

values, according to whether the exogenous shocks have unfavorable or favorable effects on cost. The *non-negative* error component, u_{ft} , on the other hand, indicates the amount by which the logarithm of cost of the f^{th} firm at the t^{th} observation exceeds the logarithm of stochastic frontier, $\ln VC(\cdot) + v_{ft}$, due to x-inefficiency. When $u_{ft} = 0$ for a particular firm, f , at observation t , it attains the cost frontier.

3.1. Specification of the stochastic frontier cost function

To analyze the productive structure of the Italian LPT industry we chose a variable operating cost model. The fixed assets investments in this sector are strictly related to government financing programs, so it is not proper to suppose that companies exhibit a cost-minimizing behavior with respect to capital too. Therefore, as Windle (1988), Levaggi (1994) and Fabbri (1998) suggest, the rolling stock should be considered as a fixed factor in the short-run. The model includes: a scalar output (Y); the prices of three variable factors, i.e. labor (L), fuel (F), materials and services (MS); a quasi-fixed input (K); a network characteristics (SP), i.e. the average commercial speed; a time trend variable (τ).

We use a composite measure of the output to reflect the global productive structure of firms. It is well-known in transportation literature that the output definition is a much debated question, since it can lead to different results, for example in terms of scale economies. The output indicator is computed by multiplying the transit firm's fleet size, measured in terms of total places offered¹⁰, and the total traveled kilometers. We want to point out some remarks about this kind of output. If we consider the operative context of the LPT industry, a firm must supply the service on a certain number of lines, offering a certain number of places and trips on this network. Our definition of output allows us to take into account the length of the network, the frequency of the service and the size of the fleet. Furthermore, this measure is particularly suitable to our specific firm sample, which includes both urban and extra-urban services. As it was not possible to separate the urban activity from the extra-urban one, we defined an aggregate output and aimed to weight their specific characteristics¹¹.

¹⁰ The total places offered were calculated by multiplying the number of vehicles owned by each unit and their average load capacity.

¹¹ Generally speaking, the extra-urban firms can perform a higher number of kilometers than the urban units, covering a larger network, but the operative context is very different (a lower number of passengers, longer trips, different traffic conditions). On the other hand, a urban company reasonably offers a higher number of places (buses are larger and also their number is higher, because there is a more intensive demand to satisfy).