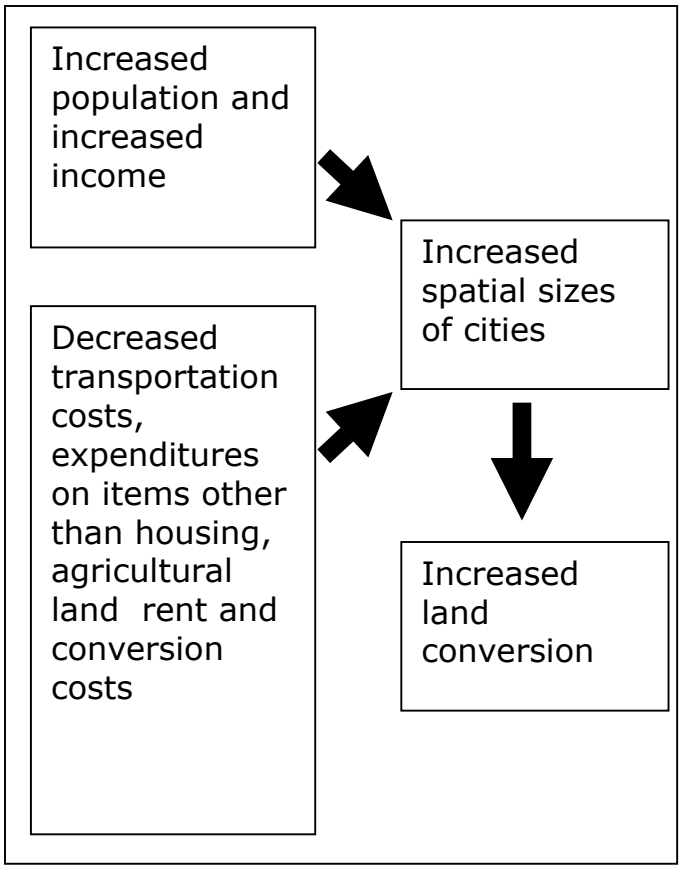


Given these assumptions, land conversion will occur if there is a change in the determinants of urban spatial sizes. Hardie (forthcoming) points to six determinants of urban spatial sizes: population, income, expenditures on items other than housing, transportation costs, agricultural land rent and conversion costs. The hypotheses are as follows:

1. An increase in population will necessitate an increase in urban spatial sizes because more people have to be housed.
2. An increase in income will result in an increase in spatial sizes of cities, given the assumption that housing is a normal good.
3. Expenditures on items other than housing are considered consumption substitutes to housing. An increase in these expenditures will result in the decrease in the demand for housing and therefore a decrease in built-up area.
4. An increase in transportation costs decreases the incentives to live farther away from the Central Business District. Increased transportation costs will therefore result in a decrease in built-up area.
5. Agricultural land rent represents the opportunity cost of urban area. The higher the rent from agricultural land, the greater the incentive to retain the land in agricultural use.
6. Increased costs of converting land from rural to urban land-use discourage expansion of urban area.

Changes in these determinants of urban area will lead to land conversion. This is illustrated in Figure 2.

Figure 2
Dynamics of Land Conversion



Increased population and income and decreased transportation costs, expenditures on items other than housing, agricultural land rent and conversion costs all lead to increased spatial sizes of cities. Increased spatial sizes of cities in turn lead to land conversion.

Lot sizes are assumed to be inversely proportional to built-up area. Cities with larger built-up area tend to have smaller lot sizes while cities with smaller built-up area tend to have larger lot sizes. It is assumed that since land prices are more expensive in highly urbanized places, lot sizes in these places would tend to be smaller.

EMPIRICAL FRAMEWORK

This study will use the following model to estimate the determinants of built-up area:

$$Area_{built\text{-}up} = \alpha + \beta_1 Y + \beta_2 L + \beta_3 A + \beta_4 N + \beta_5 C + \varepsilon \qquad \text{(eq. 3.1)}$$

where

$Area_{built\text{-}up}$ Built-up area, in hectares

Y	Average household income
L	Average residential lot size, in square meters
A	Agricultural rent, measured by agricultural income, in thousand pesos
N	Number of households, in thousand households
C	Cost of conversion, measured by value of residential construction, in thousand pesos

Given the alignment of the data sources for the dependent and independent variables, the sample for this study is drawn from Regions I through X and the Cordillera Autonomous Region. This is a sample of 63 out of 72 provinces. The National Capital Region was excluded because the entire region is considered built-up. Inclusion of the National Capital Region would have skewed the data. All data were drawn from the year 1991.

Data on the number of square meters of built-up area per province were secured from the Bureau of Soils and Water Management (BSWM) of the Department of Agriculture. Built-up areas are defined by the BSWM as those areas utilized as human settlement (residential), commercial and industrial estates and other areas such as playground, golf course, and airfield.

Agricultural income data from the 1991 Family Income and Expenditure Survey (FIES) were used as a measure of agricultural rent. The FIES Income tables divide income sources into wages, entrepreneurial activities and other sources of income. It is possible to consider the sum of agricultural wages, entrepreneurial income from agriculture, and net share of crops, fruits, livestock, poultry from other households as agricultural income.

The National Statistics Office provides tables showing the number of families as well as family receipts by source of receipt and province. These tables show the number of families earning from a particular income source and the total amount earned by families from that income source. The amount earned from agricultural sources as defined above is added for each province and divided by the number of families to derive the average agricultural income per household.

This measure is used on the assumption that household earnings accurately reflect the rent from agriculture of a particular province. Earnings from non-family entities would not be reflected here. Neither would earnings from agriculture that were transferred to another locality.

Provincial level data on average household income, and number of households were derived from the 1991 FIES. Data on the number of households for each province can be easily obtained from the FIES. Several tables, including one on "Total Number of Families" and on "Average Income and Expenditures," provide this information. Average income from agriculture per household (as defined above) was subtracted from average household income. It is this figure that is used in the analysis.

Data on housing value and average lot size are derived from the National Statistics Office quarterly tables on the number, floor area and value of private building construction for residential buildings by province from the first quarter of 1991 to the last quarter of the same year.

The data have some limitations. First, average lot size was computed based on floor area of construction and not on lot area. Second, the value of the units included in the NSO statistics reflects the value of the house and not the house and lot. Third, it was assumed that the value of the units included in the NSO statistics reflects the average housing value for the province, inclusive of houses built prior to 1991. Fourth, the NSO statistics are based on approved building permits prior to the start of construction. Thus, the data do not necessarily reflect the final value of construction. The data also do not reflect the floor area and value of residences built without building permits.

The study likewise assumes that the value of private building construction for residential buildings by province is a variable that adequately reflects the costs of conversion from rural to urban

land-use. Other factors that may add to the cost of conversion are disregarded, including the cost of capital and additional taxes incurred as a result of the conversion.

Some computations had to be made to make the raw data useful to the study. Average floor area was computed by adding the total floor area per quarter for each province and dividing this sum by the total number of residential constructions for that year. Average housing value was computed by adding the value of residential constructions for each quarter and dividing the sum by the total number of residential constructions for that year.

RESULTS

The following results were obtained:

Table 1
Repression Results of Empirical Model

	Unstandardized Coefficients			
	B	Standard Error	t-statistic	Significance
Constant	-8963.655	4929.040	-1.435	.157
Population	43.068	8.038	5.358	.000
Income	103.012	49.256	2.047	.045
Average Housing Floor Area	4.565	31.583	.128	.889
Average Housing Value	1023.064	1283.533	.825	.413
Average Agricultural Income	97.969	141.316	1.435	.157

Dependent Variable is built-up area
Number of Observations: 63
R^2 = .465:Adjusted R^2 = .418
F-statistic: 9.919
Level of Significance of the F-statistic: .000

Only the variables population (p = .000) and income (p = .045) are statistically significant. Multicollinearity diagnostics suggest that the model has an acceptable level of correlation between the variables; therefore, the coefficients of the independent variables lend themselves to interpretation. The White Heteroscedasticity test shows that the errors are homoscedastic and independent. The model as a whole also passes the White test of heteroscedasticity.

ANALYSIS

The hypothesis that population and income are positively related to built-up area is confirmed by the results. Built-up area is seen to increase with an increase in population by a factor of 43.068. This means that an increase of 1,000 households will increase built-up area by 43 hectares. Not only is the relationship between the two variables positive, it is also statistically significant (p = .000).

Built-up area is also seen to increase with an increase in income by a factor of 100.515. This means that a P1,000 increase in average household income will result in an increase of 100 hectares of built-up area. Not only is the relationship between the two variables positive, it is also statistically significant (p = .045).

These results confirm the findings of other studies which show that income and population tend to be positively correlated with built-up area. Population was shown to be significantly related to

urban area by Alig and Healy (1987), del Castillo (n.d.), Hardie, et al. (forthcoming), Verburg, et al. (2000), Kline and Alig (1999) and Brueckner and Fansler (1982). Income was shown to be significantly related to urban area by Hardie, et al. (forthcoming), Brueckner and Fansler (1982), and Alig and Healy (1987).

It is important to note, however, some differences in the manner of specification of some of the variables in the cited studies. All of these studies use built-up area as the dependent variable. Alig and Healy (1987) make a distinction, however, between built-up area as defined by the Census and that defined by the Natural Resource Inventory. The Census confines built-up areas to urban areas (central cities and urban areas outside central cities). In turn, built-up areas in predominantly rural areas are still considered rural. The National Resource Inventory Survey has a broader definition of built-up areas, which includes built-up areas in predominantly rural areas. The Census also considers small patches of forests and farmland within urban areas as urban areas while the National Resource Survey Institute would consider these as forests or farmland. The studies of Hardie, et al. (forthcoming), Brueckner and Fansler (1982) and the present study follow the definition of the US Census.

Alig and Healy (1987) estimate different equations for built-up area in central cities and built-up area in areas outside central cities. This study makes no such distinction. Where the data separate the built-up area for the central city and the province, this study incorporates the figures for the central city into the provincial data. The data for Cebu City, for example, are added to the data for Cebu province. This is because not all data on built-up areas for central cities are available.

Alig and Healy (1987) use per capita income as an independent variable. Given the framework of Hardie, et al. (forthcoming), the empirical test of Hardie, et al., and this study use mean household income per capita. Brueckner and Fansler (1982) also use household income per capita.

Hardie, et al. (forthcoming) use county population density. Brueckner and Fansler (1982) use population data. This study uses number of households per province. This is because the variable included in the framework is the number of households. Alig and Healy (1987) use population in urbanized areas as an independent variable, with a squared population term to represent the nonlinear expansion of an urbanized area as population expands. Since most of the data available for this study are provincial-level data, the number of households per province was used instead of the number of households for urbanized areas in the province.

The other variables did not turn out as expected. This may be because of the limitations of the proxy variables.

The theoretical framework led to the hypothesis that floor area is negatively related to built-up area. It is assumed that since land prices are more expensive in highly urbanized places, lot sizes in these places would tend to be smaller. This relationship is not seen in the results.

This may be because of the limitations of the proxy variable. First, not all the residential construction projects in the province may be accounted for by the average lot area of proposed residential construction since this includes only those projects with building permits. Thus, the statistic may reflect high-end construction that would tend to be associated with bigger lot size. Second, the statistic takes into account floor area and not lot area. It is possible that while floor area may be larger in more progressive cities, lot area owned by a household may be larger in the rural areas.

The theoretical framework led to the hypothesis that housing value, which is the proxy variable for costs of conversion, is negatively related to built-up area. It is assumed that if the costs of housing are greater, this will present a disincentive to build houses and will translate into a relatively smaller urban area. The paper of Hardie et al. (forthcoming) shows that house value is positively correlated to urban area.This relationship does not appear in the study results.

This may again arise because of the limitations of the proxy variable. The statistic used in this study was average housing value of proposed residential construction. First, not all the residential construction projects in the province may be accounted for by the statistic since it includes only those projects with building permits. Thus, the statistic may reflect high-end construction that would tend

to be associated with higher housing value. Second, the statistic may reflect the higher costs of construction in more progressive cities.

Hardie, et al. (forthcoming) and this study use house value as a proxy for costs of conversion. This study, however, uses mean house value while Hardie et al, applies median house value.

This study's theoretical framework hypothesizes that average agricultural income, which is the proxy variable for agricultural rent, is negatively related to built-up area. It is assumed that if agricultural rent is greater, the costs of conversion (in this case represented by the opportunity cost of converting agricultural land) will increase. Thus it is expected that higher agricultural rent should result in smaller built-up area. The papers of Hardie et al. (forthcoming) and Alig and Healy (1987) show a negative correlation between agricultural rent and built-up area. This relationship does not appear in the study's results.

This may again be because of the limitations of the proxy variable. The statistic used was household income from agricultural activities. First, the use of this statistic assumes that household earnings accurately reflect the rent from agriculture of a particular province. Earnings from non-family entities would not be reflected here. The statistic also does not include earnings from agriculture that were transferred to another locality. The income from agriculture could have been reflected in the income of that other locality. Second, higher agricultural income may be associated with provinces with more built-up area because of higher access to markets and also higher prices that can be charged for agricultural produce. Finally, the statistic reflects gross and not net income. While average agricultural income may be associated with provinces with greater urbanization, agricultural costs may also be higher in these provinces.

Hardie, et al. (forthcoming) and Alig and Healy (1987) use farmland value as a proxy for agricultural rent. This study uses agricultural income because of the lack of data on farmland value. Agricultural income is assumed to represent the opportunity costs of conversion of agricultural land to urban uses.

One final note can be made regarding the results. The constant in a linear regression model reflects the value of the dependent variable when the values of the independent variables are 0. The constant has a value of –8963.655 and is not statistically different from 0 ($p = .073$).

IMPLICATIONS OF THE RESULTS

The results validate the hypotheses that built-up area is positively correlated with population and income. But the results do not prove that built-up area is correlated (much less negatively correlated) with lot size, housing value and agricultural rent. This may be because of the limitations of the proxy variables.

The results show that built-up area expansion will result from an increase in population and income. Even if there is an increase in agricultural rent or cost of residential construction, it does not necessarily deter expansion of built-up area. If this is true, policies that would increase agricultural rent or increase the cost of residential construction would not deter expansion of built-up area as long as income and population are increasing.

It is recommended that studies be made to test alternative specifications of the three insignificant variables. Instead of using number of households per province, for example, future studies could follow the example of Hardie, et al. (forthcoming) and use population density. Future studies could also use average housing value and lot size based on value of sale and not construction costs. Average housing value based on sales rather than construction costs might reflect market value more accurately. Another measure could be urban land market value. Alternative measures of agricultural rent could also be used. These include agricultural income and expenditure data from the Farm Household Income Survey, statistics on gross crop income and returns provided by the Bureau of Soils and Water Management, data on revenues and costs from the Annual Survey of Establishments, value of agricultural production computed using data from the Bureau of Agricultural Statistics, and data on the assessed value of agricultural land.

A great opportunity to do land-use studies will be possible next year when the Bureau of Soils and Water Management compiles the recent submission of current land-use statistics of all provinces

for the Strategic Forestry Agricultural Development Zones (SFADZ). The last time these statistics were generated was in 1991. The new submission is more comprehensive because all provinces are required by law to submit data and are even required to provide statistics for the city and municipal levels.

The data could be used to verify the results of this study using the same empirical method. The Year 2000 is also a year when the Family Income and Expenditures Survey is conducted so there will be alignment of the necessary data.

Municipal level tests of determinants could also be conducted. The problem would not be land-use data but the data for the independent variables since most data are available only on the provincial level. Alternative specifications could be used for certain variables. For example, market value of agricultural land is available with the local government units. Empirical tests separating land-use determinants between urban areas and areas outside the urban area could be conducted. This would replicate statistical tests conducted by Alig and Healy (1987).

Empirical tests with change in built-up area as the dependent variable could also be made. In this case, the change in built-up area would be equal to the built-up area in the Year 2000 minus the built-up area in the Year 1991.

This study would be possible because all the data would be available for the two years. It would also be good to conduct this study because it can be safely assumed that built-up area only increases and does not tend to decrease. It would be a more direct test of land conversion.

It would also be worthwhile to replicate the study of Kline and Alig (1999) where plot level data were gathered. This kind of study would involve an empirical test with panel data where the status of a plot over two time periods is compared and a probit model is specified where the research problem is to find out the determinants of the probability that land that was previously farm or forest was converted to built-up uses.

Finally, it would be worthwhile to study the effectiveness of land-use planning and land taxes in influencing land conversion.

CONCLUSION

This study made the assumption that an expansion of built-up area will be at the expense of other landuses. Thus, an expansion of built-up area will result in a decrease in other land-uses, and this translates into the phenomenon of land conversion. This study, therefore, postulates that an increase in built-up area will result in an increase in land conversion.

Given that built-up area has been shown to expand with population and income, we can conclude from the results that land conversion will be more likely to occur in provinces with higher levels of population and income. The results of the study seem to show that land conversion is not related to the hypothesized deterrents of land conversion, namely: higher housing value and higher agricultural rent. This conclusion must be tested using alternative specifications of these individual variables.

Much can still be done to study the determinants of land conversion and spatial sizes of cities. These kinds of studies are necessary for several reasons. First, they will help in the preservation of land for agriculture and forest cover. Second, they can be used to contain urban sprawl. Third, they can test the effectiveness of policies such as land taxes and land-use zoning in influencing land-use conversion. Studies on the determinants of land conversion might also defuse this emotionally charged issue, showing that the tendency to convert land from agricultural uses is expected behavior on the part of economically rational actors.

NOTE

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