ian hospital industry experienced a wide restructuring process. However, downsizing has been limited mostly to bed, while workforce reduction has been tackled only blocking turnover, causing a large increase in medical staff per bed. Besides uncovering potential inefficiencies which can limit the impact of hospital restructuring on health expenditure, the estimation of input elasticities of substitution is important *per se*, since very few studies have addressed this issue in the economic literature, and none of these has tested different functional forms for the hospital cost function.

The remainder of the paper is structured as follows: Section 2 surveys economic literature on input substitutability in the production of hospital services. Our empirical exercise is in Section 3, where we describe our sample, the functional forms and the estimation procedures, and the results. Section 4 concludes.

1. INPUT SUBSTITUTABILITY IN THE PRODUCTION OF HOSPITAL SERVICES

While estimation of production and cost functions and efficiency analysis have received considerable attention in the literature on the hospital industry, economic studies working out also input substitutability in the production of hospital services are quite rare. A pioneering study is that by Bothwell and Cooley (1982), focusing on Health Maintenance Organizations in the U.S.. They distinguish four inputs (administrative services, hospital services, medical professional staff services, and capital expenses for maintaining a health centre), and find that administrative services are complements to all the other inputs, but that there is substitution between all other input pairs. In particular, Allen elasticity of substitution between medical staff and capital expenses (the input pair we are most interested in, to understand the observed change in input-mix), is estimated to be 0.638, which suggest small substitution possibilities. Jensen and Morrisey (1986), studying the U.S. short-term general acute care hospitals, confirm this result, estimating that elasticity of substitution of medical staff with beds ranges between 0.247 (for non-teaching hospitals) to 0.303 (for teaching ones), and elasticity of substitution between nurses and beds ranges between 0.189 and 0.305 (respectively for the same type of hospitals). These estimates are even lower adjusting output for case-mix. The same difficulties in substituting between inputs is found also for medical staff and nurses, with estimated elasticities close to 0.35 for both types of hospitals. This last result is in contrast with Cowing and Holtmann (1983). Considering New York State hospitals and computing Allen elasticities, they find substantial substitutability be-

tween nurses and other types of workers in the short-run, but no estimates are provided for substitution between labour and capital.

More recent studies include e.g. Bilodeau *et al.* (2002) and Okunade (2003). Considering hospitals in Québec, the former study estimates an hospital cost function with five inputs (labour, drugs, food, supplies, and energy). While not reporting punctual estimates of Allen elasticities, the authors interpret substitutability of supplies and energy with labour as the hospitals' general ability to substitute capital for labour. A more complete analysis of input substitutability – considering Allen, Morishima, and shadow measures of elasticities - is provided by Okunade (2003) for Health Maintenance Organizations in the U.S. The general conclusion – based on the preferred Morishima conceptual measure – is that HMOs production technology is characterised by significant but limited factor substitutions. More specifically, estimated Morishima elasticity of substitution between capital and medical staff given a change in the price of capital is 0.5124, while given a change in the wages of professional inputs is 0.667. These estimates imply that: a 10% increase in the price of capital, will cause the ratio of medical staff to capital to raise to about 5.12%; a 10% increase in the wages of medical staff, will lift the capital/professional inputs by about 6.7%.

Taken together, available evidence on factor substitutability in the production of hospital services seem to suggest that substitution is possible between capital and medical staff (both physicians and nurses), but is rather limited. In the next sections, we provide additional evidence on this point, by considering different functional forms and different concepts of elasticity of substitution.

2. EMPIRICAL ANALYSIS

2.1. The sample

As discussed in the previous sections, the aim of the paper is the study of the technological characteristics of hospital services supply, and the exploration of substitution possibilities among the different inputs involved in the productive process, especially between the number of beds and medical staff (both physicians and nurses). The data used in the econometric analysis have been obtained by the Piedmont Region (a highly industrialised area in the North-Western part of Italy), and are relative to the productive activity and the cost structure of all the hospitals operating in one of the 27 Local Health Units (LHU) active during the period 2000-2004. LHU are vertically integrated organisations funded by the Region, and responsible of a whole array of hospital and community services (e.g. France and