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Unobservable skill dispersion and comparative advantage ☆

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ABSTRACT

This paper investigates a theoretical mechanism linking comparative advantage to the distribution of skills in the working population. We develop a tractable multi-country, multi-industry model of trade with unobservable skills in the labour market and show that comparative advantage derives from (i) cross-industry differences in the substitutability of workers' skills and (ii) cross-country differences in the dispersion of skills. We establish the conditions under which higher skill dispersion leads to specialization in industries characterized by higher skill substitutability across tasks. The main results are robust when the model is extended to allow for partial observability of skills. Finally, we use distributions of literacy scores from the International Adult Literacy Survey to approximate cross-country productivity differences due to skill dispersion and we carry out a quantitative assessment of the impact of skill dispersion on the pattern of trade.

1. Introduction

The theory of comparative advantage identifies factor endowments as a key determinant of the pattern of trade. In particular, the theoretical prediction that countries endowed with larger stocks of human capital export relatively more in skill-intensive industries has received support in the literature, see Romalis (2004). In previous work (Bombardini et al., 2012b, henceforth BGP) we build on this line of research and argue that the second moment of the distribution of skills also determines comparative advantage. In particular, we find that the degree of skill dispersion has a quantitative impact on trade flows similar to that of the aggregate endowment of human capital. This paper presents a multi-country multi-industry model that shows how skill dispersion generates comparative advantage and thus provides a theoretical underpinning to the empirical evidence in BGP.

Why would the skill distribution matter for specialization and trade? We argue that industries vary in the degree of substitutability of workers' skills in the production process. In particular, some industries, such as aerospace or engine manufacturing, require completing long sequences of tasks and poor performance at any single stage greatly reduces the value of output. These are industries with low skill substitutability, or O-ring as in Kremer (1993), where efficiency improves when workers of similar skills are employed in every stage of production. In other industries, such as paper manufacturing, teamwork is relatively less important, as skills are more easily substitutable and poor performance in some task can be mitigated by superior performance in others.

We investigate theoretically whether countries with greater skill dispersion specialize in industries characterized by higher substitutability of skills across tasks. We build a model with many countries and many industries. Countries only differ in the distribution of skills in the labour force, while industries only differ in the degree of skill substitutability in the production process. At the micro level, our framework features worker heterogeneity and non-linear returns to scale; however, at the industry level, it is isomorphic to a perfectly competitive model with CRS and technological differences across many countries and industries, as in Costinot et al. (2012).

We develop the central argument in a benchmark framework in which skills are not observable by firms, adapted from Akerlof (1970). Skill unobservability is not an unusual assumption in the literature,

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see for example Grossman and Maggi (2000), Grossman (2004) and Helpman et al. (2010).[1] This modelling choice is motivated by the facts, documented in BGP, that (i) observable characteristics of workers, including age and education, account for a minor share of total variation in work-related literacy scores within countries; and (ii) groups of observationally similar workers exhibit very different degrees of skill dispersion across countries.[2] One immediate advantage of this approach is tractability in a setting with many countries and many sectors. Essentially, under skill unobservability, every worker is indifferent between employment in any two firms because there is a single (type-independent) wage that clears the labour market. In equilibrium, workers are randomly matched to firms and thus the latter inherit the skill distribution prevailing in the economy — i.e. the distribution of workers' unobservable skills in every firm is identical to the distribution of unobservable skills in the country.

The results in the benchmark model carry over with minor qualifications when cross-country differences in observable skills are introduced in the analysis. When firms can observe some components of skills, the equilibrium features sorting on observable skills by industry. As in the benchmark model, however, we show that unobservable skill dispersion fully determines the pattern of trade in equilibria with wage equalization across-countries. In light of this result, the benchmark model is best interpreted as a mechanism illustrating how the dispersion of skills among workers with otherwise identical observable characteristics affects comparative advantage. In the rest of the paper, we thus sometimes refer to unobservable skills as 'residual' skills.

We show that the interaction of skill dispersion and skill substitutability generates differences in output per worker across industries and countries, driving the pattern of international trade. The central result of the paper establishes conditions under which countries with a high dispersion of skills in the labour force are relatively more productive, and thus export relatively more, in sectors where skills are more easily substitutable across tasks. Interestingly, we also show that the effects of skill dispersion on output and specialization are isomorphic to the effects of technological differences in Ricardian models, such as Costinot et al. (2012). In this sense, our work has implications for the quantitative assessment of Ricardian comparative advantage since cross-country differences in measured total factor productivity can arise as the by-product of differences in the distribution of factor endowments.[3]

The theoretical framework developed in this paper can also be used for quantitative analysis. Using distributions of literacy scores from the International Adult Literacy Survey (IALS), we construct productivity differences attributable to skill dispersion. Cross-country differences in trade costs are calibrated to match bilateral trade flows at the industry level. We use the numerical counterpart of the model to carry out a quantitative assessment of the impact of skill dispersion on trade patterns. In particular, we measure the general equilibrium responses in industry-level trade when cross-country differences in skill dispersion are eliminated. These experiments, which we run under a variety of technology parametrizations, suggest a significant role of skill dispersion on trade flows, with different effects on different countries.

This paper is related to recent theoretical research studying how skill distributions influence the pattern of trade. The hypothesis that skill dispersion may lead to specialization was first put forth by Grossman and Maggi (2000) in the context of a two-country, two-sector model, with competitive labour markets and constant returns to skills. They show that, when skills are fully observable, cross-country differences in skill dispersion do not generate comparative advantage when production technologies display convex isoquants in worker skills.[4] Gains from trade do not exist because, in equilibrium, workers of identical abilities are paired together, i.e. self-matching prevails in every industry, making skill dispersion irrelevant.[5] Grossman and Maggi (2000) also consider the case in which a portion of individual skills is unobservable. As in our paper, workers (with identical observable skills) are randomly matched to firms. Although they show that skill dispersion generates gains from trade when both industries have convex isoquants, they cannot determine the resulting *pattern* of trade across countries, which is the main focus of this paper.[6] In order to make progress, we propose a specification of production technologies that gives us sufficient tractability to handle a wide range of substitution elasticities, i.e. varying degrees of concavity or convexity of the isoquants, in a parametric way. In combination with random matching, this assumption allows us to characterize the variation in productivity differentials arising from skill dispersion, across multiple countries and industries, which is the crucial step in pinning down the pattern of trade.

Interest in the relevance of skill distributions for trade is relatively recent. Ohnsorge and Trefler (2007) propose a Roy-type model with two-dimensional worker heterogeneity to show that, when each worker represents a bundle of two skills, the correlation of the two in the population determines comparative advantage. Grossman (2004) starts from the premise that, in some sectors, incomplete contracts make it difficult to tie remuneration to an individual worker's output. In a country with high skill dispersion highly skilled individuals prefer to sort into sectors where individual performance is easier to measure, rather than working in an industry where the common wage is dragged down by workers with relatively low skills. This type of endogenous sorting results in comparative advantage. Finally, in Bougheas and Riezman (2007) comparative advantage emerges from differential returns to skills across sectors.

The next section describes consumer preferences, production technologies and the labour market. Section 3 discusses how unobservable skill dispersion generates productivity differences across countries and industries, driving comparative advantage. Section 4 studies the optimization problem of individual firms. Section 5 analyzes the implications of skill dispersion for the pattern of international trade. Section 6 introduces observable skills in the model. Section 7 presents the quantitative analysis and our counterfactual results. The paper ends with some concluding remarks.

2. Setup

2.1. Preferences

Countries are denoted by a subscript $c \in \{1,\ldots, C\}$, which is dropped when it creates no ambiguity. Each country c is populated by a measure L_c of individuals. Utility of the representative consumer depends on the

[1] In Grossman and Maggi (2000) and Helpman et al. (2010) firms can observe a component of individual skills before hiring workers. There remains, however, another component which firms never observe. We introduce a similar extension in Section 6. In Grossman (2004), as in this paper, individual skills are unobservable by firms and the production process features imperfect skill substitutability.

[2] Naturally, firms are likely to be able to observe the skills of their employees more accurately than econometricians. Therefore, these facts should be interpreted as playing a motivational role for our modelling approach, and not as precise descriptions of the degree of uncertainty that firms face regarding the skills of their employees.

[3] Costinot et al. (2012) argue that their exogenous productivity differences aim to capture factors such as climate, infrastructure, and institutions, which affect the productivity of all producers in a given country and industry. To the extent that the distribution of human capital endowments – above and beyond observable credentials – is the product of a country's social structure and norms, our explanation would pertain to the institutional view of comparative advantage.

[4] Supermodularity implies that the marginal product of any worker is increasing in the ability of the co-worker. Submodularity of the production function implies the opposite.

[5] In the case of observable skill dispersion, gains from trade are conditional on the existence of a supermodular sector, where self-matching prevails, and of a submodular sector, where the most skilled workers are paired with the least skilled co-workers, i.e. cross-matching prevails. In this case, the country with a more dispersed skill distribution specializes in the submodular sector.

[6] When one sector displays convex isoquants and the other displays concave isoquants, they show that unobservable skill dispersion reinforces the pattern of trade induced by observable skill dispersion.