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Capital–skill complementarity and inequality: A sensitivity analysis

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Abstract

Krusell et al. in [Krusell, P., Ohanian, L., Ríos-Rull, J.V., Violante, G.L., 2000. Capital–skill complementarity and inequality: A macroeconomic analysis. Econometrica 68 (5), 1029–1053] analyzed the capital–skill complementarity hypothesis as an explanation for the behavior of the US skill premium. We refit Krusell et al.'s [Krusell, P., Ohanian, L., Ríos-Rull, J.V., Violante, G.L., 2000. Capital–skill complementarity and inequality: A macroeconomic analysis. Econometrica 68 (5), 1029–1053] model with two alternative capital equipment price series: One proposed by Greenwood et al. [Greenwood, J., Hercowitz, Z., Krusell, P., 1997. Long-run implications of investment-specific technological change. Amer. Econ. Rev. 87 (3), 342–362] and the official, revised National Income and Product Accounts (NIPA) data. We find that capital–skill complementarity is preserved, but other results were sensitive to the data used. Specifically, the fit of the model was similar to Krusell et al.'s [Krusell, P., Ohanian, L., Ríos-Rull, J.V., Violante, G.L., 2000. Capital–skill complementarity and inequality: A macroeconomic analysis. Econometrica 68 (5), 1029–1053] using the NIPA data, but not the Greenwood et al. [Greenwood, J., Hercowitz, Z., Krusell, P., 1997. Long-run implications of investment-specific technological change. Amer. Econ. Rev. 87 (3), 342–362] data. Also, both series produce estimates of the elasticity of substitution between unskilled labor and equipment that are substantially larger than Krusell et al.'s [Krusell, P., Ohanian, L., Ríos-Rull, J.V., Violante, G.L., 2000. Capital–skill complementarity and inequality: A macroeconomic analysis. Econometrica 68 (5), 1029–1053] estimates.

JEL classification: C11; C82; E24; J31

Keywords: Capital–skill complementarity; Technological change; Equipment prices

1. Introduction

Over the past thirty years, wages paid to college-educated workers have increased despite an increase in the supply of such workers. Explanations of this phenomenon increasingly focus on capital–skill complementarity (unskilled labor is more substitutable for equipment than skilled labor) and are supported by the estimates obtained in by Krusell et al. (2000). The underlying contribution of Krusell et al. (2000) was to provide an empirical foundation for the theoretical notion of capital–skill complementarity.

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Krusell et al. (2000) estimate the parameters of a constant-elasticity-of-substitution (CES) production function, using data on the prices and quantities of four factors: skilled labor, unskilled labor, structures and equipment. Their resulting production function is general enough to accommodate a broad pattern of substitutability and complementarity among the four factors. When Krusell et al. (2000) use this model to estimate the elasticities of substitution between skilled labor and equipment as well as that of unskilled labor and equipment, they find strong evidence of capital–skill complementarity. Furthermore, the model reproduces the major changes in the skill premium over time.

Krusell et al.'s (2000) paper has been widely cited, and the data and parameters estimated in this model have been used to calibrate other models. Examples include Blankenau and Ingram (2000), Crifo-Tillet and Lehman (2004), Hendricks (2002), Caselli and Coleman (2002), and Lindquist (2004).

However, Krusell et al.'s (2000) measurement of capital equipment prices is problematic: they use a deflator for nominal equipment stock that is an extension of Gordon's (1990) series that implies very rapid growth in capital, particularly after 1975. To assess the robustness of their results, we estimated their model using two additional series: the official, revised National Income and Product Account (NIPA) series for equipment investment and a price series suggested by Greenwood et al. (1997), which is an average of the NIPA series and the producer price index for capital equipment. The Bureau of Economic Analysis (BEA) has undergone a substantial effort to provide a quality-adjusted price index for the equipment series, making that series a better choice for deflating the capital stock than it was when Krusell et al.'s (2000) paper was written, almost a decade ago.

Using these two alternative data sets, we obtain several important results. First, capital–skill complementarity is extremely robust to any of the three price series used. Second, the fit of the skill premium is good for both the Gordon series used by Krusell et al. (2000) and the official NIPA series. The Greenwood et al. (1997) price series, on the other hand, is not consistent with the increase in the skill premium observed since 1980. In addition, we provide researchers with additional estimates of elasticities of substitution between equipment and skilled labor, and equipment with unskilled labor. This should serve macroeconomists in parameterizing their models and assessing the robustness of their results to changes in the values of those elasticities. Lastly, we provide an alternative methodology to that used by Krusell et al. (2000). This method is of interest in itself and can be applied to other non-linear state-space models.

2. Krusell et al.'s (2000) model

The theoretical model to be estimated is derived from a profit-maximizing firm's first-order conditions for choosing from among four factors of production: skilled labor (s_t), unskilled labor (u_t), structures (k_{st}) and equipment (k_{et}). The production-function form combines a CES aggregation of unskilled labor and an aggregation of equipment and skilled labor in a Cobb–Douglas function with structures:

$$G(k_{st}, k_{et}, u_t, s_t) = k_{st}^{\alpha}\big[\mu u_t^{\sigma} + (1-\mu)\big(\lambda k_{et}^{\rho} + (1-\lambda)s_t^{\rho}\big)^{\sigma/\rho}\big]^{(1-\alpha)/\sigma}, \tag{1}$$

where μ and λ are parameters that govern income shares, and σ and ρ are parameters that drive the elasticities of substitution between equipment and unskilled workers and equipment and skilled workers respectively.

Krusell et al. (2000) define the elasticity of substitution between equipment and unskilled labor and equipment and skilled labor to be $\frac{1}{1-\sigma}$ and $\frac{1}{1-\rho}$ respectively. However, this is only true if all other factors are held constant. When other factors change, the definition of the elasticity of substitution changes; as a result, depending on one's definition of the elasticity of substitution, $\sigma > \rho$ may not imply that unskilled labor is more substitutable with capital than skilled labor is.[2] Therefore, we compute, in addition to $\frac{1}{1-\sigma}$ and $\frac{1}{1-\rho}$, the Allen and Morishima elasticities of substitution, two frequently-used definitions of the elasticity of substitution within multi-input production functions.[3] In any case, we (and Krusell et al., 2000) define capital–skill complementarity as $\sigma > \rho$, which implies that a rise in the capital stock implies a rise in the skill premium. In addition, the skilled and unskilled labor inputs, s_t and u_t are functions of hours (h_s and h_u) and efficiency indices (ψ_s and ψ_u): $s_t = \psi_{st} h_{st}$ and $u_t = \psi_{ut} h_{ut}$.

To estimate the model, the first-order conditions are simplified into three equations. The first equation,

[2] We thank a referee for making us aware of this misconception.

[3] The interested reader is referred to Blackorby and Russell (1989) for a discussion of the different definitions of the elasticity of substitution.