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INTERMEDIATE GOODS, INSTITUTIONS AND OUTPUT PER WORKER

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Resumen

Este artículo analiza un canal específico a través del cual las instituciones afectan al producto por trabajador: el impacto de dichas instituciones en la división de la producción entre empresas. Argumentamos que las instituciones débiles aumentan los costos de transacción, en especial aquellos en que las firmas deben incurrir en sus relaciones con proveedores de bienes intermedios. Las firmas responden a estos mayores costos sustituyendo bienes intermedios adquiridos a terceros por bienes producidos en la firma. Esta sustitución reduce el grado de especialización, lo que a su vez genera pérdidas de productividad. Para testear este mecanismo, aprovechamos diferencias entre sectores en su capacidad de sustituir bienes intermedios por bienes internos. Comenzamos construyendo un índice que mide la "complejidad" de los bienes intermedios de cada sector en Estados Unidos. Usando este índice, encontramos que las industrias con una estructura de bienes intermedios más compleja sufren una mayor caída de productividad en países con instituciones débiles.

Abstract

This paper tests a specific channel through which institutions affect output per capita: the role of institutions in firm-level division of production. We argue that weaker institutions increase transaction costs, including those incurred by a firm when dealing with suppliers of intermediate goods. Firms respond to these higher costs by substituting intermediate goods produced within the firm for those externally supplied, which in turn discourages specialization and consequently decreases productivity. To test this channel, we rely on differences across sectors in their capacity to substitute internal goods for intermediate goods. We first create an index that measures the 'complexity' of a sector's intermediate structure using data from the United States. Using this index, we find that industries with a more complex intermediate goods structure suffer a relatively larger loss of productivity in countries with poorer institutions.

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1 Introduction

> [A]s human beings became increasingly interdependent, more complex institutional structures were necessary to capture the potential gains from trade. Such evolution required that society develop institutions that permit anonymous, impersonal exchanges across time and space...most societies got "stuck" in an institutional matrix that did not evolve into the impersonal exchange essential to capturing the productivity gains that came from the specialization and division of labor that have produced the Wealth of Nations.
>
> Douglas North (1994) "Economic Performance Through Time"

Institutions have received growing attention as an explanation for the large differences in income per capita observed across countries (North and Thomas (1973), North (1994)). In support of this view there is considerable evidence of a positive correlation between various measures of institutions and economic performance.[1] More recent research shows that this relationship between institutions and output per worker is in fact causal.[2] Nevertheless, there is still little evidence as to the exact mechanisms by which institutions affect output per worker. This paper is an attempt to fill this gap and in doing so explore a specific channel through which institutions affect economic outcomes.

We argue that the relationships between suppliers of intermediate goods and the firms purchasing these goods require specific investments which give rise to a holdup problem. Firms set up contracts and incentive schemes to overcome this holdup and in doing so incur in a series of additional transaction costs. In economies in which these costs are high due to a poor institutional environment (e.g. high levels of corruption or a inefficient legal system), firms will economize on transaction costs by purchasing a limited variety of intermediate goods. According to Clague (1991), for example, factory managers in LDC's frequently maintain facilities for producing their own intermediate inputs, even their own electricity to avoid relying on uncertain deliveries from suppliers. Considering that the use of a broad range of specialized inputs is a source of productivity gains, substitution into a narrower range of inputs will result in lower output per worker. In a nutshell, we argue that the productivity gains from specialization will be limited by the costs of sustaining complex contracts in a poor institutional environment. To explore this mechanism we evaluate the differential effect of an institutional change on industries with different intermediate good structures. Our main hypothesis is that in countries with high transaction costs due to poor institutions, productivity will be relatively lower in sectors which utilize a *broad* variety of intermediate goods.

[1] For evidence on the correlation of output and institutions see for example Knack and Keefer (1995), Mauro (1995) and Rodrick (1999).

[2] Hall and Jones (1999), find that variations in "social infrastructure" (a combination of institutions and government policies) explain a large share of cross country differences in output per worker. Similarly, Acemoglu, Johnson and Robinson (2000) find that as much as 3/4 of the gap between the top and bottom of the distribution of world income can be explained by institutions.

To test this hypothesis we use the U.S. Input-Output matrix to construct sectorial indices of "complexity" (the variety of intermediate commodities used by each sector) and interact them with cross country measures of institutions. The assumption behind this approach is that the existing structure of intermediate good use in the US is driven by technology differences across sectors, and that these technological differences persist across countries. Using these measures and data on productivity within the manufacturing sector for a sample of 75 countries, we find that those sectors with a more "complex" intermediate structure in the United States have relatively lower levels of output per worker in countries with corrupt or inefficient legal systems. This result is robust to cross country and sector controls and to a range of institutional variables that proxy for the cost of setting up and enforcing supplier contracts. Furthermore, using a sub-sample of countries and sectors for which data on investment is available, we find that the observed differences in output per worker are the result of differences in total factor productivity rather than capital intensity.

The channel from institutions to productivity that we explore in this paper is based on three premises: (i) that firms incur in transaction costs as a result of specificity in the supplier-producer relationship; (ii) that cross-country differences in transaction costs will lead to differences in the range of intermediate goods employed, (iii) and that production using a narrow range of intermediate goods leads to lower productivity. In what remains of this introduction we discuss each of these assumptions in detail.

Much emphasis has been placed in the development literature on the non-tradable nature of intermediate inputs.[3] We believe that underlying these arguments of non-tradability is the idea that many intermediate goods and inputs are not general purpose "off-the-shelf" goods, but involve a transformation that will adapt them to the particular productive process in which they will be employed. At the very least this transformation takes the form of a timely delivery of the exact goods ordered. Once transformed the good becomes specific and, consequently, more valuable within the relationship than outside it. If the transformation cannot be costlessly reversed, then it gives rise to specific quasi rents (a holdup problem) that will be appropriated by the parties involved without regard to ex-ante terms of trade. Firms will incur in transaction costs to overcome this holdup problem. These costs range from ex-ante contracting costs and safeguards to the ex-post costs of renegotiation or contract enforcement. Furthermore, these transaction costs will be factored into a firm's cost-minimizing decisions so that a productive structure that is more costly in terms of labor and capital payments may be optimal once transaction costs are included.

The transactions costs firms incur in will be affected by the social context in which these transactions take place (Williamson (1985)). In particular, the

[3]Porter (1992), for example, argues that foreign suppliers are imperfect substitutes to domestic suppliers because of the importance of ongoing coordination and information transfer. In addition, there is evidence of an increasing dependence of final good industries on specialized producer services (see Greenfield 1966). For these services "transformation" is extreme, in as much as production of the good cannot be separated from its final use. See Rodriguez (1996) for an extensive discussion of this point.

efficiency and probity of the legal system will affect the ex-ante costs involved in drafting and safeguarding a supplier agreement and the ex-post costs that arise from settling disputes or from non-compliance with the initial contract.[4] If a country's institutions (or social norms) are such that these transaction costs are high, then we argue that this will lead firms in that country to use a narrower range of specialized inputs, substituting them with general inputs and their own labor or capital. Evidence of substitution between purchased inputs and internal production is provided by Holmes (1995). Looking at U.S. manufacturing establishments, Holmes finds that establishments located in areas where their own industry is concentrated (and specialized inputs are more likely to be available) use purchased inputs more intensively than do isolated establishments. Additional evidence is provided by Wilson (1992), in a study of technological choice in the Mexican *maquiladoras.*

It is a broadly accepted premise that specialization leads to gains in productivity. This specialization may take the form of subdivision of labor within the firm, as in Adam Smith's pin factory, or may take place through a progressive division and specialization of industries, as emphasized by Young (1928). The end result is that production of a given good becomes increasingly indirect (or roundabout), involving large numbers of workers, machines and establishments, each carrying out a highly specialized task. In support of this premise, a series of cross country studies of input-output matrices have found a positive correlation between income per capita and the degree of specialization, or "deepening" of the productive structure. As a country develops, its productive processes are increasingly split into components resulting in an larger share of intermediate goods in total output, even after controlling for shifts in aggregate demand.[5] In the appendix we provide some additional (albeit preliminary) evidence of this in our sample.

There is also an extensive theoretical literature emphasizing the effects of an expanding variety of specialized inputs on productivity. On the one hand, the endogenous growth literature has concentrated on the role of R&D in expanding the set of specialized inputs available for production. On the other hand, a branch of the development literature has concentrated on explaining why some countries fail to take advantage even of the existing set of inputs.[6]

This paper proceeds as follows. In section 2 we present our model and motivate the empirical specification. Section 3 describes our dataset – in particular the measures of "complexity" and the institutional variables that proxy for transaction costs. Our main results, followed by results on total factor productivity and capital to labor ratios are presented in section 4. Finally section

[4] According to Lin and Nugent (1995) overcoming the holdup problem explains the creation of a series of trading instruments. Guarantees, refunds, the registration of signed contracts, bills of lading, letters of credit, contract law with penalties for non performance and product liability suits can all be explained in this way. The operation of these instruments depends on a complementary legal environment of laws and courts.

[5] See Kubo *et al.* (1986) and Chennery (1963).

[6] See Rodriguez-Clare (1996), Ciccone & Matsuyama (1996), Venables (1996). Empirical evidence on how developing countries tend to produce using a limited variety of intermediate goods is discussed in Tybout (2000).

5 concludes.

2 Model

In this section we present a simple model of a firm that incorporates the productivity gains from specialization and the transaction costs that arise from specificity in the intermediate goods market. Our purpose in doing so is to determine the effect of transaction costs on productivity, and to establish how these effects vary across firms that, for technological reasons, use intermediate goods from different numbers of sectors. The final subsection describes our empirical specification and relates it to the results obtained from the model.

We introduce transaction costs to our model in the simplest way possible: by assuming that each firm must pay additional "contracting" costs for each supplier relationship it establishes. These costs are a function of economy-wide institutions. For example, if a country has an efficient and uncorrupted legal system then this will have a favorable impact on the costs incurred by a firm to set up and enforce a supplier contract.

2.1 Model

2.1.1 Setup

Consider the case of a competitive firm that uses a Cobb-Douglas production function to combine capital, labor and a composite of intermediate goods I

$$Y = K^{\alpha} L^{1-\alpha-\beta} I^{\beta} \tag{1}$$

The firm has access to a continuum $[0, N]$ of differentiated intermediate goods. From the available varieties it selects a subset $[0, n]$, which it combines into a symmetric CES aggregate

$$I = \left(\int_0^n q(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}} \quad \sigma > 1 \tag{2}$$

where $q(i)$ is the amount used of intermediate good i and σ is the elasticity of substitution between variety i and i'.[7]

The main characteristic of this specification is that total factor productivity expands with the range of intermediate goods utilized. To see this, let $Q = \int_0^n q(i) di$ be the total quantity of intermediate goods used. Symmetry and the convexity of (2) imply that the firm will use the same quantity of each intermediate variety as long as prices are constant across varieties. Assuming that the firm purchases a constant q of each of the n varieties selected we have that $Q = nq$. Defining intermediate good productivity as $A \equiv I/Q$ we obtain that it will be an increasing function of n ($A = n^{\frac{1}{\sigma-1}}$). Note that

[7] This specification of product differentiation was developed by Spence (1976) and Dixit and Stiglitz (1977).

the productivity gains from specialization are a decreasing function of σ. If the elasticity of substitution is high, firms can easily replace one variety of the intermediate good with another, and the benefits of an expanded set of intermediates is low.

Alternatively we can express total output as,

$$Y = K^{\alpha} L^{1-\alpha-\beta} Q^{\beta} A^{\beta} \tag{3}$$

where A^{β} can now be thought of as total factor productivity. Increasing the measure of varieties used increases TFP: the same quantities of L, K and Q produce a higher quantity of output. This feature of technology is central to our analysis. At the firm level it captures the productivity gains that can be obtained from using a wider range of intermediate inputs. At the aggregate level it captures the productivity gains that can be obtained from increasing specialization.

Each variety of intermediate good used by the firm requires a transformation that renders it specific to the supplier-producer relationship and gives rise to the holdup problem. The firm, however, can write and enforce a contract with each of its intermediate good suppliers that allows it to overcome the holdup. The cost of setting up and enforcing such a contract will be a function of the institutional environment in which the firm operates and the amount of intermediate good used. This being the case, and denoting by p the price of one unit of intermediate good, the total cost of purchasing qn units will be

$$Cost(qn) = qnpe^{\gamma n}. \tag{4}$$

So that total transaction costs take the form of a mark-up over the cost of the intermediate bundle.[8] This mark-up is increasing in both the range of intermediate goods used and the variable γ, which captures the efficiency of the country's institutions in reducing the costs associated to the holdup problem.

Equation (4) introduces the key trade-off in the firm's cost minimization decision. Expanding the set of intermediate goods leads to gains in productivity – the "love of variety" property of the CES intermediate aggregate discussed above. Absent transaction costs, specialization will only be limited by the existing supply of intermediate varieties ($n \leq N$). On the other hand, expanding the range of intermediate goods will increase the transaction costs that arise from overcoming the holdup problem. At the optimal n the productivity gain of an additional variety of intermediates is exactly offset by the rise in transaction costs that incorporating that variety would entail.

2.1.2 Cost minimizing

The firm chooses the range and quantity of intermediate varieties, capital and labor that minimize the sum of production and transaction costs. We start by discussing the optimal choice of intermediates, i.e., that which maximizes the

[8] We assume that there is a market for the "untransformed" intermediate varieties which determines p.

amount of I a firm can purchase for any given expenditure on intermediates, and then characterize the optimal choice of K, L and I.

The optimal basket of intermediate goods will be characterized by

$$n^* = \frac{1}{\gamma(\sigma-1)} \quad (5)$$

$$Q^* = \frac{C_I}{pe^{\frac{1}{\sigma-1}}} \quad (6)$$

$$I^* = \frac{C_I}{pe^{\frac{1}{\sigma-1}}}\left(\frac{1}{\gamma(\sigma-1)}\right)^{\frac{1}{\sigma-1}} \quad (7)$$

where C_I is the amount spent by the firm on intermediate goods and p is the price of one unit of any intermediate good.[9]. As expected, Equation (5) shows that the range of varieties used by the firm is a decreasing function of the transaction costs γ. If the production technology of the firm is such that intermediate goods can easily be substituted, then it will economize on transaction costs and concentrate its intermediate inputs in a narrow range of varieties. Hence, for a given γ, n^* is decreasing in σ.

We turn now to the second stage of the firm's cost minimization problem – the choice of K, L and I. Rearranging (6) we obtain that the cost of acquiring one unit of Q is $pe^{\frac{1}{\sigma-1}}$. The optimal capital labor and intermediate good labor ratios are therefore given by

$$\frac{K^*}{L^*} = \frac{\alpha}{1-\alpha-\beta}\frac{w}{r} \quad (8)$$

$$\frac{Q^*}{L^*} = \frac{\beta}{1-\alpha-\beta}\frac{we^{\frac{1}{1-\sigma}}}{p}. \quad (9)$$

where w are wages and r is the user cost of capital.

Combining equations (3) with (8) and (9) we obtain an expression for output per worker, y

$$y = \left(\frac{\alpha}{1-\alpha-\beta}\frac{w}{r}\right)^{\alpha}\left(\frac{\beta}{1-\alpha-\beta}\frac{we^{\frac{1}{1-\sigma}}}{p}\right)^{\beta} A^{\beta} \quad (10)$$

where the three terms at the right hand side of the equation decompose output per worker into capital accumulation, intermediate good accumulation and TFP respectively.

2.1.3 Comparative statics

Having characterized the optimal production decision of the firm, we turn now to the key question of this section. We are interested in the differential effect of a change in γ on firms with different $\sigma's$. In particular, we are interested in the

[9] We assume that $n^* < N$.

differential effects of γ on output per worker y and on total factor productivity A.

Given that $A = n^{\frac{1}{\sigma-1}}$ we can rearrange (10) so that the logarithm of labor productivity is

$$\log y = C_{(\alpha,\beta,\sigma)} + \beta \log \frac{w}{p} + \alpha \log \frac{w}{r} - \frac{\beta}{\sigma - 1} \log \gamma \tag{11}$$

where $C_{(\alpha,\beta,\sigma)}$ is a function of α, β and σ.[10] When cross differentiating with respect to γ and σ the only nonzero term will come from the TFP term:

$$\frac{\partial^2 \log y}{\partial\sigma\partial\gamma} = \frac{\partial^2 \beta \log A}{\partial\sigma\partial\gamma} = \frac{\beta}{\gamma(\sigma-1)^2}, \tag{12}$$

so that all of the differential change in output per worker across firms with different σ, that results from a change in the cost of contracting can be attributed to changes in total factor productivity. The sign of this cross derivative is positive: a rise in contracting costs will have a larger impact on the output per worker of 'low σ' firms. Faced with a higher cost of transactions, firms will choose to economize on the number of contracts they establish (or their reliance on a large number of intermediates) by cutting back on the range of intermediate goods they use. The 'low σ' firms, are those firms for which substitution is difficult, it is therefore these firms that will suffer the largest reductions in output per worker as a result of higher γ.[11]

2.2 Empirical Methodology

From equation (5) we know that n^* decreases with σ. An additional implication of the positive sign on this cross partial is that firms which for technological reasons choose a **complex** production structure (high n^*) will be hit harder in their productivity by a rise in γ. Our main hypothesis follows from this result: industries that use a more extensive range of intermediate goods (more "complex" industries) in a the U.S. (a country with low transaction costs) will have relatively lower productivity levels in countries in which the cost of establishing and enforcing a supplier relationship is higher. The key assumption is that there are sectorial differences in technology - so that some sectors are particularly well suited for a decentralized production structure. In our model this corresponds to assuming that σ varies across sectors producing different final goods.[12]

Our basic specification follows from equation (11). Looking at the right hand side of this equation one can see that the first term corresponds to a 'sector variable'. Assuming that β and α do not change across sectors, we can see that the second and third terms are 'country variables'. The fourth term is the one

[10] $C_{(\alpha,\beta,\sigma)} \equiv \alpha \log\left(\frac{\alpha}{1-\alpha-\beta}\right) + \beta \log\left(\frac{\beta}{1-\alpha-\beta}\right) - \frac{\beta}{\sigma-1} - \frac{\beta}{\sigma-1}\log(\sigma-1)$.

[11] We come back to the assumptions behind 12 later in the paper when dealing with the robustness of our main results.

[12] A regression of intermediate good use on sector confirms that there are important sectorial effects in the use of intermediate goods in our sample.

we are interested in and corresponds to the interaction between a measure of the sector's 'complexity' ($\frac{1}{\sigma-1}$) and a measure of the country's transaction costs ($\log(\gamma)$). As σ and γ are unobserved we use proxies to measure both variables.

The basic specification that results is

$$P_{cs} = \phi\,(comp_s \times f_c) + \delta_c + \delta_s + \upsilon_{cs} \quad (13)$$

where P_{cs} is the outcome in country c and sector s, typically the log of value added per worker.[13] Our main explanatory variable is ($comp_s \times f_c$), where $comp_s$ is some measure of complexity (described in detail below), and f_c is a measure of the costs of setting up reliable supplier relationships in each country. We also include country and industry dummies that absorb differences in productivity common to all sectors of an given economy (δ_c) or common to a given sector across different economies (δ_s). This empirical framework allows us to estimate the different effects of high contracting costs across sectors $\widehat{\beta} = \frac{\partial^2 P}{\partial\sigma\partial\gamma}$.

3 Description of Data and Key Variables

This section describes our sample and main variables. We describe additional control variables as we introduce them in the text. We start the section by motivating and explaining our measures of intermediate good complexity, and in doing so provide a very brief overview of input-output accounting. In the following subsection we describe our main dependent variables: value added per worker, capital per worker and a measure of total factor productivity. These variables are constructed using data from the UNIDO dataset. We also briefly describe our sample, in particular the countries included in our main specifications. The final subsection covers the institutional variables we have used to measure the legal environment - and argues that the three measures of institutions we use are proxies for the transaction costs involved in setting up supplier relationships across the countries included in out sample.

3.1 Indicators if intermediate good complexity

Cross country data on intermediate good usage is not widely available, and when it is its usefulness is limited by comparability issues. Because of this we turn to the methodology developed by Rajan and Zingales (1998) and construct measures of intermediate good use that are based on data for U.S. industries. The assumption behind this approach is that the existing structure of intermediate good use in the US is driven by technology differences across sectors, and that these technological differences persist across economies.

[13] Value added can be written in term of total output as

$$VA_s = \theta_s p_{Y_s} Y_s$$

where Y_s is output in sector s, p_{Y_s} is price of goods produced by sector s, and θ_s is the share of total output that goes to value added. Assuming that a change in γ changes $\theta_s P_{Y_s}$ in the same proportion across different sectors, we can take value added as a good proxy for Y.

We construct measures of "complexity" using intermediate good requirements from the 1992 United States Input-Output matrix. The Input-Output (IO) matrix, specifically the Use Table, provides a detailed (484 commodity) account of the commodities purchased by each industry, making it possible to determine the exact components used by each sector to produce its final output. The use of IO matrices to construct measures of sector interdependence is certainly not a new idea. There is an extensive literature using IO matrices to measure linkages (a-la Hirshman) between sectors, evaluate structural transformations etc... More recently, Clague (1991) constructs two of the variables we use (the number of intermediate sectors and the Herfindahl index) to measure sector "self-containment": the degree to which a product depends on inputs from other sectors of the economy. For Clague, sectors that are self contained rely to a lesser extent on the existing transport and distribution mechanism. He uses this measure to estimate the determinants of trade flows, and underlying productivity differences, for six developing economies.

In the US IO matrix, industries are classified according to IO categories based on the Standard Industrial Classification (SIC). The key units of study in the matrix are productive establishments, classified according to their primary activity. Classification by establishment implies that large multi-sector corporations are split into components. The same methodology is followed for value added and employment data in the UNIDO dataset. The advantage of this approach is that it allows us to obtain measures of complexity and productivity that are independent of ownership structure. The disadvantage is that we cannot evaluate the degree to which ownership structures themselves change to accommodate different institutional environments. For example, a common argument is that the *chaebols* of Korea, or the *grupos* of Latin America are an optimal response to poor institutions. Belonging to a conglomerate pools financial resources and allows the establishment of supplier networks that, by solving any holdup problem, rely much less on the external legal environment for their operation.

We have data on value added and employment for industries in the manufacturing sector classified according to the 3 digit ISIC (rev 2). To create compatible intermediate good measures, we build a cross-walk between the 484 industry IO classification and the 3 digit ISIC (Rev 2) classification using information provided by the BEA in the Survey of Current Business (see Lawson (1997)). The cross-walk is available from the authors by request. Using this cross walk it is straightforward to determine the number of IO commodities used in final good production and the amount of each commodity purchased by each ISIC manufacturing sector.

Figure (1) reproduces Chart 1 from Lawson (1997), and provides an overview of the Use Table in the U.S. IO accounts. In the table each column indicates the commodities **used** by the respective industry. To construct our measures of intermediate good usage we collapse the IO industry columns into ISIC aggregates. Based on this data we then construct the measures of intermediate good "complexity" described below. Note that the intermediate good measures are not restricted to manufacturing sectors but include all 484 sectors contained in the IO matrix.

In the simple model presented in section (2), symmetry renders $n^*_{USA,s}$ a sufficient statistic of a sector's intermediate use complexity. In practice, however, use of intermediate goods is far from symmetric. This being the case we complement $n^*_{USA,s}$ with 3 additional "complexity" measures. We want to avoid giving excessive weight to commodities from which purchases are very small, so we employ indices that capture the overall dispersion of intermediate good purchases. In particular, for each ISIC sector we constructed: a Gini index, a Herfindahl index and the share in total intermediates of the 20 largest commodities. All of these indices have traditionally been used to capture concentration in the industrial organization literature (see Tirole 1988, pp 221-23).

Except for $n^*_{USA,s}$ these indices are all decreasing in the dispersion of intermediate good use. So, for example, an industry that buys small amounts of intermediate goods from a large number of commodities will have low concentration index. To simplify the interpretation of the results, we choose to use the negative values of the three concentration measures so that "complexity" is increasing with each of the indices. Table (1) resports two of the normalized "complexity" measures for each ISIC sector in addition tro measures of intermediate good use and capital labor ratios. All of the measures are (not surprisingly) correlated.

A couple of points regarding our measures of intermediate good use. First, these indices of "complexity" are not measures of intermediate good use, or intensity. In fact the correlation between the share of intermediates in output and the Herfindahl index (for example) is only 0.2. Second, for expositional purposes we refer throughout the text to the "complexity" of sectors. Although we recognize that there are many other interpretations of complexity, in this study we choose will refer to "complexity" as the dispersion of intermediate goods across commodities.

3.2 Main dependent variables - data on industries

We obtain data on value added, employment and gross fixed capital formation from the 1997 3-digit UNIDO Industrial Statistics Database. The UNIDO database contains data for the period 1963-93 for the 28 manufacturing sectors that correspond to the 3 digit ISIC code (revision 2). A large number of countries are included in the original dataset - however the sample is constrained by the cross country availability of many of our independent variables. For our main specification our sample includes 75 economies. A list of these countries is detailed in Table (2) together with the number of sectors for which data is available. As is clear from the figure Figure (2) tthere is a high correlatin between output per worker from the UNIDO dataset and GDP per capita.

Our objective is to determine how the legal system has a differential effect on the productivity of different sectors depending on the complexity of their intermediate good transactions. Hence, our main dependent variables are all productivity measures. Although ideally we would wish to work with a measure of total factor productivity (TFP) obtaining this measure is problematic.

For a start, as capital stock data is not available, it requires construction of an estimated capital stock based on gross fixed capital formation data. Constructing this series requires assumptions about depreciation rates and extrapolating missing data, and reduces the number of available observations considerably. Construction of a measure of TFP also requires information on the share of capital in value added for each (sector $\times$ time $\times$ country) observation. This data is not available in the UNIDO dataset, so that in addition to previous assumptions, construction of a TFP measure requires a proxy for the capital share per sector.

With the above caveats in mind we use value added per worker as our main dependent variable. Specifically, we use the 1980-90 average of log value added per worker. This variable allows for a larger sample, and is assumption free. In addition, as shown in figure (2), value added per worker is also closely correlated to GDP per capita – ultimately the variable that cross country studies seek to explain. The main disadvantage of this measure of productivity is that is does not allow us to determine whether poor institutions affect output per worker via the choice of capital labor ratio or via sector TFP. Bearing in mind the limitations discussed above, we address this issue by complementing our main results for output per worker with regressions for capital per worker and TFP.

In the UNIDO dataset value added is expressed in units of local currency. To facilitate the interpretation of the estimated coefficients we convert value added for each year into constant purchasing power US dollars using PPP exchange rates from the Penn World tables.[14] We choose to work with period averages to minimize business cycle effects. Finally, we choose the decade of the 80s because of data availability.

To construct the capital stock variable we use the perpetual inventory method described in Acemoglu and Zilibotti (2001), and assume a depreciation rate of 8% per year. We convert nominal data on investment into constant purchasing power U.S. dollars, and then adjust the dollar values by US CPI inflation. To construct the TFP variable we assume that capital shares are constant across countries and over time, and equal to the capital shares in the US economy (from BEA data). This is clearly a simplification, however more detailed data on factor shares in value added is not available for a significant number of countries.

3.3 Institutional Variables

We measure the efficiency of the legal system with survey scores for corruption, rule of law and efficiency of the judiciary. All three variables attempt to measure the cost of accessing the legal system, and the probability that the outcome of this process is a fair reflection of existing laws and contracts. Our main variable, is an index of corruption. This measure is from La Porta et. al (1999), and is based on the average of monthly surveys by Political Risk Service between

[14] Because we are working in logs our main results are not affected by the choice of deflator –as long as a common deflator is used for all sectors of a given country.

1982 and 1995. Political Risk Service reports a value between 0 and 10, with 10 corresponding to the countries in which government is perceived to be less corrupt. Figure (3) plots the corruption index against GDP per capita.

The rule of law variable, measures the "equality of citizens under the law and access of citizens to a non-discriminatory judiciary". This variable is constructed by the Fraser Institute (average 1994-95), using a scale of 1 to 10, in which 10 corresponds to a better rule of law. Our final variable is the efficiency of judiciary between 1980 and 1983, from Mauro (1995). This data is based on surveys by Business International, and ranks efficiency on a scale of 1 to 10, with higher values corresponding to more efficient judiciary.

4 Regression Results

This section shows that poor institutions have a larger effect on output per worker in those sectors with a more complex intermediate structure in the United States. Specifically, we find the estimated coefficient on the interaction between measures of intermediate good complexity and country-wide measures of corruption, denoted ($comp_s \times corr_c$), to be positive and significantly different from zero at conventional confidence levels. We demonstrate that this effect is not driven by omitted country variables correlated with corruption, and is robust to sectorial controls for human and physical capital intensity. Finally, we evaluate whether our results are driven by alternative models for productivity differences – a horse race of alternative explanations. We find that even after controlling for these alternative mechanisms our interaction term is positive and significant at conventional confidence levels. We also find that the estimated ($comp_s \times corr_c$) coefficient is remarkably stable across a broad range of alternative specifications.

4.1 Baseline Results

Columns (1) through (4) of table (3) show the results of estimating equation (13) on data from the UNIDO manufacturing dataset. The dependent variable, y_{sc}, is average value added per worker in sector s of country c during the 1980's. In all cases the estimated coefficient on the ($comp_s \times corr_c$) interaction is positive and significant at conventional confidence levels. We obtain almost identical results over the period 1977-1987 and 1983-1993.[15] The interpretation of this result is straight-forward: output per worker in more "complex sectors" (in the narrow sense discussed above) is relatively higher in countries with lower levels of corruption. For subsequent analysis we concentrate on one index of complexity - the Herfindahl index. However, results are robust to the choice of any of the alternative complexity measures reported in columns (1) to (4).

To evaluate the implications of these coefficients we look at the differential effect of a one standard deviation rise in the corruption index (≈ 0.75) on the value added per worker of sectors with different degrees of complexity. Taking

[15] The estimated coefficients on the ($comp_s \times corr_c$) interaction – for the herfindhal index – are 0.212 and 0.184 respectively.

the extremes: the effect of this change on the sector with the highest complexity ($herf \approx 4.15$) will be 0.57 units larger than the effect on value added per worker of the least complex sector ($herf \approx 0.35$).[16] This differential increment in value added per worker compares with a sample mean of ≈ 10 and a sample standard deviation of ≈ 0.9.

Note that the effects of corruption common to all sectors in an economy are captured by the country dummies. Although not reported here, many of the estimated coefficients on the country dummies are individually significant at conventional confidence levels, and we can easily reject the hypothesis that country dummies are jointly equal to zero. As expected, sector dummies are also individually significant at conventional confidence levels, and we can also easily reject the hypothesis that sector dummies are jointly equal to zero.

Columns (5) and (6) include the share of intermediate goods in total sector output interacted with our measure of corruption. We include this control to evaluate the possibility that the positive coefficient on the ($comp_s \times corr_c$) interaction is due to the effects of a larger share of intermediates in output more than an increased reliance on multiple sectors (complexity). We find that including this variable does not affect our main result: the ($comp_s \times corr_c$) interaction is still positive and significant.

We obtain very similar results using the other two measures of the legal system discussed above. In the last two columns of table (3) we report the results of regressions for value added per worker using interactions between complexity and rule of law and complexity and judicial efficiency. In both cases the estimated coefficient on the interaction term is positive and significantly different from zero. For expositional purposes we center our discussion on corruption, although the main results (and the mechanism behind these results) carry through for these alternative institutional measures.

4.2 Robustness Checks

In this subsection we discuss additional hypothesis –all due to omitted variables– for why we might estimate a positive coefficient for ($comp_s \times corr_c$) in our regression of value added per worker. We are concerned with interaction terms: i.e. country variables interacted with sector variables that are correlated with ($comp_s \times corr_c$). The additional sectorial dimensions we are particularly concerned with are: capital intensity (physical and human), dependence on external finance for investment and intermediate good purchases, and recent trends in productivity growth. To address these concerns, we start with the regressions for value added per worker presented in the previous section and add plausible proxies for the – potential – omitted variables. In some cases we find that our output per worker regressions provide support for these hypothesis. In all cases the inclusion of these additional cases results in negligible changes in our estimates of the differential effect of corruption on complex and simple sectors.

[16] $(4.15 - .035) * 0.75 * 0.2 = 0.57$

4.2.1 Omitted Country Variables

To control for the possibility that our results are driven by omitted country-level variables that are correlated with the corruption index, the specifications reported in table (4) include interactions between complexity and cross country measures of financial development, capital per worker and the degree of trade openness and output measured by GDP. In all cases the inclusion of these proxies results in negligible changes in our estimates of the differential effect of corruption on value added per worker.

The lack of a well developed financial sector may have a larger impact on the production decisions of firms in sectors with complex intermediate good structures.[17] This could happen, for example, if complex sectors require larger amounts of working capital and therefore rely more heavily on short term finance. To control for the potential effects of financial development on output per worker we estimate (13) including an additional interaction between complexity and financial development. As a measure for financial intermediary development we reproduce the "private credit" variable constructed by Beck, Levine and Loayza (1999). This variable measures the ratio of credit by private financial intermediaries to the private sector over GDP. As shown in column (1), the estimated coefficient on this interaction is not significantly different from zero.

Trade openness may also have a differential impact on the productivity of sectors that use a broader range of intermediate goods. Traditionally, losses originating from trade restrictions have been chalked up to changes in the prices of a fixed variety of tradable goods. However, as argued by Romer (1994), in the presence of fixed distribution costs, trade restrictions not only affect the price but also the variety of goods available for consumption (or in this case production). A plausible hypothesis, is that the impact of this variety loss is more severe in complex sectors. Therefore, to control for the differential effect of trade openness on sectors with varying degrees of complexity, column (2) includes an interaction between trade openness and intermediate good complexity. The measure of openness we use is the average share of imports and exports over nominal GDP for the period 1980-90. We construct this series using data from the International Financial Statistics database. Again, we find that in this specification the coefficient on $(comp_s \times corr_c)$ is positive, significant and only marginally different from the estimated coefficient in our baseline specification.

Column (3) of table (4) includes the interaction between average capital per worker per country during the 80s (the variable $KAPW$, in Penn World Tables – Mark 5.6) and intermediate good complexity. The estimated coefficient is not significantly different from zero, so that the effect of relative factor abundance on output per worker does not vary across firms with different degrees of complexity. As in all previous specifications, the estimated coefficient on the $(comp_s \times corr_c)$ interaction is positive and significant.

If a subset of intermediate goods are non tradable, and production of the intermediates involves a fixed cost (be it static or dynamic) then the size of the

[17] We are grateful to Claudio Raddatz for this point.

domestic market will influence the range of intermediate goods available. To control for this mechanism, and its effects on sectors with varying degrees of complexity, column (4) includes an interaction between complexity and the size of the domestic market, as measured by GDP (in constant 1995 US dollars). Neither the interaction is significant nor the estimated coefficient on $(comp_s \times corr_c)$ changes significantly with the inclusion of this variable.

As a final control for omitted variables, we instrumentalize the corruption index using the settler mortality variable from Acemoglu, Johnson and Robinson (2001). The results of this instrumentalization are reported in column (6) of table (4). We also report OLS estimates for the instrumentalized sample in column (5). The stability of the estimated coefficient on our main interaction term corroborates our previous results: our main result does not appear to be driven by omitted country variables correlated with the corruption index.

4.2.2 Variations in Factor Intensity

To control for the possibility that our estimated coefficient on the $(comp_s \times corr_c)$ interaction is biased by a combination of cross sector differences in factor intensity and cross country differences in (relative) factor prices, this subsection introduces a series of interactions between measures of factor intensity and country variables that proxy for factor prices. We find that the estimated coefficient on the $(comp_s \times corr_c)$ interaction is still positive and significant in all specifications and remarkably stable, confirming the robustness of our main result.

Complex sectors are relatively less capital intensive (the correlation between Herfindahl and K/L is 0.4). If countries with low levels of corruption are those in which the ratio of wages to the user cost of capital is high, then our result may be biased by this omitted interaction. In terms of equation (11) this translates into omitting the term $\alpha \log(w/r)$, where $\frac{d\alpha}{d\sigma} > 0$ and $\frac{d(w/r)}{d\gamma} < 0$. This scenario would imply that

$$\frac{d^2 \log y}{d\sigma d\gamma} = \frac{\beta}{\gamma(\sigma-1)^2} + \frac{d\alpha}{d\sigma}\frac{d(w/r)}{d\gamma}\frac{r}{w} < \frac{\beta}{\gamma(\sigma-1)^2} \tag{14}$$

Analogously, our results may be biased if the intermediate intensity (β) is correlated with σ and corruption is correlated with the ratio of wages to the price of "standard" intermediate goods, p.

To address both potential omitted variables problems, table (5) reports the results of estimating an expanded version of equation (13):

$$\log y_{sc} = \phi_0(\alpha_s \log \omega_c) + \phi_1(\beta_s \log \rho_c) + \phi_2(comp_s \times f_c) + \delta_c + \delta_s + \mu_{cs}. \tag{15}$$

In equation (15) α_s corresponds to one of two measures of capital intensity in the United States: the share of capital payments in output from the U.S. IO matrix (1992)[18], or the log capital to labor ratio from the NBER manufacturing

[18] To construct this measure we follow the BEA, see Lum, Moyer and Yuskavage(2000), so that the share of capital in total output is defined as $\alpha = \frac{Other\ v.added}{Output}$.

productivity dataset, k_s (average 80-90).[19] In turn, β_s is the ratio of intermediates to total output, from the US IO matrix. We use the country level variables described in the previous subsection (corruption, financial development, capital per worker and openness) as proxies for the relative prices $\omega_c = w_c/r_c$ and $\rho_c = w_c/p_c$.[20]

Columns (1) and (2) of table (5) report the results of regressions for log value added per worker that include measures of capital and intermediate good intensity interacted with corruption: $(\alpha_s \times corr_c)$ and $(\beta_s \times corr_c)$. In both cases the estimated coefficients on $(\alpha_s \times corr_c)$ are negative, and in the case of log capital per worker, k_s, significant at conventional confidence levels. For the interaction between corruption and intermediate good share we obtain a negative and significant coefficient.[21]

The results of estimating equation (15) using log capital per worker and intermediate share interacted with the other country variables are shown in columns (3) to (8). In Columns (3) and (4) factor shares are interacted with financial development. The estimated coefficient on the capital share interaction is positive in both cases, and significant when the $(k_s \times corr_c)$ interaction is also included. In countries with poorly developed financial markets the effective cost of capital is higher (lower ω_c) so firms substitute out of capital and into labor. The consequence being lower value added per worker. A similar explanation is likely to be behind the results presented in columns (5) and (8). The estimated coefficient on the $(k_s \times openness)$ interaction is positive and significant, so that output per worker is relatively higher in capital intensive industries of "open" economies. If the openness variable is a proxy for trade barriers, and a fraction of capital goods are imported, then *cet. par.*, ω will be lower in closed economies.

The next set of specifications included in table (5) report estimated coefficients on the $(k_s \times capital\ to\ labor_c)$ interaction. Although the negative coefficient reported in column (4) is puzzling, once the $(k_s \times corr_c)$ interaction is included the estimated coefficient is positive, although no longer significant. Column (9) combines all of the previous interactions. Including these additional country×sector interactions does reduce the estimated effect of our main interaction term. Nevertheless, the estimated coefficient continues to be positive and significant.

The negative coefficient for the $(k_s \times corr_c)$ interaction is requires an explanation. For a start, the effect of this interaction cannot be explained through the channel used to justify equation (14). In that case the sign would be positive! An alternative explanation is that our corruption index is serving as a proxy to a different hold up problem, that between labor and capital. If our measure of corruption is positively correlated with the power of workers to extract rents from capital, then the result discussed above would hold. If this is case, a

[19] Note that $\ln \frac{K}{L} = \ln\left(\frac{w}{r}\right) + \ln\left(\frac{\alpha}{1-\alpha-\beta}\right)$ so that, holding $\left(\frac{w}{r}\right)$ constant $\ln \frac{K}{L}$ is increasing in α.

[20] We also included interactions of the ex-post real interest rate with capitalintensity. Our basic results where unaffected.

[21] We obtain (but do not report) similar results using the measures of capital share in value added and capital per worker constructed by the U.S. Bureau of Labor and Statistics.

measure of the level of unionization in each country should better capture this effect and, render the estimated ($k_s \times corr_c$) coefficient insignificant. With this in mind, we interact $k_s$with a measure of trade union membership as a percentage of the labor force from Rama and Artecona (2000).[22]. The results of this additional specification are reported in column (10) of table (5). The estimated coefficient on the ($k_s \times union_c$) coefficient is positive and significant: in countries with high levels of unionization labor intensive sectors are relatively less productive. Furthermore, the ($k_s \times corr_c$) interaction is no longer significant after controlling by unionization. As in all previous specifications the estimated coefficient for the ($comp_s \times corr_c$)interaction remains positive and significant.

4.2.3 Differences in Human Capital Intensity

To control for possible biases originating from sector differences in human capital intensity we estimate equation (15) substituting $\alpha_s$with measures of human capital intensity and ω with cross-country measures of human capital abundance. We use three proxies for sector differences in human capital intensity: (i) share of college graduates in the wage bill per sector, (ii) share of high school dropouts in the wage bill per sector and (iii) share of productive workers in the wage bill (a proxy for low skill workers).

The shares of college graduates and high school dropouts in the wage bill are from Autor, Katz and Krueger (1998) and are constructed from the U.S. Current Population Survey (CPS). We use the average of the 1980 and 1990 CPS data. The share of productive workers in the wage bill is an average over the 1980-90 period, and is constructed from the NBER Manufacturing Productivity dataset.

To measure cross country differences in human capital abundance we use two variables from the Barro and Lee (1996) educational achievement dataset, available for download from the NBER web page: average years of schooling and the percentage of adult population with no formal education.

The results of these estimates are reported in table (6). Although not significant at conventional confidence levels the estimated coefficient on the interaction between capital intensity and corruption is negative(columns (1) to (4)). Columns (5) and (6) show the results of including the interaction between the share of college graduates and country measures of human capital. In both cases, as expected, the effects of higher levels of country-wide human capital are large in those sectors that use educated workers more intensively. The estimated coefficients, however, are not always significantly different from zero. More importantly, as is evident from column (6) our main result does not appear to be the result of omitted interactions related to human capital intensity.

[22] The variable we use corresponds to the period 1985-1989. It includes workers of both sexes in the public and the private sectors. In some countries, union membership may include unemployed and retired workers who pay their dues. The variable is based on the number of active contributors declared by the trade unions themselves and on labor force estimates. When declared membership is larger than the labor force, a 100 percent membership rate is reported

4.2.4 External Finance and TFP growth

In their paper on financial development and growth, Rajan and Zingales (1998) find that a poorly developed financial system has a larger impact on the growth of those sectors that, for technological reasons, rely more heavily on external funds to finance their investment. Could this mechanism also affect their choice of technology and capital labor ratios? To evaluate this hypothesis we interact the Rajan & Zingales measure of external financial dependence with corruption and financial development variables in our value added per worker regressions. External finance dependence is the fraction of capital expenditures not financed by a firm's internal cash flow and is constructed from accounting data for publicly listed U.S. firms over the 80s. The results, shown in columns (1) and (2) of table (7) indicate that none of the external finance interactions is significantly different from zero, and that inclusion of these variables does not alter the estimated coefficient on $(comp_s \times corr_c)$.

In addition to financing fixed capital investment, external funds may be needed to purchase intermediate goods. If a firm operates in a country with an underdeveloped financial market, then it may alter its choice of intermediate varieties to overcome the high costs of securing financing for these goods. To control for the effects of this mechanism on our results we construct measures of short term financing relative to production costs and total sales. These measures are constructed using firm level data from the Compustat database. Specifically, they correspond to the average within each sector of the firm's ratios of accounts payable to total costs and sales respectively. These ratios are then averaged over the period 1980-1990.[23] Columns (3) to (6) report the estimates of our regression when controlling for the interaction between accounts payable and financial development. As one can observe from the table, these new variables are not statistically significant and do not affect the estimated coefficient on our main interaction.

The holdup problem that exists in specific relationships between factors of production can reduce the rate of adoption of new technologies. Because quasirents insulate the destruction margin, firms continue using outdated production methods beyond the point at which an economy with perfecting contracting would switch. As argued by Caballero and Hammour (2000) this technological "sclerosis", will be more severe in countries with poor institutions. At a sectorial level, the consequences of the "sclerosis" will be largest in those sectors that have experienced the highest rates of technological progress in recent years, as it is in those sectors that countries with poor institutions will lag furthest behind. With these mechanisms in mind, and to control for the possible effects of corruption on technological adoption and productivity, we interact our measure of corruption with two proxies for productivity growth: (i) growth in total factor productivity in the US over the 1970-1985 period and (ii) investment as a fraction of the capital stock for the US in the 1980s. The first variable attempts to measure technological change directly, the second relies on the response of investment to changing productivity.

[23] We thank Claudio Raddatz for his help in constructing these variables.

The results of these estimates are shown in columns (7) through (10) of table (7). After controlling for the interactions of both variables with financial development, the estimated coefficients on the interactions between investment and corruption and TFP growth and corruption are positive and, in the case of TFP growth, significant. Corruption has a larger effect on output per worker in those sectors in which US TFP has grown by most. These results are interesting as of themselves, and suggest areas for additional research using sector level data. Furthermore, the estimated coefficient on the $(comp_s \times corr_c)$ interaction remains positive, significant and is only marginally different from our baseline estimate.

4.3 Capital Per Worker and Total Factor Productivity

In this section we show that the differential effect of corruption on output per worker is due to differences in TFP more than to differences in capital per worker. We start by constructing estimates of capital per worker k for a subsample of countries and sectors in which long enough sequences of investment data are available.[24] To construct a measure of TFP we use the share of capital to value added from the US IO matrix as a proxy for the share of capital in value added across countries. Hence, $\log A = \log y - \alpha \log k$, where y is value added per worker. We then employ the same empirical framework used above and estimate the differential effects of corruption TFP and capital per worker.

Table (8) reports estimates of the differential effect of corruption on k and A between sectors with varying degrees of intermediate good complexity. The specification of these regressions parallels that of table (5) column (1): we successively include our main interaction term $(comp_s \times corr_c)$, an interaction between the intermediate good share and corruption, an interaction between capital intensity and corruption and the usual set of country-sector dummies.

Columns (A) to (D) show the results for the log of capital per worker, $\ln k$. Although the estimated coefficient on the interaction $(comp_s \times corr_c)$ is positive, it is not significantly different from zero in any of the specifications. If corruption has effects on $\ln k$, we cannot reject the hypothesis that these effects do not vary across sectors with different levels of complexity. The estimated coefficient on the interaction between financial development and the capital to labor ratio, on the other hand, is positive and significant, suggesting that capital intensive firms substitute out of capital to a larger degree than labor intensive firms in countries with underdeveloped financial markets.

The results for total factor productivity, $\ln A$, are shown in columns (E) through (H). Not surprisingly, given the above results, in all specifications the estimated coefficient on our main interaction is positive and significant: the effect of corruption on total factor productivity is largest in complex sectors.

[24] We construct the capital stock variable using a perpetual inventory method.

5 Conclusions

Using measures of intermediate good purchases for manufacturing sectors in the U.S. this paper shows that sectors with more "complex" intermediate structures have relatively lower productivity levels in countries with poor institutions. In a sub-sample of firms for which data on investment is available, we find that these differences in output per worker are the result of differences in total factor productivity and not capital intensity. We believe these results provide evidence for a specific mechanism through which institutions affect productivity: their effect, via transaction costs, on the use of specialized intermediate inputs.

Although beyond the scope of this paper, we believe that two sets of complementary results provide additional evidence of mechanisms through which institutional variables affect output per worker. In the first place, we find that those sectors for which productivity growth has been highest in the U.S. are relatively less productive in countries with poor institutions. This result suggests that a high transaction cost environment dampens the adoption of new technologies by insulating less productive firms from destruction and by distorting the entry incentives for new, more productive firms. In second place, using cross-country data on labor force unionization, we find evidence that labor intensive sectors are relatively less productive in highly unionized environments. If the potential hold up by labor is higher in countries with high levels of unionization, then this will affect the ex-post returns on capital and technology and may explain our findings on output and unionization.

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7 Appendix. Productivity Growth and Intermediate Shares

To complement the input-output "deepening" results, put forward by Chennery and others we directly evaluate whether those country/sectors that have increased their share of intermediate goods in output by most, are also those sectors that have experienced the highest growth rates in value added per worker. The setup is very similar to that used in the value added per worker regressions:

$$\hat{y}_{sc} = \delta_c + \delta_s + \beta \hat{\imath}_{sc} + \phi \log(y_{sc}) + \mu_{cs} \tag{16}$$

where $\hat{y}_{sc}$is the growth in value added per worker between the average for 1967-71 and 1987-91, $\hat{\imath}_{sc}$is the growth of the intermediate share in output per sector over the same period, $\log(y_{sc})$ is the log initial level of value added per worker (a catch-up term) and $\delta_c, \delta_s$are country and sector dummies respectively. We find the estimate of $\beta$to be positive and significant at conventional confidence levels:[25] growth in value added per worker has been highest in those sectors that have experienced the largest increases in their use of intermediate goods. Although we do not as yet have an explanation for the growth in intermediate good usage (i.e. technological or institutional) we do believe that this result opens a series of additional questions on the impact of specialization on output and growth.

[25] Again, we use averages to reduce the impact of business cycle variations in y. We estimate equation (16)for a sample of 73 countries and 1600 (country $\times$ sector) observations and

1. Table Sector Variables
2. Table Countries in Sample
3. Table Complexity
4. Table Country Controls
5. Table Factor Intensity
6. Table Human K
7. Table Additional Controls
8. Table A & K

1. Fig IO
2. Fig GDP vs. Productivity
3. Fig Corruption
4. Fig Parameters

Table 1: Sector Variables (normalized)

ISIC name	ISIC code	n	Herfindhal Index	Intermediates / Output	log (K/L)
Food	311	1.333	0.497	1.226	1.028
Beverages	313	0.879	0.794	0.931	1.205
Tobacco	314	0.762	1.519	0.611	1.199
Textiles	321	0.828	1.049	1.119	0.934
Clothes	322	0.806	1.232	1.105	0.567
Leather	323	0.520	1.488	1.076	0.726
Footwear	324	0.403	1.825	1.042	0.627
Wood	331	1.179	1.156	1.077	0.899
Furniture	332	1.091	0.462	0.930	0.742
Paper	341	1.018	0.983	1.052	1.159
Publishing	342	0.923	0.907	0.770	0.830
Industrial Chemicals	351	0.996	1.761	1.118	1.260
Other Chemical	352	1.165	0.586	0.929	1.227
Refineries	353	0.813	4.160	1.503	1.575
Petroleum & Coke	354	0.608	1.492	1.170	1.093
Rubber	355	0.872	0.545	0.918	0.995
Plastic	356	1.018	1.366	0.969	0.923
Pottery	361	0.520	0.560	0.665	0.828
Glass	362	0.696	0.703	0.799	1.081
Non Metallic	369	1.055	0.467	0.943	1.081
Iron	371	0.974	0.810	1.111	1.272
Non Ferrous Metals	372	0.952	0.668	1.245	1.147
Fabricated Metal	381	1.304	0.847	0.969	0.949
Machines	382	1.480	0.352	0.982	0.980
Electric Machinery	383	1.370	0.533	0.913	0.942
Transport	384	1.729	0.549	1.175	1.015
Professional & Scientific	385	1.326	0.383	0.722	0.881
Other	390	1.311	0.450	0.961	0.828
Total		0.998	1.005	1.001	1.000

Source: Authors calculations based on the U.S. IO matrix 1992 (as described in text).

Table 2: Countries Included in Main Sample

Complete country name	Freq.	Complete country name	Freq.
ALGERIA	28	KUWAIT	22
ARGENTINA	28	LUXEMBOURG	7
AUSTRALIA	28	MADAGASCAR	20
AUSTRIA	28	MALAWI	16
BANGLADESH	27	MALAYSIA	28
BELGIUM	28	MALTA	25
BOLIVIA	27	MEXICO	26
BOTSWANA	3	MOROCCO	8
BRAZIL	28	NETHERLANDS	24
CAMEROON	23	NEW ZEALAND	28
CANADA	28	NICARAGUA	26
CHILE	28	NIGERIA	23
CHINA,P.R.: MAINLAND	26	NORWAY	28
COLOMBIA	28	PAKISTAN	28
CONGO, REPUBLIC OF	7	PANAMA	25
COSTA RICA	25	PAPUA NEW GUINEA	18
DENMARK	28	PERU	28
DOMINICAN REPUBLIC	28	PHILIPPINES	28
ECUADOR	28	POLAND	28
EGYPT	28	PORTUGAL	27
FINLAND	28	SENEGAL	20
FRANCE	26	SINGAPORE	24
GHANA	27	SOUTH AFRICA	28
GREECE	28	SPAIN	28
GUATEMALA	28	SRI LANKA	26
HONDURAS	2	SWEDEN	28
HONG KONG, CHINA	26	SWITZERLAND	5
HUNGARY	27	TAIWAN, CHINA	28
ICELAND	21	TANZANIA	23
INDIA	28	THAILAND	26
INDONESIA	24	TOGO	5
ISRAEL	28	TRINIDAD AND TOBAGO	22
ITALY	28	TURKEY	28
JAMAICA	6	UNITED KINGDOM	28
JAPAN	28	UNITED STATES	28
JORDAN	26	URUGUAY	28
KENYA	25	VENEZUELA	28
KOREA	28	ZIMBABWE	28
		Total	**1884**

Source: 3 digit ISIC UNIDO Industrial Statistics Database, average 1980-90 (as described in text)

Table 3: Effects of intermediate good complexity on productivity

	Dependent variable: log (value added per worker)							
	Complexity Interacted with Corruption:						Complexity Interacted with:	
	(1)	(2)	(3)	(4)	(5)	(6)	Rule of Law	Efficiency of Judiciary
- Gini index	4.651 ***					3.566 ***		
	(1.231)					(1.218)		
Number intermediate commodities (n*)		0.211 ***						
		(0.085)						
- Herfindhal index			0.235 ***		0.192 ***		0.016 ***	0.055 ***
			(0.052)		(0.057)		(0.007)	(0.013)
- Share of top 20 commodities				0.913 ***				
				(0.241)				
Intermediates/ Output					-0.354 *	-0.607 ***	-0.037	-0.082 **
					(0.204)	(0.194)	(0.023)	(0.048)
R^2	**0.979**	**0.979**	**0.979**	**0.979**	**0.979**	**0.979**	**0.978**	**0.985**
# obs	**1884**	**1884**	**1884**	**1884**	**1884**	**1884**	**1944**	**1528**

Notes:

Robust standard errors in parenthesis. Single asterisk denotes statistical significance at 90% level of confidence, double 95%, triple 99%.

Included but not reported country and sector dummies.

Sample:

Source: 3 digit ISIC UNIDO Industrial Statistics Database, average 1980-90 (as described in text)

Table 4: Complexity and other cross country variables

	Dependent variable: log value added per worker)					
	OLS					I.V.
	(1)	(2)	(3)	(4)	(5)	(6)
- Herfindhal index x Corruption	0.197 ***	0.179 ***	0.225 **	0.187 ***	0.155 ***	0.173
	(0.067)	(0.058)	(0.106)	(0.075)	(0.067)	(0.126)
Intermediates/Output x Corruption	-0.319	-0.369 *	-0.376 *	-0.353 *	-0.291	-0.468
	(0.205)	(0.205)	(0.237)	(0.207)	(0.254)	(0.455)
- Herfindhal index x Financial development	0.004					
	(0.029)					
- Herfindhal index x Openness		0.006				
		(0.034)				
- Herfindhal index x Capital per worker			0.020			
			(0.364)			
- Herfindhal index x GDP (in 1995 US$)				0.028		
				(0.476)		
R^2	**0.981**	**0.981**	**0.833**	**0.981**	**0.985**	**0.984**
# obs	**1776**	**1777**	**1291**	**1884**	**1204**	**1204**

Notes:

Robust standard errors in parenthesis. Single asterisk denotes statistical significance at 90% level, double 95%, triple 99%.

Included but not reported country and sector dummies.

Column (6) reports instrumental variable estimates. The corruption index is instrumented by settler mortality from Acemoglu et al (2000).

Sample:

Source: 3 digit ISIC UNIDO Industrial Statistics Database, average 1980-90 (as described in text)

Table 5: Controls for factor intensity

	Dependent Variable: log (value added per worker)										
Model :	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
- Herfindhal index x Corruption	0.166 ***	0.165 ***	0.215 ***	0.168 ***	0.201 ***	0.166 ***	0.222 ***	0.150 ***	0.151 **	0.163 ***	0.144 **
	(0.055)	(0.054)	(0.054)	(0.054)	(0.068)	(0.065)	(0.052)	(0.055)	(0.065)	(0.055)	(0.065)
Intermediates / Output x Corruption	-0.687 ***	-0.295		-0.065		0.243		-0.296	0.570	-0.232	-0.236
	(0.238)	(0.207)		(0.233)		(0.345)		(0.210)	0.358	(0.208)	(0.208)
Share of capital in output x Corruption	-0.131										
	(0.092)										
K/L x Corruption		-0.345 ***		-0.544 ***		-1.042 ***		-0.409 ***	-1.378 ***	-0.065	-0.367 ***
		(0.121)		(0.154)		(0.227)		(0.126)	(0.244)	(0.157)	(0.124)
K/L x Financial Development			0.049	0.191 **					0.234 ***		
			(0.063)	(0.078)					(0.074)		
Intermediates / Output x Financial Development			-0.175 *	-0.180 *					-0.096		
			(0.093)	(0.105)					(0.097)		
K/L x Capital per worker					-0.944	1.496			1.283 *		
					(0.615)	(0.927)			(0.932)		
Intermediates / Output x Capital per worker					-1.849 *	-2.337 *			-2.550 *		
					(1.044)	(1.410)			(1.425)		
K/L x Capital per worker							0.137 **	0.200 ***	0.439 **		
							(0.063)	(0.064)	(0.177)		
Intermediates / Output x Capital per worker							-0.082	-0.039	-0.468		
							(0.093)	(0.091)	(0.241)		
K/L x Unionization										(0.010) ***	
										(0.003)	
- Herfindhal Index x Unionization											(0.001)
											(0.001)
R^2	**0.979**	**0.979**	**0.981**	**0.981**	**0.835**	**0.839**	**0.981**	**0.981**	**0.857**	**0.981**	**0.981**
# obs :	**1884**	**1884**	**1776**	**1776**	**1291**	**1291**	**1777**	**1777**	**1181**	**1771**	**1771**

Notes:

Robust standard errors in parenthesis. Single asterisk denotes statistical significance at 90% level of confidence, double 95%, triple 99%.

Included but not reported country and sector dummies.

Sample:

Source: 3 digit ISIC UNIDO Industrial Statistics Database, average 1980-90 (as described in text)

Table 6: Controls for human capital intensity

	Dependent Variable: log (value added per worker)											
	(1)		(2)		(3)		(4)		(5)		(6)	
- Herfindhal index x Corruption	0.165	***	0.174	***	0.171	***	0.184	***	0.182	***	0.184	***
	(0.055)		(0.054)		(0.054)		(0.055)		(0.055)		(0.055)	
K/L x Corruption	-0.286		-0.260		-0.315	**	-0.395	**	-0.338	**	-0.263	
	(0.156)		(0.177)		(0.129)		(0.139)		(0.141)		(0.156)	
Intermediates / Output x Corruption	-0.331		-0.309		-0.317		-0.209		-0.241		-0.290	
	(0.233)		(0.217)		(0.217)		(0.219)		(0.220)		(0.236)	
Share of college graduates in wage bill x Corruption	-0.058										-0.173	
	(0.081)										(0.120)	
Share of high school dropouts in wage bill x Corruption			0.063									
			(0.085)									
Share of production workers in wage bill x Corruption					0.133						-0.029	
					(0.155)						(0.172)	
Share of college graduates in wage bill x % of pop. with no formal ed.							-0.060				-0.185	***
							(0.043)				(0.068)	
Share of college graduates in wage bill x % average years of school.									0.019		-0.125	
									(0.056)		(0.093)	
R^2	**0.979**		**0.979**		**0.979**		**0.981**		**0.981**		**0.981**	
# obs	**1884**		**1884**		**1884**		**1803**		**1803**		**1803**	

Notes:

Robust standard errors in parenthesis. Single asterisk denotes statistical significance at 90% level of confidence, double 95%, triple 99%.

Included but not reported country and sector dummies.

Sample:

Source: 3 digit ISIC UNIDO Industrial Statistics Database, average 1980-90 (as described in text)

Table 7: Growth and financing controls

	Dependent Variable: log (value added per worker)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
- Herfindhal index x Corruption	0.160 ***	0.156 ***	0.162 ***	0.163 ***	0.170 ***	0.172 ***	0.161 ***	0.161 ***	0.149 ***	0.143 ***
	(0.055)	(0.055)	(0.055)	(0.055)	(0.054)	(0.054)	(0.055)	(0.055)	(0.055)	(0.055)
Intermediates / Output x Corruption	-0.298	-0.268	-0.265	-0.228	-0.307	-0.273	-0.284	-0.247	-0.390 **	-0.396 **
	(0.204)	(0.203)	(0.204)	(0.204)	(0.209)	(0.210)	(0.211)	(0.211)	(0.190)	(0.190)
K/L x Corruption	-0.350 ***	-0.356 ***	-0.317 **	-0.314 **	-0.319 **	-0.317 **	-0.340 ***	-0.336 ***	-0.348 ***	-0.350 ***
	(0.124)	(0.125)	(0.125)	(0.125)	(0.125)	(0.126)	(0.121)	(0.122)	(0.122)	(0.122)
External finance / Investment x Corruption	0.007	0.034								
	(0.019)	(0.022)								
External finance / Investment x Financial development		-0.017								
		(0.010)								
Accounts Payable / Costs x Corruption			(0.106)	(0.075)						
			(0.104)	(0.133)						
Accounts Payable / Costs x Financial development				-0.034						
				(0.064)						
Accounts Payable / Sales x Corruption					(0.043)	(0.024)				
					(0.030)	(0.043)				
Accounts Payable / Sales x Financial development						-0.018				
						(0.023)				
Investment / Capital Stock x Corruption							0.052	0.131		
							(0.077)	(0.091)		
Investment / Capital Stock x Financial Development								-0.053		
								(0.038)		
TFP growth x Corruption									0.012	0.038 **
									(0.014)	(0.016)
TFP growth x Financial Development										-0.019 **
										(0.008)
R^2	**0.979**	**0.981**	**0.979**	**0.981**	**0.979**	**0.981**	**0.979**	**0.981**	**0.979**	**0.981**
# obs :	**1884**	**1776**	**1884**	**1776**	**1884**	**1776**	**1884**	**1776**	**1884**	**1776**

Notes:

Robust standard errors in parenthesis. Single asterisk denotes statistical significance at 90% level of confidence, double 95%, triple 99%.

Included but not reported country and sector dummies.

Sample:

Source: 3 digit ISIC UNIDO Industrial Statistics Database, average 1980-90 (as described in text)

Table 8: Capital per worker and TFP - main specification

	log (K/L)				log (A)			
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
- Herfindhal index x	0.109	0.131	0.121		0.555 ***	0.572 ***	0.490 ***	0.365 ***
Corruption	(0.087)	(0.091)	(0.090)		(0.133)	(0.135)	(0.124)	(0.127)
Intermediates / Output x		-0.192	-0.219			0.147	0.353	-0.853 **
Corruption		(0.287)	(0.294)			(0.396)	(0.392)	(0.324)
K/L x			0.148				-1.207 ***	
Corruption			0.262				(0.257)	
Capital share in output x								-0.894 ***
Corruption								(0.145)
K/L x				0.392 ***				
Financial Development				(0.105)				
R^2	**0.750**	**0.750**	**0.751**	**0.756**	**0.966**	**0.966**	**0.967**	**0.968**
# obs :	**1258**	**1258**	**1258**	**1251**	**1224**	**1224**	**1224**	**1224**

Notes:

Robust standard errors in parenthesis. Single asterisk denotes statistical significance at 90% level of confidence, double 95%, triple 99%.

Included but not reported country and sector dummies.

Sample:

Source: 3 digit ISIC UNIDO Industrial Statistics Database, average 1980-90 (as described in text)

Figure 1: The U.S. input-output accounts - Use Table

		INDUSTRIES										**FINAL DEMAND (GDP)**							**TOTAL**
		Agriculture	Mining	Construction	Manufacturing	Transport	Trade	Finance	Services	Other	Total Intermediate	Personal Consumption	Gross Private Fixed Inv.	Change in inventories	Exports	Imports	Government Consumption	GDP	COMMODITY OUTPUT
COMMODITIES	Agricultural products																		
	Minerals																		
	Construction																		
	Manufactured products																		
	Trade																		
	Trade																		
	Finance																		
	Services																		
	Other																		
	Non-comparable imports																		
	Total Intermediate Inputs																		
VALUE ADDED	Employee compensation																		
	Indirect business tax and non-tax liability																		
	Other value added (*)																		
	Total																		
TOTAL INDUSTRY OUTPUT																			

* Other value added consists of: Consumption of fixed capital, net interest, proprietors income, corporate profits, rental income of persons, business transfer payments and subsidies less current surplus of government enterprises.

Source: Lawson (1997).

Figure 2: log (value added per worker) and log (GDP per capita PPP)

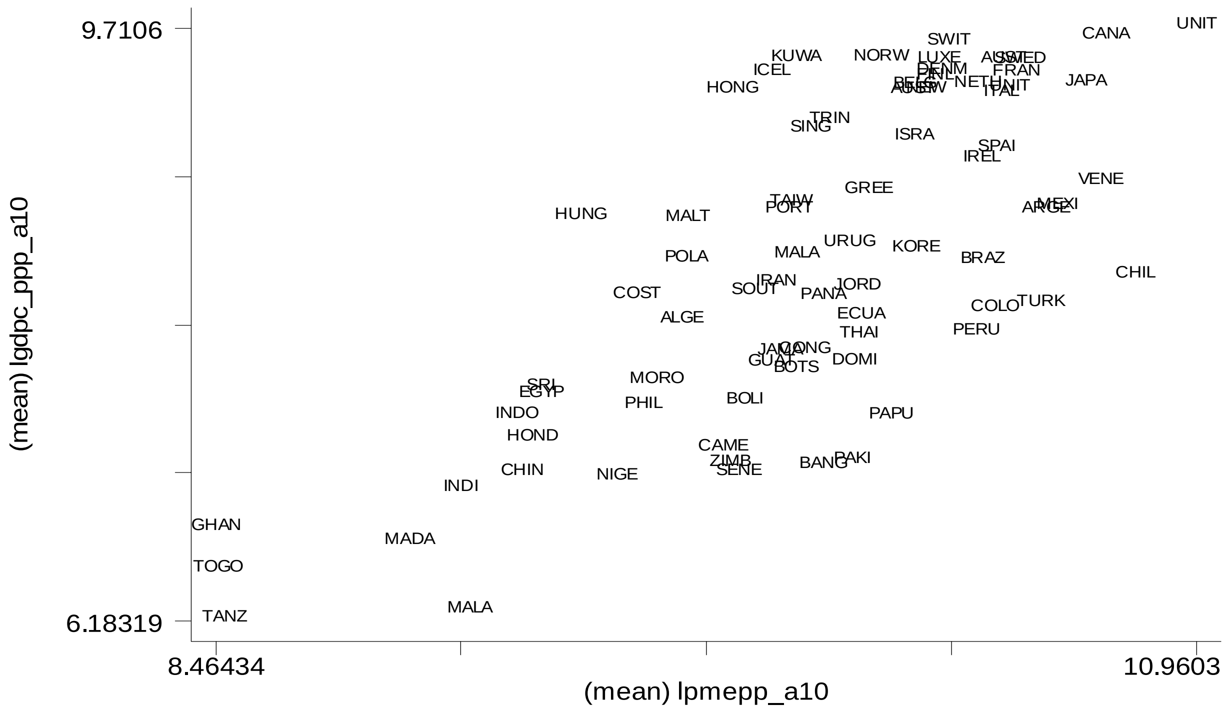
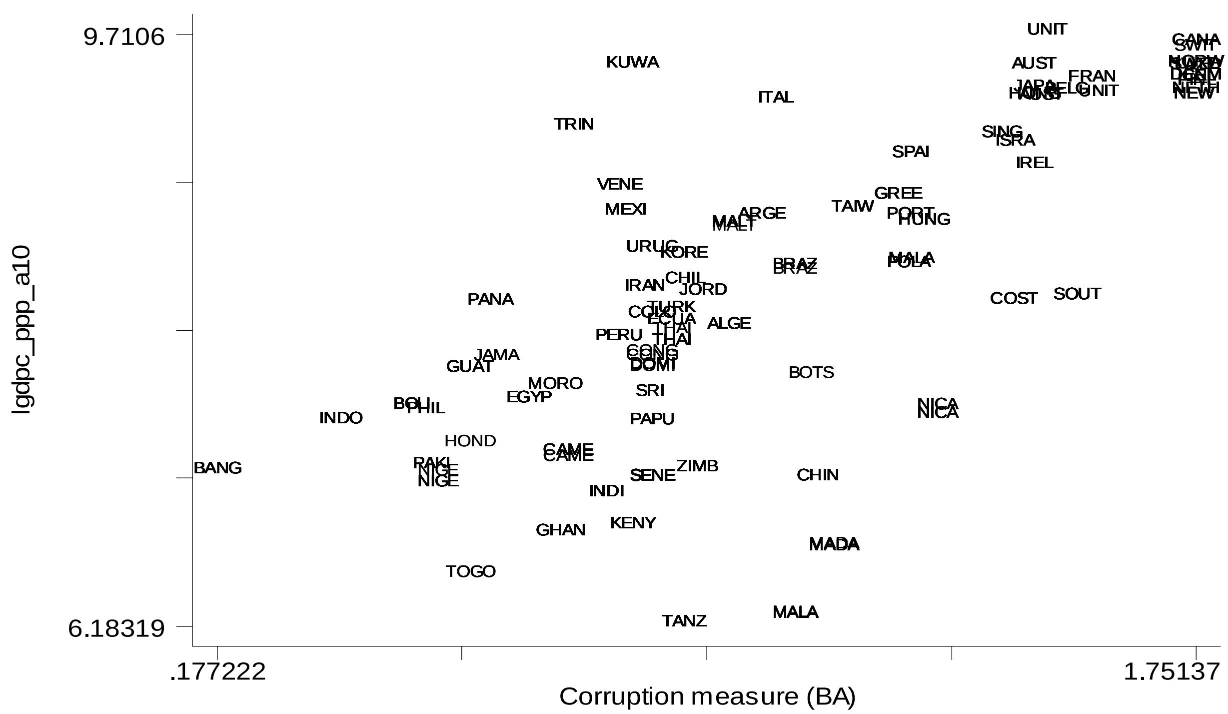


Figure 3: Corruption index and log (GDP per capita PPP)



Source: 3 digit ISIC UNIDO data, Penn World Table (5.6) and Mauro (1995).

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