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Estimation of external effects from the quarrying sector using the hedonic pricing method

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ABSTRACT

The quarrying sector is characterized by external effects, which are not commonly reflected in mineral prices. The aim of this study is to estimate the external effects from aggregate quarries which are in close proximity to population centers, by using the hedonic pricing method. The study was conducted on three quarries adjacent to population centers, with different characteristics in terms of quarrying, topography and type of population. By applying an econometric estimation of the shadow price on properties adjacent to the quarries, the results indicate that proximity to quarries lead to a negative impact on property values. According to the study's results, increasing the distance from the quarry by 10%, correlates with an increase of about 1% in the property's value. Despite substantial differences between the various quarries, the resulting effect is nearly identical, suggesting that the perceived damage is similar among the different populations. The external effects from the quarries cause a decrease of roughly 8.6% in property prices. These findings have several evidence based policy implications regarding the allocation of quarry franchises and on setting a levy on the activity of quarries in close proximity to population centers.

1. Introduction

The mining and quarrying sector in Israel constitutes an essential and strategic sector in the domestic economy, as their activities assure continued supply of raw materials for construction. A large part of the quarries is located in close proximity to population centers, in order to lower the cost of transporting the raw materials. However, the presence of mines and quarries in the vicinity of populations is usually accompanied by external effects (externalities) (Muller et al., 2011; Trigg and Dubourg, 1993), which are not usually reflected in the mineral prices. The main externalities attributed to the quarrying sector are damage to the landscape, air pollution, noise, dust and vibrations (Kontogianni et al., 2012; Willis and Garrod, 1999). Additional external effects caused by quarrying activities, but not estimated in this study, are damage to the ecological diversity and resource depletion.

It is quite difficult to measure and isolate the negative externalities caused as a result of proximity of an environmental hazard (Damigos, 2006). A common method for estimating such externalities is the Hedonic Pricing Method (HPM) (Damigos and Kaliampakos, 2006).

The Hedonic Pricing Method (HPM) attempts to estimate the effect of the environmental factors (e.g., noise, air quality, proximity to a park, pollution, *etc.*) on prices of tradable goods (e.g., house prices), by comparing identical products that are not affected by the environmental factors. The HPM theory refers to a product as a "bundle of characteristics" in which the price of the product embodies the sum of its characteristic values (*i.e.*, the value of the total benefits and costs involved in the use of the product). Using econometric assessment methods, the weight attributed by the individual to the environmental component (noise, air quality, landscape, *etc.*) can be isolated from the total value of the product. The method uses market prices so that the environmental component receives the relative share of the price of the product (e.g., house price) in the model. The common use of the method is to estimate the effect of environmental factors on real estate prices that are close to the factor (park, waste site, *etc.*). The basis of this method is that the apartment price is a combination of the characteristics of the apartment – size, number of rooms, floor level, area and environmental characteristics, such as landscape, noise, air quality, *etc.* The advantage of the HPM is that it uses available market data and not subjective opinions.

The HPM begins with the perception that some goods may be distinguished by their various characteristics (Rosen, 1974). According to this theory, consumers value various goods, such as property, based on

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both intrinsic and external characteristics. These characteristics may include structural attributes, neighborhood attributes and environmental attributes, such as proximity to contaminated sites (USEPA, 2009). This estimation is carried out by using an econometric model that isolates consumers' preferences with respect to the various components of a property and their impact on price.

There is extensive literature on the impact of various environmental hazards, such as heavy industries, landfills and quarries on nearby real estate prices. These studies surveyed a wide range of damage caused by environmental hazards, which are reflected in the prices of nearby residential properties. Farber (1998) found that individuals are willing to pay more for properties that are located farther from an environmental nuisance, due to health risk concerns. Farber (1998) concludes that environmental hazards have adverse effects on property prices and that these effects diminish with distance from the hazard. Brasington and Hite (2005) estimated the relationship between property prices and proximity to different environmental hazards in six major metropolitan areas in Ohio, USA. The researchers found that a change rate of 10% of the environmental hazard is correlated with a change of 0.63% in the property prices. Pope (2008) examined the external effects arising from the proximity to an airport, particularly from exposure to noise, and found a decrease of 10.7% in property prices. Hite (2009) examined the impact of a landfill on rents within a radius of 3 miles, and found that a change of 10% in the distance from the landfill is correlated with a change of 1.07% in property prices. De Vor and De Groot (2011) examined the environmental impacts resulting from the activity of two heavy industrial zones in the Netherlands, and found that a change of 10% in the distance of an apartment from the hazard, is correlated with an average rate of change of 0.9% in the apartment price.

A number of studies have also examined the environmental impacts caused by mining and quarrying activities. Trigg and Dubourg (1993) examined the environmental effects arising from a coal mine in England, and found a decrease of 10%–40% in house prices, depending on the distance from the mine. Hite (2006) examined the environmental effects arising from a gravel pit in Ohio, USA, and found that a change of 10% in the distance of an apartment from the quarry is correlated with an average change of 1.3% in the apartment price. Neelawala et al. (2013) examined the environmental effects arising from mining and smelting of copper and lead in Australia, and found that a change of 10% in the distance of an apartment from the mine is correlated with a change of 0.7% in the apartment price.

A number of studies on this subject have been conducted in Israel, estimating the external effects of various environmental hazards. Becker and Lavee (2003) estimated the external costs of noise from roads using the HPM for real estate transactions in various cities in Israel, and found a negative correlation between noise from roads and real estate prices. Shelem et al. (2011) estimated a decline of 14% in housing prices as a result of an increase in the awareness to pollution emitted from a nearby factory. Lavee (2012) carried out a feasibility analysis for moving a polluting factory, in order to reduce its externalities on the nearby population. However, to date, no study has been carried out for estimating the external effects arising from the mining and quarrying sector in Israel.

As can be seen from the presented studies, many researchers have used the HPM to estimate the impact of various environmental hazards on property prices in their vicinity, in order to assess the external costs resulting from the activity of the hazard. The aim of this study is to examine and compare the external effects caused by several major quarries in Israel, which are located nearby population centers. In order to estimate the external effects arising from the quarrying sector activities, an analysis will be carried out by using the HPM and examining the price elasticity in relation to the distance from the quarry. This study, unlike previous studies, examines a number of different quarries with different quarrying volumes and different terrains in various residential areas, and compares between them. We compare between the local impact and the regional impact (on the neighboring towns). In addition, we compare between quarries in different regions and during different periods of activity. Finally, we compare our research results to the results of studies in other countries, to observe whether there are differences in the sensitivity of Israel's population compared with other populations. This comparison will allow us, inter alia, to determine whether it is appropriate to draw the same conclusions to all quarries in Israel and suggest policy decisions (such as a quarrying levy) accordingly.

2. The econometric model

In the model, we estimate the variations in property prices as a function of distance from the quarry. To isolate the impact of the quarry on the property prices, we add control variables to the regression – these variables are all the observable characteristics affecting the housing prices. The estimation is carried out by a multivariate regression using the ordinary least squares (OLS) method. According to Rosen (1974), the hedonic price function can be described formally as follows:

$$p_i = f(s_1, \ldots, s_k; n_1, \ldots, n_m; d) \quad (1)$$

where p_i is the transaction price of an apartment *i*, *f* is the function that links between the apartment price and the characteristics of the apartment structure (*s*), the characteristics of the apartment's neighborhood (*n*), and the distance of the apartment from the hazard. The model's assumption is that the housing market is in equilibrium, *i.e.*, all the individuals maximize their benefit, given the prices of the alternative apartments. The benefit of an individual *j*, who lives in apartment *i*, is given in the following equation:

$$u_j = u(x; s_1, \ldots, s_k; n_1, \ldots, n_m; d) \quad (2)$$

The individual's utility function is concaved when the variable *x* is all the remaining products that the individual consumes. The price of *x* is normalized to 1 and the income of individual *j* is given in terms of *x*. That is, the individual's budget constraint is given by the following equation:

$$y_j = p_i(s_1, \ldots, s_k; n_1, \ldots, n_m; d) + x \quad (3)$$

Maximizing the individual's benefits under his budget constraint requires selecting *x* and $(s_1, \ldots, s_k; n_1, \ldots, n_m; d)$ who meet the budget constraints and first order conditions. Thus, the partial derivative of the cost with respect to one of the characteristics would yield the marginal effect of the same variable on the apartment's price. For instance, the marginal effect of one of the characteristics of the apartment's structure, s_4, on the apartment's price is:

$$\partial p_i / \partial s_4$$

2.1. The model equation

The model equation determines the definition and meaning of the hedonic price. There are three common different types of equations: a linear equation, a semi-logarithmic equation and a double log equation, when the preferred function is determined depending on the subject of research (Sayag, 2010). In this study, we chose to use the double log function (Log–Log) which estimates a property's price elasticity with respect to changes in its characteristics. This was chosen for the following reasons:

2.2. The shadow price is determined as a percentage of the property's value

Since the sample includes a range of various properties in different areas, the flexibility of the logarithmic estimation allows us to estimate the damage to the various properties, without creating a bias in the estimate. For example, a new apartment in a prestigious neighborhood, or an old apartment in a less prestigious neighborhood. If the variable was linear, the shadow price would have been fixed for both