production function, in which the non-negative technical inefficiency effects were a linear function of variables involving firm characteristics, together with their interactions with the input variables of the frontier function[21]. Battese and Coelli (1993, 1995) extended these approaches model to accommodate panel data, which permits to include both firm-specific and time effects in the model adopted to explain inefficiencies.

Coelli (1996) wrote a computer program, FRONTIER Version 4.1, that automates the ML method for estimation of the parameters of Battese and Coelli (1995) model and also allows to specify the stochastic frontier in terms of a dual cost relationship instead of a production function. The availability of such a program, which permits to easily estimate a stochastic cost frontier and analyze the sources of x-inefficiency, further allowing unbalanced panel data (as the sample we have at hand), induced us to apply the Battese and Coelli (1995) model for studying the effects of regulatory constraints on the cost efficiency of public transit systems in Italy[22]. The objective, in particular, is to investigate whether the predictions from the theory of incentives in regulation (Laffont and Tirole, 1993) help explain differences in productive efficiency, i.e. *do high powered incentive regulatory schemes increase efficiency as compared to low powered schemes?* To do this, we start from issues of a stochastic cost frontier model recently developed by Gagnepain and Ivaldi (1998)[23].

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[21] This makes their model a non-neutral shift of the traditional average response function, in that the marginal products of inputs and marginal rates of technical substitution (MRTS) depend on the firm-specific variables in the inefficiency model.

[22] A ML systems estimator, involving the cost frontier and the factor-share equations, would provide more efficient estimators of the parameters of a cost function than the single-equation estimator automated in FRONTIER. This system approach also has the advantage of explicitly accounting for allocative inefficiency (reflected in the error terms of the factor-share equations), that represent violations of the first-order conditions for cost minimization. However, a frontier systems estimator suffers from some problems. First, it is not as yet automated in any computer package, hence one would need to write code for it in some way (using SAS, GAUSS or TSP) that is often very time-consuming. Second, once one specifies flexible functional forms, such as the translog form, where the implied production function cannot be derived, the decomposition of the overall cost efficiency into technical and allocative components (what has come to be known as “the Greene problem”) requires some restrictive assumptions, and none of the existing approaches (e.g., Ferrier and Lovell, 1990; Kumbhakar, 1991; Mensah, 1994; Kumbhakar, 1997) is exempt from criticism from some quarter. Further, estimation problems often arise when one tries to numerically solve the rather complicated likelihood functions that are involved.

[23] These authors directly incorporate into the cost minimization problem the distortions on productive activity due to regulatory constraints and the presence of informational asymmetries in the regulator-firm interaction. In this way, the error component the literature generally attributes to cost inefficiency, u_{ft}, is already built-in and the econometric frontier model exactly coincides with the theoretical cost model, without the necessity of adding other more than a random disturbance term to account for exogenous shocks and potential measurement faults. In this work we do not utilize the economic-theory-based methodology employed by Gagnepain and Ivaldi (1998). However, the present study constitutes a useful exploratory analysis that could provide insights about the impact on cost efficiency of the investigated variables. Thus, it represents the starting base for future more elaborated works.