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International Trade and Technological Diversification

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Abstract

Developing countries feature much higher fluctuations in the growth rate of per capita income than developed ones, partly due to specialization in volatile industries. This paper justifies this specialization pattern drawing on two observations: i) at the industry level, the standard deviation of industry-specific productivity shocks is negatively related to the number of intermediate inputs used in final production; ii) institutional quality represents a source of comparative advantage across industries with different number of inputs due to contractual frictions along the supply chain.

Keywords: Income volatility, technological diversification, institutional comparative advantages.
JEL *Classification:* F1, F4.

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1 Introduction

It is well known that the growth process of developing countries over the past four decades has been more volatile than the growth process of developed countries. Figure 1 plots the standard deviation of per capita income growth against average income per capita for a large sample of countries over the period 1960-2000 and shows that the two variables relate negatively. Identifying the sources of volatility differences across developed and developing countries represents a crucial task in the macroeconomic research agenda for several reasons: aggregate volatility, indeed, depresses growth (Ramey and Ramey (1995)), raises inequality (Laursen and Mahajan (2005)) and, in presence of financial market imperfections, causes substantial welfare costs.

There are two ways to interpret the negative relation between growth volatility and income levels. The first view focuses on country-specific shocks, arguing that poor countries are characterized by greater macroeconomic risk due to their lack of political stability and their strong reliance on commodity production. Yet, countries differences in aggregate volatility are only partially explained by differences in political and monetary stability and natural resources endowments (e.g. Kraay and Ventura (2007)). The second view focuses on sector-specific shocks and compositional effects, suggesting that high volatility in poor countries simply reflects specialization in sectors that are intrinsically more volatile. Empirically, both arguments find strong support suggesting that the two views are complementary. Indeed, Koren and Tenreyro (2007b) report that country-specific shocks explain half of the differences in volatility between developed and developing countries, while the remaining half is accounted for by differences in sectoral composition.

The aim of my paper is to analyze the sources of such compositional effects and to propose an explanation for why developing countries tend to specialize in more volatile sectors. The premise for the theory is twofold. On one side, this paper takes a technological view of volatility differences between sectors, which arguably depends on the diversification of input-output structures across many intermediate inputs. On the other side, given that more diversified sectors usually show greater contract intensities as producers need to deal with a wider range of suppliers, this paper recognizes that institutional quality can be a source of comparative advantages and specialization in production.

More specifically, my paper augments a North-South Ricardian model of international trade in two respects. First, I consider that the economy can produce a continuum of final goods and that final goods production requires a continuum of intermediate goods, which are subject to imperfectly correlated productivity shocks. Then, final output is less volatile in sectors where the production technology uses a relatively large number of intermediate goods. Second, I introduce contracting frictions using the incomplete contract framework, as in Williamson (1985) and Grossman and Hart (1986). In particular, I consider that final producers (upward firms) outsource intermediate goods to downward suppliers (downward firms) and that intermediate goods are relationship-specific. When parties cannot write ex-ante enforceable contracts, this situation leads to the well-known hold-up problem, where parties bargain over the division of revenues from production. Assuming that contract enforcement is weaker in South, in this region upward firms experience a cost disadvantage in sectors where the number of intermediate inputs, and therefore contract intensity, is greater. The model, then, proposes a view where legal institutions represent a source of comparative advantage across sectors with different output volatility.

The model then studies the consequences of an improvement in legal institutions in South and points out two opposing effects. On one hand, a better contract enforcement improves efficiency in production, expanding both the specialization set of South towards less volatile sectors and raising the relative wage in South. On the other hand, this improvement has an additional effect which might lead to divergence, rather than convergence, in aggregate income across North and South. As shown in the model, weak contract enforcement implies that the price of intermediate varieties in South includes a markup over marginal cost, which is transferred into an higher price for final goods. Then, weak contract enforcement in South leads to an income redistribution from North consumers to South firms. This result resembles the welfare implications of an improvement in institutional quality obtained by Levchenko (2007) by merging an Heckscher-Ohlin-Ricardo model of international trade with the incomplete contract literature.

Data seems to give support to the two crucial assumptions that drive the results of the model. The first set of empirical evidence shows that sectoral output volatility is significantly and negatively correlated with the number of intermediate inputs used in each sector. Sectoral output volatility is measured as the standard deviation of the cross-country average growth rate of value added per worker in each sector using UNIDO data on a set of 28 manufacturing sectors and 45 countries, where the number of intermediate inputs in each sector is measured using US input-output tables in order to capture pure technological differences across sectors. This result is closely related to a very recent evidence provided by Krishna and Levchenko (2009) using only US data. The second set of empirical evidence shows that countries with better institutions tend to export relatively more in sectors that use a relatively large number of intermediate inputs, consistently with the idea that legal institutions represent a source of comparative advantage between sectors with different degrees of contract intensity. This evidence is closely related to Nunn (2007), who focuses on the fraction of inputs that are relationship-specific rather than on the number of inputs.

My paper is closely related to the literature that studies the effects of trade integration on income volatility. Past studies (e.g. Easterly, Islam, and Stiglitz (Easterly et al.), Bejan (2006), Cavallo (2007), di Giovanni and Levchenko (2006), di Giovanni and Levchenko (2008), among others) have addressed this topic mainly from an empirical point of view. Trade openness appears to raise income volatility, especially in developing countries, as a consequence of specialization and vulnerability to external shocks. Theory, however, is still lacking behind. One exception is Kraay and Ventura (2007). These authors propose a model where comparative advantage leads developed countries to specialize in sophisticated industries while developing countries specialize in traditional industries. The two industries differ with respect to their market structure, rather than their intrinsic volatility as assumed in my model. Then, as sophisticated industries face more inelastic demand, fluctuations in supply cause opposing changes in prices which stabilize income growth in developed countries. Recently, Krishna and Levchenko (2009) have taken a stand that is very close to my paper. These authors argue indeed that institutional quality represents a source of comparative advantage across sectors with different level of complexity. As complexity is negatively related to output volatility, developing country specialize in more volatile sectors. Finally, my paper also contributes to a wider literature that studies the factors linking volatility and development (e.g. Greenwood and Jovanovic (1990), Saint-Paul (1992), Obstfeld (1994), Acemoglu and Zilibotti (1997), Koren and Tenreyro (2007a)). These paper, however, do not explicitly address the consequences of trade integration on income volatility.

The remaining of the paper proceeds as follows. Section 2 presents the empirical evidence that serves to motivate the theoretical analysis. Section 3 proposes a simple model of international trade under uncertainty and discusses its main predictions in terms of country specialization over sectors with different level of output volatility. Section 4 concludes.

2 Motivating evidence

This section describes a twofold empirical evidence, which suggests that: i) sectors that use a relatively small number of intermediate inputs are characterized by larger fluctuations in productivity; ii) country with better institutions tend to export relatively more in sectors that use a large number of intermediate goods. This evidence is then used to motivate a theoretical model suggesting that legal institutions represent a source of comparative advantage among sectors with different intrinsic volatilities.

The first set of evidence studies the relation between the number of intermediate inputs used in each sector and the volatility of global sector-specific productivity shocks. Following Koren and Tenreyro (2007b), global sector-specific productivity shocks can be identified using the following decomposition for the growth rate of value added per worker in each manufacturing sector s and country c:

$$g_{s,c,t} = \gamma_{s,c} + \lambda_{s,t} + \mu_{c,t} + \epsilon_{s,c,t}. \tag{1}$$

The first component, $\gamma_{s,c}$, captures the long-term trend in the growth rate of value added per worker in each sector s and country c. The second component, $\lambda_{s,t}$, captures global sector-specific shocks, i.e. events that affects the productivity of a specific sector in all countries. Global process innovation or price fluctuations in major production inputs enter in this category. The second component, $\mu_{s,t}$, captures country-specific shocks, i.e. events that affects the productivity of all sectors in a specific country. Clear examples are labor market reforms or financial liberalizations. The third component, $\epsilon_{s,c,t}$, captures all residual shocks, i.e. events that are specific to each sector and each country.

Assuming that the country-specific shocks $\mu_{c,t}$ are zero on average, i.e. $\sum_{c=1}^{C} \mu_{c,t} = 0$,[1] it is possible to measure global productivity shocks in each sector as the cross-country

[1]Notice that this is equivalent to express country shocks as relative to the world average

average of the innovations in the growth rate of value added per worker with respect to the long term trend, i.e. $\hat{\lambda} = \sum_{c=1}^{C}(g_{s,c,t} - \gamma_{s,c})$ for each sector s. Finally, the "intrinsic" volatility of each sector s, i.e. the fraction of total volatility of the growth rate $g_{s,c,t}$ in each sector and country that depends on sector-specific shocks, is measured by $\hat{\sigma}_{\lambda} = \sqrt{\frac{\sum_{t=1}^{T}\hat{\lambda}_t^2}{T}}$.

Using UNIDO Indstat 2006 data on value added per worker for a panel of 28 manufacturing sectors in 45 countries in the period 1963-2000, it is possible to see that some sectors have been systematically affected by larger fluctuations in productivity growth.[2] Table (1) reports that sectors as Non-ferrous metals, Iron and Steel, Petroleum refineries are at the top end of the most volatile sectors, while sectors as Food products, Printing and publishing and Other chemicals are at the bottom end.

Let's now see whether the volatility of sector-specific shocks shows a significant correlation with the number of intermediate inputs used in each sector. Indeed, it could be argued that productivity growth should respond more to shocks to individual inputs in sectors with a less diversified input structure, either because idiosyncratic input-specific shocks cannot be diversified across many goods or because input substitution is limited due to technological reasons. Data on the number of intermediate inputs in each sector are sourced from Cowan and Neut (2007), which use US input-output tables to construct a measure of sectoral diversification or complexity. As suggested by Rajan and Zingales (1998), the focus on the United States allows to capture pure technological differences across sectors. In order to control for alternative determinants of sectoral volatility, I use data on capital, skill and natural resource intensity in each sector in the United States. Data definitions and sources for the control variables are reported in Table 1. Figure 2a confirms this argument showing that the correlation between the standard deviation of global sector-specific shocks and the number of intermediate goods, conditional on capital, skill and natural resource intensity in each sector, is negative and statistically significant.

The negative correlation between input diversification and volatility is maintained when

[2]The countries included in the sample are: Australia, Austria, Bangladesh, Belgium, Canada, Chile, Colombia, Denmark, Ecuador, Egypt, Finland, France, Ghana, Greece, Guatemala, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Kenya, Malaysia, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, South Korea, Spain, Sri Lanka, Sweden, Turkey, United Kingdom, United States, Uruguay, Venezuela, Zimbabwe.

I measures input diversification using the Herfindhal index of intermediate good shares. This index measures the level of diversification in each sector using both the number of inputs and the quantity of each individual input effectively used in final production. Given that this index takes high values when input demand is concentrated only in few items, we should expect that the volatility of productivity growth in each individual sector is positively related with the Herfindhal index. As shown by figure 2b the partial correlation is positive, although it is not statistically significant.

The second set of empirical evidence studies whether good legal institutions lead to a comparative advantage in sectors that use a large number of intermediate goods. This hypothesis is tested by estimating the following equation:

$$\ln x_{s,c} = \alpha_s + \alpha_c + \beta_1\, n_s Q_c + \beta_2\, k_s K_c + \beta_3\, h_s H_c + \epsilon_{s,c}$$

where $x_{s,c}$ denotes country c exports in sector s; n_s denotes the number of inputs used in sector s; Q_c is a measure of the quality of contract enforcement in country c; h_s and k_s denote respectively skill and capital intensities in sector s; H_c and K_c denote country c's endowments of skilled labor and capital; α_s and α_c capture sector and country fixed effects. This estimating equation is similar to the ones used by Levchenko (2007) and Nunn (2007). Data definitions and sources are as in Nunn (2007). OLS estimates are reported in the first column of Table 1. The estimated coefficient for the interaction between the number of intermediate inputs and institutions quality is positive and statistically significant, suggesting that country with better institutions have on average a comparative advantage in sectors that use a large number of intermediate goods. Finally, the second column of Table 1 reports the two-stage IV estimates, where the first stage controls for the potential endogeneity of legal institutions using data on the legal origins of all countries in the sample.

3 Model

Consider a world economy that lasts for one period. The world economy is constituted by two regions, North and South, each including a continuum with mass one of countries. Each country has the technology to produce a continuum of final goods, denoted by $i \in [0, 1]$, and a continuum of intermediate goods, denoted by $j \in [0, 1]$. Final goods are used for consumption and can be traded across countries. Intermediate goods, instead, are used to produce final goods and cannot be traded. Each country is populated by three types of agents: a continuum with mass one of workers/consumers, a continuum of *upward* firms, which produce only final goods, and a continuum of *downward* firms, which produce only intermediate goods.[3] All agents are competitive and risk neutral. Consumers/workers are endowed with one unit of labor and one share of all firms operating in their country and have symmetric Cobb-Douglas preferences over the final goods i. Lastly, there are no cross-country differences in preferences and technology.

3.1 Technology

Each upward firm in final good sector i has access to a Leontief technology that requires one unit of labor and m units of a composite intermediate good to produce one unit of final output. The composite intermediate good is produced by each upward firm using a continuum of perfectly substitutable intermediate varieties j, as described by

$$X = \int_0^{J_i} \theta_j \, x_j \, dj$$

where x_j denotes the quantity of each variety j used in the production of the composite good X, J_i is the total number of varieties used and θ_j denotes a productivity shock on each variety.

Assuming that the shocks θ_j are idiosyncratic and are observed only at the end of the period, upward firms can reduce future output volatility by raising the number of varieties j. Let's now assume that productivity shocks are imperfectly distributed across intermediate goods and independently distributed across countries, as stated by the following assumptions.

Assumption 1 *In each country there exists a continuum of equally likely states of technology, $s \in S \equiv [0,1]$, which determine the productivity θ_j of each intermediate good j, as in*

$$\theta_j = \begin{cases} \frac{1}{dj} & if \quad s = j \\ 0 & if \quad s \neq j \end{cases} .$$

[3]Notice that the number of firms in each country is not fixed but is determined in equilibrium.

This formalization is similar to Acemoglu and Zilibotti (1997) and Martin and Rey (2004) and captures in a tractable way the main ingredient of the model: expected output is increasing in the number of intermediate goods as a result of a technological diversification effect. Indeed, by raising the number of intermediate good varieties used in final production, upward firms are able to diversify the productivity shocks on each individual variety and reduce fluctuations in future output.

Assumption 2 *The states of technology s are independently drawn across countries, both within and across regions.*

Assumption 2 greatly simplifies the analysis, ruling out aggregate uncertainty and making the problem of upward firms in each country perfectly symmetric.

Diversification of productivity shocks among varieties j, however, is costly. Consider, for instance, that each worker spends time in learning how to use each intermediate variety. Then, when the number of intermediate varieties is J_i, each upward firm needs, for each unit of labor used in final production, an additional amount of labor $\kappa_i C(J_i)$, where κ_i is increasing in the index i and $C(\cdot)$ is a zero-valued, strictly increasing and convex function, i.e. $C(0) = 0$, $C'(\cdot) > 0$ and $C''(\cdot) > 0$. In particular, the parameter κ_i reflects technological differences across final good sectors in the cost of combining different inputs and, as shown below, determines the number of intermediate varieties used in each sector. The convexity of the cost function reflects, instead, the existence of non-linearities in the relation between technological complexity and the cost of technology adoption and guarantees the existence of an internal solution where the mass of intermediate goods used in final production may differ from one.

Upward firms cannot produce intermediate varieties internally. In order to produce the composite intermediate good, then, each upward firm in final good sector i must purchase J_i intermediate varieties from an equal number of suppliers, or downward firms, each producing only one intermediate variety j. Production technology is assumed to be symmetric across all varieties j, uses only labor and is not subject to productivity shocks, as described by

$$x_j = l_j \tag{2}$$

where l_j denotes the labor used to produce a quantity x_j for variety j.

3.2 Outsourcing, contracts and legal enforcement

The main point of the model is to study how cross-country institutional differences cause comparative advantages and shape specialization across sectors with different levels of intrinsic volatility. To that end, I take two additional and fairly realistic assumptions. The first assumption is:

Assumption 3 *Each intermediate variety j used in final production is relationship-specific.*

As shown by Williamson (1985) and Grossman and Hart (1986), the specificity of intermediate varieties can result in a two-sided bargaining process over the division of final output between each downward supplier and the upward firm, commonly known as the "hold-up" problem. The threat of future hold-ups, then, provokes an efficiency loss in production, as the ex-ante incentives of downward suppliers and upward firms now depend on the ex-post allocation of bargaining powers rather than on the marginal contribution to future output. Yet, incentives can be correctly aligned and the inefficiency removed by writing ex-ante contracts between the two parties. In this model, I consider that the quality of contract enforcement differs across the two countries.

Assumption 4 *In North there is complete contract enforcement, while in South courts enforce contracts only with probability* $0 < \phi < 1$.

It is now convenient to describe the timing of events in order to clarify the structure of the model.

1. Each upward firm in the final good sector i in North (South) chooses the number J_i (J_i^*) of intermediate varieties to use in final production and outsource the production of each variety to a single supplier chosen among the competitive pool of downward firms. Due to symmetry, each outsourcing contract specifies a quantity x_i (x_i^*) and a price τ_i (τ_i^*) for each variety j used in the final sector i.

2. In North, contracts are enforced and each supplier must deliver the quantity x_i at unit price τ_i. In South, instead, only a fraction $1 - \phi$ of suppliers is forced by courts to deliver the quantity x_i^* at unit price τ_i^*. The remaining fraction ϕ can renege on the initial contract and bargains with the upward firm over the price $\hat{\tau}_i^*$ of each unit of the intermediate variety produced.

3. The state of technology in each country is observed and the upward firm produces only if the state of technology is $s \in [0, J_i]$ ($s \in [0, J_i^*]$). Given that states of technology are independently drawn across countries, in North (in South) upward firms can produce only in a mass J_i (J_i^*) of countries.

Let's now provide a short intuition for the inefficiency created by the enforcement friction. Notice first that the assumptions of the model permit to focus exclusively on the investment of upward firms in technological diversification (which ultimately determines the number of intermediate varieties used in final production). Indeed, given the Leontief technology, downward firms produce a constant quantity m for each intermediate varieties, independently of the quality of contract enforcement in the contract. Consider first the benchmark case of North. In this case, the price of each intermediate variety is specified ex-ante by the contract and are set at marginal costs due to perfect competition among the pool of potential suppliers. Upward firms then can fully appropriate production rents and choose the number of intermediate varieties to maximize expected profits. In South, instead, upward firms know that they would have to share future production rents with a fraction of their suppliers. Then, they internalize just a fraction of expected profits and reduce investment in technology adoption. As discussed later on with further details, this lead to a positive gap between the production costs of South and North, which increases with the number of intermediate varieties or contract intensity of each final good sector.

3.3 Equilibrium

In this section I solve for the equilibrium of an integrated economy where there are no barriers to trade in final goods. Recall that cross-country symmetry within each region allows to focus on a simple North-South equilibrium, where the only source of comparative advantages is the difference in contracts enforcement. Let's now begin the equilibrium analysis from the supply side of, respectively, North and South, taking factors prices as given.

3.3.1 Supply side in North

Consider a final good sector i in a given country in North. Set the amount of labor used in final production by each upward firm equal to one.[4] Then, each firm needs at least m units of the composite intermediate good to produce one unit of final output. Given that the varieties j are subject to idiosyncratic shocks, the upward firm maximizes expected profits by setting the quantity of each variety to $x_j = m$ and by choosing a number J_i of varieties that satisfies

$$p_i = w\Big(m + \kappa_i C'(J_i)\Big), \tag{3}$$

where I have already substituted for the equilibrium price of each intermediate variety, i.e. $\tau_i = w$. Condition (3) states that the expected marginal gain from raising the number of intermediate varieties by one unit must be equal to its marginal cost, which is given by the sum of the price paid to downward firms for each variety j and the marginal increase in the cost of technology adoption. Furthermore, expected profits of upward firms are equal to zero in equilibrium due to free entry in each final good sector and the following condition must also hold:

$$p_i = w\left(m + \frac{1 + \kappa_i C(J_i)}{J_i}\right). \tag{4}$$

Combining conditions (4) and (3), it is possible to pin down the number of intermediate varieties J_i and the equilibrium price p_i for any final good i produced in North for any given labor wage w. Clearly, the number of intermediate varieties is decreasing in the parameter k_i, which measures technological differences across sectors in the cost of combining intermediate inputs in final production. Henceforth, it will be convenient to reorder the final good sectors such that κ_i is decreasing in i and, thus, the number of intermediate goods is increasing in i. It is also important to remark that these values are obtained under full-efficiency in final production. In the following section, I will compare these conditions with the ones describing the supply side equilibrium is South under weak contract enforcement.

[4] This assumption is without loss of generality as there are constant returns to scale in production. It only ensures that in the general equilibrium we can solve for the number of firms in each sector i rather than for total production.

3.3.2 Supply side in South

Consider now a final good sector i in a given country in South. The characterization of the supply side for each sector i in South is obtained by solving for the sub-game perfect equilibrium of the three-stage game described before. Let's proceed by backward induction, starting from the penultimate stage. In this stage, outsourcing contracts are enforced by courts with probability $1 - \phi$. By the law of large number, then, the same fraction of downward suppliers is forced by courts to fulfill the initial contract and deliver a quantity $x_i^* = m$ at unit price $\tau_i^* = w^*$ for the intermediate variety produced. With probability ϕ, instead, contracts are not enforced. In this case, each supplier enters a bilateral Nash bargaining game with the upward firm over the non-contractual price $\hat{\tau}_i^*$. The following assumption defines the bargaining powers of the upward firm and each intermediate supplier.

Assumption 5 *Let $1 - \beta(J_i^*)$ define the bargaining power of the upward firm and $\beta(J_i^*)$ the bargaining power of each downward supplier that can renege on the contract. Furthermore, let $\beta(J_i^*)$ be a decresing function of J_i^*, i.e.* $\frac{d\beta(J_i^*)}{dJ_i^*} < 0$.

Assumption 5 states that the fraction of total revenues appropriable by upward firms is inversely related to the number of intermediate suppliers faced in the negotiation process. Undoubtedly, this assumption is crucial. It implies that the inefficiency created by weak contract enforcement varies across sectors, biasing the comparative advantage of South towards sectors with a low level of diversification. Nevertheless, this assumption could arise endogenously as a solution of a multilateral bargaining game between the upward firm and the mass of downward firms. Following Hart and Moore (1990), the equilibrium distribution of revenues for the multilateral game is determined by the Shapley value of each player, which measures the average contribution of each player to final output. Consider two extreme examples. When final production requires the cooperation between the upward firm and all downward firms, i.e. intermediate varieties are perfect complements, each player has the same Shapley value, given by the the value of final revenues divided by the number of players. Then, the value appropriable by the upward firm is inversely related to the number of downward firms. Instead, when final production requires the cooperation between the upward firm and only one downward firm, i.e. intermediate varieties are perfect substitutes, the Shapley value of the upward firm is equal to half the value of final revenues while the remaining half is equally divided across downward firms. In such a case, the value appropriable by the upward firm is independent of the number of downward firms. Assumption 5, then, can be considered as a description of an intermediate case, where the slope of the value appropriable by the upward firm with respect to the number of intermediate supplies lies between these two extremes.

Solving for the Nash-bargaining outcomes, it is possible to define the expected revenues of the upward firm and each downward supplier as in[5]

$$r_u = (1 - \phi\beta(J_i^*))J_i^* p_i^* \quad \text{and} \quad r_d = \phi\beta(J_i^*)p_i^* + (1-\phi)m\, w^*.$$

In the first stage of the game, then, downward firms accept the outsourcing contract only if they can expect a positive profit from intermediate production, or equivalently

$$\beta(J_i^*)\, p_i^* \geq w^*\, m. \tag{5}$$

Provided (5) is satisfied, each supplier j produces a quantity $x_j^* = m$ for each intermediate variety. At the same time, the upward firm maximizes expected profits by choosing the mass J_i^* of intermediate varieties such to satisfy[6]

$$(1 - \phi\beta(J_i^*))p_i^* = (1-\phi)w^*\, m + \kappa_i C'(J_i^*)w^*. \tag{6}$$

By comparing conditions (6) and (3), it is possible to show that upward firms in South underinvest in technology adoption. Indeed, the average price of intermediate varieties now exceeds the marginal cost of production, as implied by (5). Furthermore, given that $\frac{d\beta(J_i^*)}{dJ_i^*} < 0$, the underinvestment in technology adoption is inversely related to the number of intermediate varieties used in each sector.

[5]In the Nash-bargaining game, the non-contractual price is set to $\hat{\tau}_i^* = \frac{\beta(J_i^*)p_i^*}{m}$, such to maximize the net gains from trade between the upward firm and each intermediate supplier, defined by

$$G = (p_i^* - \hat{\tau}_i^* m)^{1-\beta(J_i^*)}(\hat{\tau}_i^* m)^{\beta(J_i^*)}$$

for each variety $j \in [0, \phi J_i^*]$.

[6]Notice that I have assumed without loss of generality that the upward firm takes the future bargaining power as given when choosing the number of intermediate goods.

Finally, free entry in each sector i implies that in equilibrium expected revenues equal production costs, as in

$$(1-\phi\beta(J_i^*))p_i^* = \frac{(1-\phi)J_i^* m + 1 + \kappa_i C_i(J_i^*)}{J_i^*} w^*. \tag{7}$$

Combining conditions (7) and (6), we can then pin down the number of intermediate good varieties J_i^* and the equilibrium price p_i^* for any final good i produced in South for any given wage w^*. Once again, the number of intermediate varieties used in final production is increasing in the index i.

3.3.3 Comparative advantages

The pattern of comparative advantages can now be characterized in a manner similar to Dornbusch et al. (1977) by comparing relative prices for each final good i in the two regions. Using (4) and (7), the price of each final good i in North relative to South equals,

$$\frac{p_i}{p_i^*} = A(i)\frac{w}{w^*}, \tag{8}$$

where $A(i) = \left(1-\phi\beta(J_i^*)\right) \frac{\left(1+J_i m+\kappa_i C(J_i)\right)/J_i}{\left(1+(1-\phi)J_i m+\kappa_i C(J_i)\right)/J_i}$ denotes the inverse of the relative unit production costs, or the relative productivity, of upward firms in South in each final sector i.[7] Notice now that $d\beta(J_i^*)/di > 0$ implies that the relative productivity of upward firms in South is downward sloping:[8] Then, as i, and thus the number of downward suppliers J_i^*, increases, upward firms in South lose bargaining power and inefficiency in production is magnified. Then, for any relative wage $\frac{w^*}{w}$, the model predicts that South specializes in the production of final goods $i \in [0, \bar{i}]$ and North in the production of final goods $i \in [\bar{i}, 1]$, where the threshold sector $\bar{i}$ is defined by,

$$\frac{w^*}{w} = A(\bar{i}). \tag{9}$$

Having determined the pattern of comparative advantages between North and South for any relative wage $\frac{w^*}{w}$, we need now to compute the relative demand of North and South to determine the equilibrium value of the relative wage.

[7] Production costs are expressed per units of expected output.

[8] This is a necessary condition when the price of the final goods i increases with the number of intermediate varieties used in production, i.e. $\kappa_i C'(J_i)$ is increasing.

3.3.4 Demand side and trade balance

Trade balance between the two regions requires that the fraction of North aggregate income spent on final good varieties produced in South equals the fraction of South aggregate income spent on final good varieties produced in North. Aggregate income in North is equal to the wage rate w, as firms' profits are zero on average and total population is equal to one.[9] Instead, aggregate income in South is equal to the wage rate w^* plus the profits of downward firms, denoted by the integral on the right hand side: as shown before, indeed, weak contract enforcement in South allows downward firms to extract positive rents from intermediate good production. Using the properties of Cobb-Douglas preferences, the trade balance condition between North and South can be written as follows,

$$\bar{i}\, w = (1 - \bar{i}) \left(w^* + \int_0^{\bar{i}} n_i^* J_i^* \phi \Big(\beta(J_i^*) p_i^* - w^* m \Big)\, di \right), \tag{10}$$

where n_i^* denotes the number of upward firms in each sector $i \in [0, \bar{i}]$ in South. A more detailed derivation of (10) is contained in the appendix.

Substituting for the number of upward firms n_i^* in each sector $i \in [0, \bar{i}]$ of South using both optimality in demand and the labor market condition, the trade balance condition can be rearranged as follows,

$$\frac{w^*}{w} = B(\bar{i}) = \frac{\bar{i}}{1 - \bar{i}} \Gamma_{\bar{i}}, \tag{11}$$

where $\Gamma_{\bar{i}} \equiv \left[1 + \frac{\int_0^{\bar{i}} \frac{p_0^*}{p_i^*} \left(\phi \beta(J_i^*) \frac{p_i^*}{w^*} - m \right) di}{\int_0^{\bar{i}} \frac{p_0^*}{p_i^*} \frac{1 + J_i^* m + \kappa_i C(J_i^*)}{J_i^*}\, di} \right]^{-1}$. Given that $B(\bar{i})$ is upward sloping, conditions (9) and (14) pin down the values of $\bar{i}$ and $\frac{w^*}{w}$. Finally, the equilibrium of the model is fully characterized (up to the choice of the wage rate in one of the two country) by retrieving the levels of production in each final good sector i using labor market clearing conditions.

[9] In equilibrium, indeed, the expected profits of upward firms are zero due to free-entry and the profits of downward firms are zero given that the contractual price of intermediate goods is equal to the average cost of production of intermediate varieties.

3.4 Institutional improvement and relative welfare

Let's now study what is the effect of a better contract enforcement in South (i.e. a lower ϕ) on the relative welfare of the two regions. Clearly, the improvement in contract enforcement improves efficiency in final production. As upward firms are less likely to be held up by their downward suppliers, they internalize a larger fraction of future revenues and their investment in technology adoption approaches the first-best. Then, the efficiency gain tends to translate into an higher relative wage in South. Consider indeed the relative productivity schedule $A(i)$, defined as in condition (8). A lower value of ϕ, which measures the likelihood of hold-ups in production, shifts $A(i)$ upward and make it flatter. Everything else equal, an improvement in legal institutions then expands the specialization set of South and, given that the quantity of labor available in South must be now allocated over a larger number of sectors, the relative wage in South increases.

However, an improvement in legal institutions has an additional effect on South aggregate income, which could lead to divergence, rather than convergence, in relative welfare. Weak contract enforcement, indeed, implies that the price of intermediate varieties in South includes a markup over the marginal cost, as implied by (5). Given that the markup is transferred into an higher price for final goods, weak contract enforcement in South leads to an income redistribution from consumers in North to downward firms in South and, thus, to consumers in South. Then, improving institutions in South have an ambiguous effect on relative welfare.

The comparative statics analysis, then, delivers quite striking results. In the context of a trade integrated world, weak contract enforcement in one region leads to specialization towards less complex and more volatile sectors, but is not necessarily welfare detrimental. In some sense, this result is close to Levchenko (2007). This author introduces the incomplete contract framework into an otherwise standard Heckscher-Ohlin-Ricardo model of international trade and shows that an improvement in institutional quality in one country might have a negative impact on the gains from trade of the country itself.

4 Conclusion

It is a well documented fact that developing countries have experienced a more volatile income growth with respect to developed countries in the period 1960-2000. Recent empirical evidence has shown that the higher volatility in developing countries can be accounted for both by more pronounced country-specific shocks and by a specialization structure biased towards more volatile sectors. This paper, then, focuses on the sources of these compositional effects and proposes a view according to which developing countries specialize in more volatile sectors as a consequence of weak legal institutions.

This paper augments a standard North-South Ricardian model in two respects. First, I consider that the economy can produce a continuum of final goods and that final goods production requires a continuum of intermediate goods, which are subject to imperfectly correlated productivity shocks. Then, final output is less volatile in sectors where the production technology uses a relatively large number of intermediate goods. Second, I introduce contracting frictions using the incomplete contract framework, as in Williamson (1985) and Grossman and Hart (1986). In particular, I consider that final producers (upward firms) outsource intermediate goods to downward suppliers (downward firms) and that intermediate good are relationship-specific. When parties cannot write ex-ante enforceable contracts, this situation lead to the well-known hold-up problem, where parties bargain over the division of future revenues from production. Assuming that contract enforcement is weaker in South, in this region upward firms experience a cost disadvantage in sectors where the number of intermediate inputs, and therefore contract intensity, is greater. The model, then, proposes a view where legal institutions represent a source of comparative advantage across sectors with different output volatility.

This paper also provides empirical evidence that is consistent with the assumptions that drive the result of the model. First, I show that sectors that use a relatively small number of intermediate goods tend to suffer from more volatile sector-specific productivity shocks. This evidence suggests that output fluctuation in individual sectors depends on technological factors that affects the degree of diversification across individual production inputs. Second, I show that countries with better institutions tend to export relatively more in sectors that use a relatively large number of intermediate inputs, consistently with the idea that legal institutions represent a source of comparative advantage between sectors with different degrees of contract intensity.

Finally, the model studies the consequences of an improvement in legal institutions in South and points out two opposing effects. On one hand, a better contract enforcement improves efficiency in production, expanding both the specialization set of South towards less volatile sectors and raising the relative wage in South. On the other hand, this improvement has an additional effect which might lead to divergence, rather than convergence, in aggregate income across North and South. As shown in the model, weak contract enforcement implies that the price of intermediate varieties in South includes a markup over marginal cost, which is transferred into an higher price for final goods.

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A Trade Balance

Trade balance requires that the fraction of North income spent on final good varieties produced in South equals the fraction of South income spent on final good varieties produced in North. Let's now compute the aggregate income in both regions. In North, aggregate income is equal to the wage rate w since firms' average profits are zero in equilibrium. Instead, South income is equal to the labor income w^* plus the profits of downward firms. Let's now compute the profits of downward firms in each sector $i \in [0, \bar{i}]$. Let J_i^* be the number of intermediate good varieties used by each upward firm in sector i and n_i^* the number of upward firms in each country and sector i. As implied by Assumption 1 and 2, in each state of nature final output of good i is positive (and equal to n_i^* as each upward firm can produce at most one unit of output) in a number J_i^* of countries and zero in the remaining $1 - J_i^*$ countries. Then, downward firms' profits in each sector $i \in [0, \bar{i}]$ are equal to,

$$J_i^* \left[n_i^* J_i^* \left(\frac{\beta(J_i^*)}{J_i^*} p_i^* - w^* m \right) \right] + (1 - J_i^*) \left[n_i^* J_i^* \left(-w^* m \right) \right] = n_i^* J_i^* \Big(\beta(J_i^*) p_i^* - w^* m \Big),$$

such that the aggregate income in South is given by,

$$w^* + \int_0^{\bar{i}} n_i^* J_i^* \Big(\beta(J_i^*) p_i^* - w^* m \Big) \, di.$$

Finally, as consumers preferences are Cobb-Douglas, the trade balance condition between North and South can be written as follows,

$$\bar{i}\, w = (1 - \bar{i}) \left(w^* + \int_0^{\bar{i}} n_i^* J_i^* \Big(\beta(J_i^*) p_i^* - w^* m \Big) \, di \right). \tag{12}$$

Let's now simplify further the above condition. This simplification requires a few steps. First, notice that labor market clearing requires that the following condition is satisfied in equilibrium,

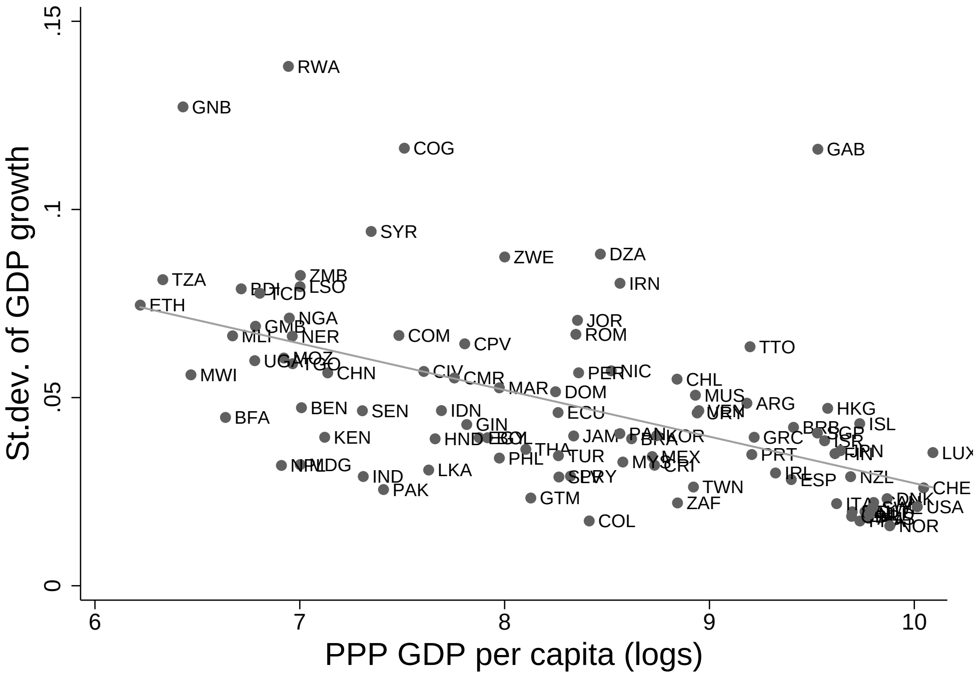
$$\int_0^{\bar{i}} n_i^* J_i^* \left(\frac{1 + \kappa_i C(J_i^*)}{J_i^*} + m \right) di = 1, \tag{13}$$

where the term within the integral denotes the amount of labor used in each sector $i \in [0, \bar{i}]$. Second, notice that $n_i^* J_i^*$ measures both the number of firms that get positive output in sector i and the total output of final good i in each state of nature, as each upward firm can produce at most one unit of output. Using optimality in demand, we can then substitute for $n_i^* J_i^* = \frac{p_0^*}{p_i^*} n_0^* J_0^*$ in both (12) and (13). Finally, substitution of (13) into (12) allows to rewrite the trade balance condition as follows,

$$\frac{w^*}{w} = B(\bar{i}) = \frac{\phi(\bar{i})}{1-\bar{i}}, \tag{14}$$

where $\phi(\bar{i}) = \int_0^{\bar{i}} (1-\beta(J_i^*)) \left(1 + \frac{m}{\kappa_i C'(J_i^*)}\right) di$.

Figure 1: **Aggregate Volatility and Development**



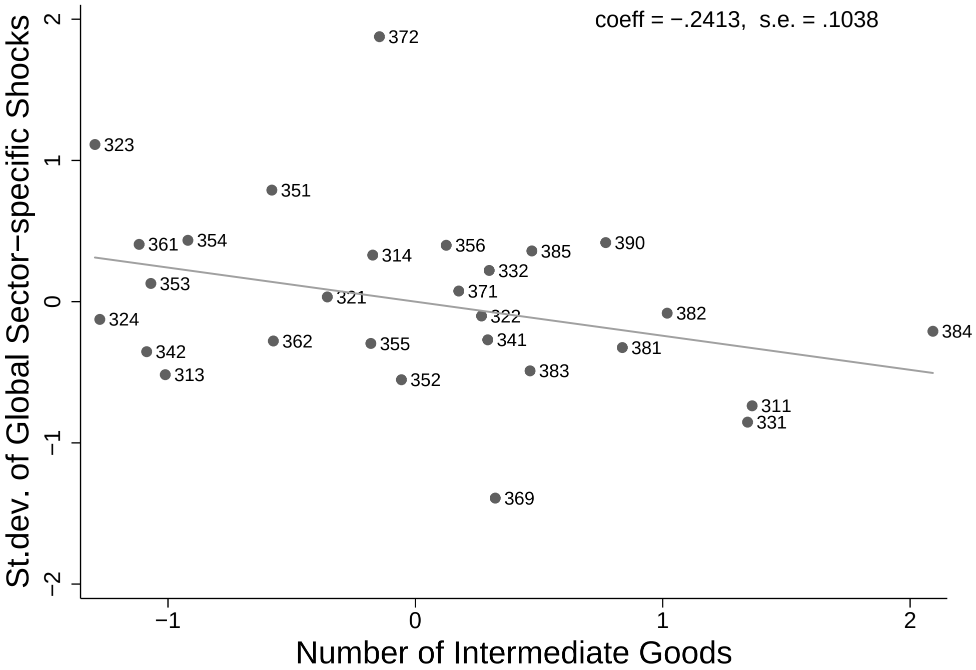
Notes: The plot shows the standard deviation of the growth rate of GDP per capita over the period 1960-2000 against the average GDP per capita in 2000 PPP dollars over the same period.

Table 1: **Data description**

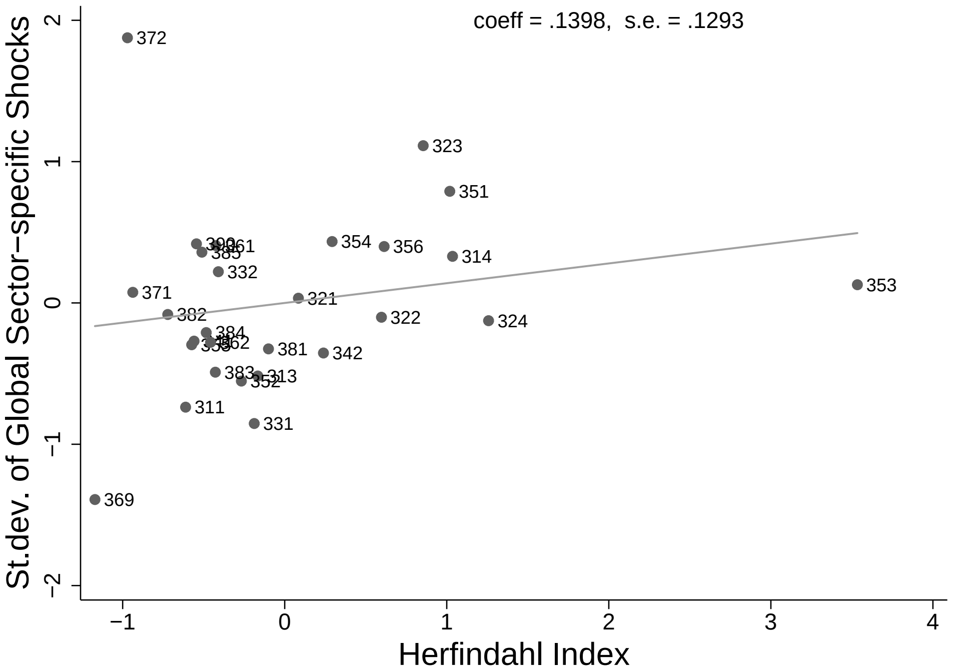
isic3	description	sectorsd	n	herfindhal	Kint	Hint	NRint
372	Non-ferrous metals	3.17	-0.15	-0.44	1.24	-0.26	1
371	Iron and steel	1.63	-0.09	-0.26	1.99	-1.25	1
353	Petroleum refineries	1.63	-0.60	4.17	2.26	0.26	1
354	Misc. petroleum and coal products	1.41	-1.24	0.64	-0.09	-0.24	1
341	Paper and products	1.02	0.07	-0.03	1.08	-0.65	1
351	Industrial chemicals	0.64	0.01	1.00	0.96	0.66	0
323	Leather products	0.61	-1.53	0.64	-0.82	-0.22	0
331	Wood products, except furniture	0.19	0.58	0.20	-0.14	-1.21	1
356	Plastic products	0.04	0.07	0.48	-0.19	-0.17	0
361	Pottery, china, earthenware	-0.02	-1.53	-0.59	-0.65	-0.72	0
390	Other manufactured products	-0.03	1.00	-0.73	-0.34	0.56	0
321	Textiles	-0.14	-0.54	0.06	0.38	-0.76	0
369	Other non-metallic mineral products	-0.21	0.20	-0.71	0.76	-0.26	1
385	Professional and scientific equipment	-0.31	1.06	-0.83	-0.85	1.66	0
362	Glass and products	-0.32	-0.95	-0.40	0.72	-1.40	0
314	Tobacco	-0.43	-0.76	0.68	-1.95	-0.41	0
382	Machinery, except electrical	-0.45	1.54	-0.87	0.15	0.96	0
332	Furniture, except metal	-0.45	0.29	-0.72	-1.26	0.53	0
355	Rubber products	-0.47	-0.41	-0.60	0.33	-0.84	0
384	Transport equipment	-0.54	2.34	-0.60	0.12	0.35	0
324	Footwear, except rubber or plastic	-0.56	-1.91	1.09	-0.83	-1.13	0
381	Fabricated metal products	-0.63	0.97	-0.21	0.11	0.09	0
322	Wearing apparel, except footwear	-0.77	-0.60	0.30	-1.81	-1.12	0
313	Beverages	-0.84	-0.38	-0.29	0.39	1.07	0
383	Machinery, electric	-0.95	1.19	-0.63	-0.05	1.52	0
311	Food products	-0.97	1.06	-0.67	0.10	-0.88	0
342	Printing and publishing	-1.10	-0.25	-0.13	-0.98	2.28	0
352	Other chemicals	-1.16	0.55	-0.55	-0.63	1.57	0

Notes: all variables (with the exception of natural resource intensity) have been normalized such that they have mean zero and standard deviation equal to one. $Sectorsd$ measures the volatility of global sector-specific shocks in each sector and is computed as described in the main text. n and $herfindahl$ are respectively the number of intermediate inputs and the Herfindahl index of input shares in each sector. Both variables are constructed using the 1992 US input-output tables by Cowan and Neut (2007). $Kint$ and $Hint$ measure respectively capital and skill intensity in each sector. Both measures are constructed using the NBER Manufacturing Productivity database, as in **?** and Nunn (2007). Capital intensity is defined as the log of total real capital stock divided by value added in each sector in the United States in 1996. Skill intensity is defined as the log of the ratio of non-production worker wages to total wages in each sector. Natural resource intensity is a dummy variable that takes value one if the sector use natural resources intensively and is sourced from Braun (2002).

Figure 2: **Sectoral volatility and intermediate goods**



(a)



(b)

Notes: The plot provides a graphical representation of the partial correlation between the standard deviation of global sector-specific shocks and a) the number of intermediate goods b) the Herfindahl index of input shares, while controlling for measures of sectoral capital, skill and natural resources intensity.

Table 2: **Estimation Results**

	OLS	IV-2LS
$n_s Q_c$	1.833***	4.303***
	(0.597)	(0.935)
$k_s K_c$	0.143**	0.144**
	(0.072)	(0.073)
$h_s H_s$	1.124***	1.231***
	(0.290)	(0.287)
Country fixed effects	Yes	Yes
Sector fixed effects	Yes	Yes
R^2	0.98	0.98
Obs.	1633	1633

***,**,* represent significance at 1%, 5%, and 10%, respectively. Heteroskedasticity-consistent standard errors are reported within parenthesis. IV-2LS estimates are computed substituting the index of institutions quality Q_c with a first-stage OLS estimate of Q_c on three legal origins dummies, i.e. $legor_{uk}$, $legor_{fr}$, $legor_{ge}$.