Trade Liberalization and Specialization Dynamics

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Abstract

This paper advances in the analysis of the changes in economic structure induced by trade liberalization policies. Exploiting a rich sectoral data, the paper attempts to answer the following questions: a) do we in fact see trade liberalization bring about major structural changes in national productive structure? and b) when observable, do those changes conform to the patterns that classical trade theory would predict? In order to answer these questions, a statistical model of distribution dynamics to study production specialization patterns is used, and growth regression relating specialization with relative endowments are estimated, using those estimation to study the relationship between endowments, trade costs, industry characteristics and specialization in a multi-country multi-good framework.

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1 Introduction

Inspired by the idea that trade liberalization is a policy reform essential to promoting growth, a large number of developing countries undertook important trade reforms during the last quarter of the 20th century. For example, Wacziarg and Welch [2008] count almost 70 countries that liberalized their economies in the late '80s and early '90s. As a result, in the year 2000 almost 75% of countries could be considered open, compared with only 25% in 1980. This spate of massive trade liberalization represents an excellent field for analyzing openness' manifold effects on national economies.

In this paper, I will focus specifically on one such effect: trade liberalization's impact on national productive structure. Classical trade theory suggests that gains from trade are obtained by moving economic resources toward those sectors in which a country enjoys comparative advantage. The resultant expectation is that moving from restricted to freer trade will entail observable changes in countries' respective economic structures. Moreover, in the Heckscher-Ohlin model, these changes are related to relative factor endowments.

Exploiting a relatively rich sectoral data for a large set of countries, this paper attempts to answer the following questions: a) do we in fact see trade liberalization bring about major structural changes in national productive structure? and b) when observable, do those changes conform to the patterns that classical trade theory would predict?

Many specialized studies have explored the relationship between trade liberalization and aggregate economic growth.[1] While a number of these inquiries do conclude that there is a positive correlation between trade policy openness and growth, various other studies find no such correlation, and some even judge the association negative. Various factors explain why this literature is so inconclusive: difficulties in measuring trade policy adequately; the simultaneous action of several different policies, and reforms, susceptible of impacting growth; the frequent impossibility of analyzing all the relevant controls; absence of a testable counterfactual; endogeneity of the liberalization decision; etc.

[1] Earlier contributions include Dollar [1992], Sachs and Warner [1995], and Edwards [1998] . Later Rodrik and Rodriguez [2001] survey skeptically this literature. Some papers that try to address the problems stated in the latter are Greenaway et al. [2002], Giavazzi and Tabellini [2005] Wacziarg and Welch [2008] and Estevadeordal and taylor [2008].

Because these facts make it almost impossible to arrive at a final conclusion in studies of the sort, I have chosen to focus instead on whether or not liberalization episodes do in fact generate significant changes in the productive structure of the economy, independently of the possible correlation between applied liberalism and growth. To be sure, we cannot be certain those structural changes are exclusively due to trade liberalization (because of the simultaneousness of reforms as described in the last paragraph). As long as those changes prove consistent with the predictions of classical trade theory, nonetheless, at least we cannot fail to recognize that trade liberalization is a meaningful influence on industrial reconfiguration.

I will briefly discuss what this paper is not. It is not a direct test of comparative advantage. In order to test that, I would be obliged to deal somehow with data on typically unobservable autarky prices, in the vein of Bernhofen and Brown [2004]. This is an approach that I have not found practicable for the countries and the period in the sample. Also, this paper is not a direct test of the effect of endowments on the localization of production, something that has already been extensively studied.[2]

Rather, this paper is an attempt to advance in the analysis of the changes in economic structure induced by a policy of trade liberalization. In that regard, there are certain papers that can be considered relevant for the analysis developed here. For example, Wacziarg and Seddon [2004] examine the impact of trade liberalization episodes on the cross-sector movement of labor. Unlike their paper, nevertheless, mine focuses on productive specialization and not resource movements, and I also consider changes over longer periods of time. So too, Estevadeordal and Volpe [2008] have a paper similar in spirit, but their focus is on the impact of relative prices on sectoral production specialization patterns, exclusively in Latin America.

In order to answer the proposed questions, I will advance in two directions. First, I will use a transition-matrices analysis to model the dynamics of industrial specialization. In this way, I can capture the principal features of the evolution of the entire distribution of specialization indexes, addressing issues such as persistence versus mobility of industrial structure and changes in the overall degree of specialization over time.

Second, following a very simple neoclassical model linking production to endowments, I will

[2] See Harrigan [2002] for a complete survey. A major criticisms of this methodology is found in Bernstein and Weinstein [2002].

construct growth regressions where changes in the degree of specialization are related to the level of, and changes in, relative endowments. Then I will use those results to study the relationship between endowments, specialization, trade cost and industry characteristics in a multi-country multi-good framework. Here, my methodology is inspired by Markusen and Venables [2007].

Overall, evidence suggests that countries which liberalized their economies in the last quarter of the past century experienced a substantial degree of mobility, at least if we consider large transitional periods. In those countries, mobility is higher than in countries already open by that time, and those which continued to be closed. Finally, it is patent that changes in the degree of specialization depend in part on degree of capital intensity. In the sample of liberalized economies, changes from a lower level of specialization toward a higher one are more frequent than the opposite, save that the reverse is true in capital-intensive sectors.

Moreover, changes in specialization are related to countries' capital abundance only in non capital-intensive sectors. The data show no relationship between specialization and endowments in capital-intensive sectors, as when trade costs decrease the countries concerned tend not to specialize in those particular sectors. In addition, the explanatory power of endowments on specialization is higher in non capital-intensive sectors.

The next section will proceed to descriptive analysis of the transition matrices used. Section three will present the results of the econometric specification process by which I relate specialization to endowments. The final section concludes.

2 Transitional Dynamics in the Liberalized Economies

In this section, I will use a statistical model of distribution dynamics to study production specialization patterns. This methodology has been developed by Quah [1993] and Quah [1996] in the context of cross-country growth literature, and by Proudman and Redding [2000] and Redding [2002], among others, in the context of comparative advantages and specialization. Using an industry's GDP share as a measure of a country's degree of specialization, I construct transition-probability matrices that provide an accurate picture of specialization's dynamics. The main advantage of this approach is that, instead of using a particular moment of a distribution, transition matrices allow us to analyze the evolution of the entire distribution of industrial sectors' shares. Thus, it becomes possible to address issues such as persistence versus mobility in productive structure, changes in the overall degree of specialization across countries and time, and whether or not there is an increase in the degree of long-run specialization.

The choice of the measure of productive specialization $s_{ict} = \frac{Value\,Added_{ict}}{GDP_{ct}}$ (the share of industry i in country c GDP at time t) is motivated by Harrigan [1997].[3] Using the dual representation of aggregate technology, and assuming that the revenue function can be adequately approximated by a translog functional form, he shows how industry share is a theory-consistent measure of sectoral specialization and relates to relative prices, technology and factor endowments. In the next section I will come back to this model in order to test the effect of factor endowments on specialization after trade liberalization.

As we are interested in specialization within manufacturing, and given that a decline in the manufacturing sector's average share of the whole economy could drive the results, I will normalize all the data by dividing, at each point in time, the share of a sector in a country's GDP by total manufacturing's share in GDP:

$\tilde{s_{ict}} = s_{ict} \backslash \frac{\sum_i VA_{ict}}{GDP_{ict}} = \frac{VA_{ict}}{\sum_i VA_{ict}}$

Thus the normalized measure of specialization $\tilde{s_{ict}}$ is the share of industry i in the total manufacturing sector of country c at time t.

The main sample is the set of countries that, according to Wacziarg and Welch [2008], opened their economies in the '80s and '90s. Using a comprehensive survey of country case studies of liberalization, they determine the year which uninterrupted openness began.[4] At times, I will compare the results in that sample with the sample of countries that opened their economies in prior decades, and also the sample of countries that at the end of last century were still closed. Altogether, I will work with twenty-four separate industrial sectors.[5]

[3]Other papers that use the same framework are Harrigan and Zakrajsek [2000], Redding [2002], and Estevadeordal and Volpe [2008].

[4]This is the list of countries that liberalized since the end of the '70s and having data of industry value added for the beginning of the '80s and end of the '90s: Argentina, Bangladesh, Bolivia, Brazil, Bulgaria, Cameroon, Chile, Colombia, Costa Rica, Cote d'Ivoire, Czech Republic, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Ethiopia, Ghana, Guatemala, Honduras, Hungary, Kenya, Latvia, Macedonia, FYR, Madagascar, Mexico, Morocco, Nepal, Nicaragua, Panama, Peru, Philippines, Poland, Romania, Slovak Republic, Slovenia, South Africa, Sri Lanka, Tanzania, Trinidad and Tobago, Tunisia, Turkey, Uganda, Uruguay, and Venezuela.

[5]ISIC rev.2. I exclude, tobacco, petroleum refineries, miscellaneous petroleum and coal products and other manufactured products not classified elsewhere.

2.1 Construction of Transition Matrices

Following Redding [2002], let s_{ict} denote the extent of specialization of country c in industry i at time t. We can characterize the pattern of specialization at any point in time by the cumulative distribution function of s_{ict} across countries and industries $F_t(s)$. We can define a probability density function λ_t such that: $\lambda_t((-\infty, s]) = F_t(s) \, \forall s \in \Re$. The dynamics of a country's pattern of specialization correspond to the evolution of the entire cross section distribution of s over time.

This evolution can be modelled using a stochastic difference equation in the form:

$$\lambda_t = P(\lambda_{t-1}, u_t), integer\, t \tag{1}$$

where $\{u_t : integer\, t\}$ is a sequence of disturbances to the entire distribution and P maps disturbances and probability measures into probability measures. Absorbing the disturbances into the definition of the operator and assuming that this stochastic difference equation is first-order, operator P is time-invariant, and the space of possible values of s is divided into a number of N discrete cells. Then P becomes a matrix of transition probabilities.

$$\lambda_{t+1} = P^T(\lambda_t) \tag{2}$$

$$\begin{bmatrix} \lambda_{t+1}^1 \\ \vdots \\ \lambda_{t+1}^N \end{bmatrix} = \begin{bmatrix} p^{11} & ..... & p^{1N} \\ & \ddots & \\ p^{N1} & ..... & p^{NN} \end{bmatrix}^T \begin{bmatrix} \lambda_t^1 \\ \vdots \\ \lambda_t^N \end{bmatrix} \qquad p^{kl} \geq 0, \sum_l p^{kl} = 1$$

Now λ_t is a $N \times 1$ vector of probabilities that an industry occupies a given grid cell at time t and p^{kl} denotes the probability that an industry that is in grid k at time t moves to grid l. Each element of this vector, λ_t^i defines a particular level of specialization and a movement from one state to another implies a change in the degree of specialization. Thus, higher values along the diagonal of the transition matrix denote persistence, while larger off-diagonal terms indicate mobility. There exist several ways of dividing the space of possible values for s into a number of intervals. One possibility would be to make the space discrete in terms of uniformly defined states (i.e., country-industry-year observations would be divided roughly equally between the cells, generally quintiles or deciles).[6]

Note that I have implicitly assumed common distribution function of s and common stochastic process across countries (i.e., $F_{ct}(s) = F_t(s)$, $\lambda_{ct} = \lambda_t$ and $P_c = P \; \forall c$. Thus, we can pool observations across countries and industries, estimating a single transition probability matrix. We can also extend the analysis to allow for cross country heterogeneity in the stochastic process, such that different sets of countries (e.g., open vs. closed countries) have different transition matrices.

In summary, what we want to know is: given that sector i in country c is in the $k-th$ quintile/decile of the pooled distribution of specialization indexes in year t, what is the probability that this sector will be in the $l-th$ quintile/decile of the distribution in year $t+n$?

The matrix of transition probabilities could be estimated by Maximum Likelihood. (Anderson and Goodman [1957]) Denoting n_{kl} the empirically observed number of transition from state k to l, then:

$$\underset{p^{kl}}{Max} \ln L = \sum_k \sum_l n_{kl} \ln p^{kl}$$
$$s.t \quad p^{kl} \geq 0, \sum_l p^{kl} = 1$$

The solution is: $\overset{\wedge}{p^{kl}} = \frac{\sum_t n_{kl,t}}{\sum_t \sum_l n_{kl,t}}$: the number of changes from k to l in all periods divided by the total number of observations that at any point of time begin in k. The standard deviation can be estimated as: $\overset{\wedge}{\sigma}_{\overset{\wedge}{p^{kl}}} = \sqrt{\frac{\overset{\wedge}{p^{kl}}(1-\overset{\wedge}{p^{kl}})}{n_k}}$

Once the transition matrix is estimated, we can obtain the ergodic (stationary) distribution of λ. This represents the long-run distribution towards which pattern of specialization evolve, and it is presumed to remain unaltered in time. When it is compared with the initial state, the ergodic distribution provides information on the evolution of the external shape of our measures of specialization distribution. Furthermore, the ergodic distribution gives us insights into convergence or polarization in specialization across different sectors.

The stationary distribution must satisfy: $\lambda = P^T \lambda \Rightarrow (I - P^T)\lambda = 0$. Here λ is an eigenvector associated with a unit eigenvalue of P^T If there is only one unit eigenvalue, then the stationary distribution is unique and the limit stationary distribution does not depend on the initial distribution. We say in this case that the process is asymptotically stationary. The fact that P is a stochastic

[6] Alternatively, one could work in terms of proportionally defined states. Additionally, with a large number of observations, it is possible to analyze the evolution of continuous probability measures and estimate the stochastic kernel associated with P^*

matrix (i.e., $p^{ij} \geq 0, \sum_j p^{ij} = 1$) guarantees that it has at least one unit eigenvalue, and that there is some λ that satisfies $(I - P^T)\lambda$. Moreover, if P is a stochastic matrix with $(p^{ij})^n > 0 \quad \forall(i,j)$ for some value of $n \geq 1$ then it has a unique stationary distribution, and the process is asymptotically stationary (see Ljungqvist and Sargent [2000]).

The information about the degree of mobility or persistence in the pattern of specialization could be summarized by mobility indexes, defined as a continuous real function $M(\cdot)$ over the set of transition matrices, such that $0 \leq M(P) \leq 1$, where 0 implies immobility and 1 perfect mobility. Among several possibilities (See Shorrocks [1978] and Geweke et al. [1986]), we will compute the following indexes of mobility:

$M1 = \frac{K - tr[P]}{K-1}$. This index captures the relative magnitude of diagonal and off-diagonal terms (recall that the diagonal elements of P give the probability of staying in the same class). In the case of total persistence, the elements of the diagonal are equal to 1 (and then $M1 = 0$). In the perfect mobility case, all of the cells have the same value and $trace = 1$, and $M^1 = 1$. Notice that that the mean length of stay in state k is $\frac{1}{1-p^{kk}}$ so M^1 is just the inverse of the harmonic mean of these lengths, scaled by $\frac{n}{n-1}$.

$M2 = 1 - |det(P)|$. Since P is a transition probability matrix there is always one eigenvalue equal to 1 and the other eigenvalues have modulus lower than one The smaller the modulus of an eigenvalue, the faster its corresponding component converges toward an ergodic distribution. Moreover, the product of the eigenvalues is equal to the determinant of the matrix, which explains the logic of this mobility index.[7]

Finally, as the dominant (i.e., the slowest) convergence term is given by the second largest eigenvalue (ξ_2), a final index of mobility is computed as $M3 = 1 - |\xi_2|$.

Using the transition matrices, spatial homogeneity could be tested by dividing the whole sample into R mutually exclusive and exhaustive subsamples (set of countries), and testing whether transition matrices estimated for each of the subsamples are significantly different from the entire sample's estimated matrix.

In this case the null hypothesis is: $H_0)$ $p^{kl}(r) = p^{kl}$ $\forall r = 1...R$ and $H_A)$ $\exists r : p^{kl}(r) \neq p^{kl}$. If in each row of transition matrix for the entire sample there are at least two non-zero transition

[7] A problem of $M2$ is that it gives the completely mobile value when any two rows or columns of the matrix are identical.

probabilities, and each of the R subsamples has a positive number of observations, then the statistic:

$$Q^{(R)} = \sum_{r=1}^{R}\sum_{k=1}^{N}\sum_{l \in B_k} n_k(r)\frac{(\hat{p}^{kl}(r) - \hat{p}^{kl})^2}{\hat{p}^{kl}} \sim \ asy \ \chi^2\left(\sum_{k=1}^{N}(a_k-1)(b_k-1)\right) \tag{3}$$

where $\hat{p}^{kl}$ is the probability transition estimated for the whole sample, and $\hat{p}^{kl}(r)$ is the corresponding transition probability estimated for the r-th sub-sample. $B_k = \left\{l : \hat{p}^{kl} > 0\right\}$; is the set of nonzero transition probabilities in the $k-th$ row of the transition matrix estimated for the entire sample (i.e., transitions for which no observations are available in the entire sample are excluded) and $b_k = \#B_k$ the number of elements in the set B_k. Similarly $a_k = \#A_k; where A_k = \{r : n_k(r) > 0\}$ is the number of sub-samples in which observations for the $k-th$ row are available. $n_k(r)$ denotes the number of observations initially falling into the $k-th$ class within the $r-th$ sub-sample.

2.2 Results

I estimate transition probabilities over different periods of time and dividing the space of possible values of the specialization measure into five discrete grid cells.[8] Recall that the distribution of quintiles has been constructed considering the entire sample of countries that liberalized their economies since the '80s. The Value-added data are collected from Nicita and Olarreaga [2007] for the years 1980-2004.

Table 1 shows estimates for 2, 10, and 20 transition periods (i.e., we estimate the changes in value-added share for a given industry between t and $t+2$, $t+10$, and $t+20$ respectively). The first row and column of numbers denote the upper endpoint of the corresponding grid cell (for example, one quintile of all the country-year-industries have a share lower than 0.8% and one quintile have a share higher than 6.4%) . Thereafter, each row reports the estimated probability of having passed from one state into another after two, ten or twenty years. For example, cell (1,1) of the matrix is the probability that a sector in the lowest quintile of the distribution remains there, while cell (1,2) represents the probability that a sector in the lowest quintile will ascend to the second quintile after

[8]Results do not change if deciles are considered instead.

the transition period.

Table 1: Transition Matrices
Countries with Trade Liberalization in the '80s and the '90s

	0.008	0.019	0.035	0.064	>0.064
0.008	0.87	0.11	0.01	0.01	0.00
0.019	0.13	0.71	0.15	0.01	0.00
0.035	0.01	0.15	0.65	0.18	0.01
0.064	0.01	0.02	0.17	0.69	0.12
> 0.064	0.00	0.00	0.01	0.12	0.87

Transition period: 2 years

	0.008	0.019	0.035	0.064	>0.064
0.008	0.76	0.17	0.03	0.02	0.01
0.019	0.21	0.50	0.21	0.06	0.02
0.035	0.05	0.23	0.40	0.27	0.05
0.064	0.02	0.06	0.27	0.47	0.19
> 0.064	0.00	0.01	0.04	0.22	0.72

Transition period: 10 years

	0.008	0.019	0.035	0.064	>0.064
0.008	0.70	0.20	0.03	0.06	0.00
0.019	0.35	0.33	0.20	0.08	0.04
0.035	0.10	0.20	0.38	0.28	0.05
0.064	0.05	0.14	0.26	0.34	0.22
> 0.064	0.01	0.02	0.08	0.24	0.66

Transition period: 20 years

Comparison of the three previous tables reveals an obvious but useful result: the difference in the degree of mobility when we analyze dynamics using different transition periods. Values along the main diagonal (which indicates persistence) are much higher when we consider two-year changes than when we consider ten or twenty years. The estimated probability of moving out of one quintile of the distribution varies from .13 to .35 when we consider two-year changes, and from .30 to .67 for twenty-year changes. In fact, considering 20 years' transition, it is more probable that an industry in the second quintile of the distribution will descend to the first quintile than that it will remain in the second one.

Here we have an obvious finding which (Shorrocks [1978] expresses thus: "...there will be a tendency to give an inflated mobility value to the structure defined over the longer period. In a short space of time there is little opportunity for movement, even if the structure is inherently very mobile"). This result is nonetheless useful in explaining why many studies that try to link trade liberalization to either reallocation or structural transformation of the economy find little in the way of conclusive results: most of them use differences in differences or compare situations a few years before and after an episode of liberalization, considering one-, two- or at most five-year changes.

For example, Wacziarg and Seddon [2004] employ internationally comparable panel data for a broad sample of liberalization episodes in order to examine the impact of trade liberalization episodes on movements of labor across sectors. They find a positive but relatively small-scale and statistically less than robust effect of trade liberalization on sectoral 3-digit level labor reallocation. Combining results at a 1-digit level of disaggregation and a 4-digit level for the manufacturing sector, they have concluded that episodes of trade liberalization do not appear to be followed by structural upheaval.

They compute measures of structural change (specifically the magnitude of changes in sectoral employment shares) and job reallocation (to isolate the fraction of jobs that move from sector to sector independently of overall employment gains or losses) in the pre- and post-liberalization regimes, using two variants of the measures: differences in shares or reallocation over two and five years.

However, transition-dynamics analysis shows that working only with differences in two or five years creates a bias toward finding no upheaval. Factors such as previous expectations of liberalization, persistence of labor response, and counteractive policies and barriers to factor mobility could explain the (lack of) results obtained. In the robustness check portion of the paper, they do try to control for these factors, but the lack of data makes it difficult to arrive at any valid conclusions in this respect. In that sense, exploiting the fact that we now have several years of data before and after liberalization episodes, we can consider changes over larger periods of time and compare results using different spans of time.

In order to explore further the differences that arise when consider different time intervals, Table 2 presents the three mobility indexes (see previous subsection) computed for various transition periods. All the three indexes increase monotonically with the length of the transition period.

According to Shorrocks [1978], M2 and M3, while taking into account the characteristic roots of the transition matrix, have the advantage of somehow compensating for the length of the time interval. Therefore, the table shows how productive structures in the liberalized economies appear to be much less rigid when our analysis embraces enough time to observe changes in them.

Table 2: Mobility Indexes over Different Transition Periods

	M1	M2	M3
1year	0.23	0.68	0.05
2years	0.30	0.80	0.07
5years	0.42	0.92	0.12
10years	0.53	0.98	0.18
15years	0.58	0.99	0.21
20years	0.65	1.00	0.25

The foregoing analysis strongly suggests that an adequate time frame for observing significant changes in productive structure after an episode of trade liberalization is longer than those the literature usually considers. However, once having enough data to consider larger transition periods, one can ask whether or not the countries that liberalized their economies have experienced more transformations that have other economies.

Table 3 shows the mobility index (M1)[9] computed for various transition periods for three groups of countries: those that liberalized in the '80s and '90s, those that were already open before the last quarter of the past century; and those that remain closed today.

Table 3: Mobility Index M1 over Different Set of Countries and Transition Periods

	Open90	Open60	Never
1year	0.23	0.13	0.23
2years	0.30	0.19	0.29
5years	0.42	0.29	0.36
10years	0.53	0.40	0.44
15years	0.58	0.48	0.52
20years	0.65	0.55	0.57

For any transition period, mobility is higher in the group of liberalized economies. Note that results for 1- and 2-year changes are very similar between liberalized and closed economies, probably

[9]Results are equivalent when one considers M2 or M3.

because many of the transitions in the liberalized countries were computed while they were still closed (e.g., for a given country liberalized in 1990, all the data, and hence transitions, of the '80s correspond to a closed economy). Yet, when we analyze more extensive periods, the evidence shows that countries opened in this period did in fact experience deeper changes in their economic structures. On the other hand, countries that were already open seem to have shown less mobility, probably because their economic structures were already shaped before the '80s.

To further explore the differences between liberalized economies and those who were already open in the '70s, I compare transition matrices for both sets of countries and test spatial homogeneity. Table 4 shows the results, using 10-year transition periods.[10] Elements along the main diagonal are higher in the sample of economies already open in the '70s, indicating liberalized economies tended to have more mobility in their pattern of specialization during this period. To test whether both subsamples are statistically different from each other, we use 3 and obtain Q=180.77 which clearly rejects the null hypothesis of spatial homogeneity ($\chi^2_{20}(0.995) = 40.0$).

Table 4: 10 years Transition Matrices

	0.008	0.019	0.036	0.066	>0.066
0.008	0.81	0.14	0.03	0.02	0.01
0.019	0.20	0.57	0.17	0.05	0.01
0.035	0.04	0.21	0.49	0.22	0.03
0.066	0.01	0.04	0.24	0.52	0.20
>0.066	0.00	0.00	0.03	0.19	0.77

Sample: All Countries

	0.008	0.019	0.036	0.066	>0.066
0.008	0.78	0.16	0.03	0.02	0.01
0.019	0.21	0.51	0.20	0.06	0.02
0.035	0.05	0.24	0.40	0.26	0.05
0.066	0.01	0.06	0.27	0.46	0.20
>0.066	0.00	0.01	0.05	0.22	0.72

Sample: Liberalized Countries

As a last exercise, I use the ergodic distribution to study specialization in the liberalized economies. Considering the 10-year transition matrices, ergodic distribution for the whole sample is vector: $\lambda'_\infty = \begin{pmatrix} 0.22 & 0.19 & 0.19 & 0.21 & 0.20 \end{pmatrix}$. Thus in the long run, there is no trend toward

[10]The results do not change when different transition periods are considered.

	0.008	0.019	0.036	066	>0.066
0.008	0.84	0.12	0.03	0.01	0.00
0.019	0.20	0.62	0.15	0.03	0.00
0.035	0.02	0.19	0.57	0.19	0.02
0.066	0.00	0.03	0.21	0.56	0.20
>0.066	0.00	0.00	0.02	0.17	0.81

Sample: Open Economies

specialization (for in that case, we should observe higher values in the first and last quintile). So, in these liberalized economies considered as a whole, there is no indication of polarization between industries.

However, the aggregate analysis conceals the dynamics of specialization according to sector characteristics. Therefore, I will divide the sectors into two categories according to their capital intensity: low and high. Then I compare the changes from one quintile to another for each group of industries. The results are shown in Table 5

Table 5: Quintile Change/Persistence and Capital Intensity

	Non Capital Intensive	Capital Intensive	Average
Decrease	0.181	0.235	0.209
Maintains	0.594	0.564	0.579
Increase	0.224	0.201	0.212
Total	1.00	1.00	1.00
Ratio Increase-Decrease	1.239	0.852	1.019

The table shows how the change from one quintile to another differs according the capital intensity of the sectors. For non capital-intensive ones (e.g., food, garment, wood and furniture, metal products) there is a 24% more changes from a lower quintile toward a higher than from a higher toward a lower. Yet, the opposite occurs in capital-intensive sectors (typically chemicals and machinery). For the whole sample of liberalized countries, the number of increases and decreases cancels out, generating the ergodic result I commented above.

In summary, this section has made several points. a) Mobility in liberalized economies does prove significant if the analysis covers a period long enough to allow for measuring transitions. b) Mobility is higher in economies that experienced a trade reform in the '80s and '90s than in either closed economies or already open ones. c) In particular, dynamics are statistically different between economies that were liberalized in the last quarter of the twentieth century and economies that had already been liberalized before. d) Finally, the data do show a tendency toward specialization in capital-non intensive industries.

3 Trade Liberalization, Endowments, and Specialization

In this section, I will describe a precise econometric relationship between specialization and factor endowments that arises from a very simple neoclassical model. Then, I will briefly present the main results of a generalized multi-countries and multi-good factor proportion model in which specialization is determined by the interaction between relative endowments and trade costs (Markusen and Venables [2007]). Results obtained from data on liberalized countries will be compared to the main points of this model.

3.1 Econometric Specification

The starting point is a simple neoclassical model inspired by Harrigan [1995], who focuses empirically on the production side of factor-proportions theory. International differences in production are determined by international differences in factor supplies. Assuming constant return to scale and also a perfect competitive markets for inputs and outputs, a country's national product is given by its revenue function:

$$\pi(p, v) = \max_{y}\{p \cdot y \mid y \in Y(v)\} \tag{4}$$

where p, v and y are vectors of prices, productive factors and net output, and $Y(v)$ is a compact production set.

The gradient of π w.r.t p[11] gives the net supply vector:

$$y = \pi_p(p, v) = \pi_{pv}(p, v) \cdot v = R \cdot v \tag{5}$$

Where R represents the matrix of Rybczynski derivatives, whose i, kth element is: $\frac{\delta^2 \pi(p,v)}{\delta p_i \delta v_k}$. Because of that, these linear relationship between gross output and factor endowment are called Rybczynski equations.

[11] Assuming differentiability as well as linear homogeneity of y w.r.t v

With factor price equalization, R matrix is the same in all countries. Thus, (net) outputs[12] in each country are the same linear function of national factor endowments. The assumption of identical R turns this model from a standard neoclassical formulation into a model of the international location of production. Moreover, by adding very simple assumptions about consumption we can obtain the Hecksher Ohlin theorem.

Note that this result is also attainable from full-employment condition of factors: $v = A \cdot y$. Assuming there are equal numbers of goods and factors, we can invert the matrix A of cost-minimizing input coefficients, so $y = A^{-1} \cdot v \Rightarrow R = A^{-1}$.

Moreover, differences in technology can be introduced in the model (Fitzgerald and Hallak [2004]). Hicks-Neutral productivity differences are such that one unit of factor f in country c is equivalent to a_c units of that factor in a benchmark country. Hence 5 becomes:

$$y^c = R\tilde{v^c} = Ra^c v^c \tag{6}$$

Where $\tilde{v^c}$ is the vector of productivity-adjusted factors, and I explicitly introduced the superscript c to denote countries. Working with industries' value-added and three sectors (physical capital, skilled and unskilled workers[13]), and adding a disturbance term to 6 we can estimate the following regressions:

$$y_i^c = r_{ik} a^c K^c + r_{is} a^c S^c + r_{iu} a^c U^c + \epsilon_i^c \tag{7}$$

Where the subscript i refers to each of the twenty-four industries studied here. These are precisely the same regressions that Harrigan [1995] worked on.[14] Considering $L^c = S^c + U^c$ the total number of workers in country c, we can rewrite 7 as:

$$\frac{y_i^c}{a^c L^c} = r_{iu} + r_{ik} \frac{K^c}{L^c} + (r_{is} - r_{iu}) \frac{S^c}{L^c} + \tilde{\epsilon}_i^c \tag{8}$$

According to Fitzgerald and Hallak [2004] this lead to a reduced form that relates specialization

[12] One can also consider gross output, since in this simple model the share of value added in gross output is common across countries.

[13] The stock of arable land, sometimes considered a proxy for natural-resources endowment, does not add explanatory power in any of the further regressions.

[14] All his regressions has a constant that accounts for omitted endowments

to factor proportions and captures the intuition of the Heckscher-Ohlin model yet preserving a close relation to the Rybczynski estimates. They find that the term $a^c L^c$ is highly correlated with country GDP. As it is also highly correlated with total manufacturing value-added, and modifying the subscripts to explicitly allow for the time dimension, I arrive to the following regressions:

$$\tilde{s_{ict}} = \beta_{it}^0 + \beta_{it}^1 \frac{K_{ct}}{L_{ct}} + \beta_{it}^2 \frac{S_{ct}}{L_{ct}} + \mu_{ict} \tag{9}$$

Thus, β coefficients relate changes in relative factor abundance to changes in relative sectoral value added at any moment in time. It is important that these coefficients, being related to the r_{iv} of the Rybczynski R matrix, somehow reflect production techniques in a very broad sense. But what 9 actually represents is the existence of a common underlying structural relationship between factor endowments and specialization.

We are interested in the effect of the endowments over the changes in specialization in those countries liberalized in the '80s and '90s. Notice that time differences of 9 can be expressed in the following way:

$$\Delta^t \tilde{s_{ic}} = \gamma_i^0 + \gamma_i^1 \overline{\left(\frac{K_{ct}}{L_{ct}}\right)} + \gamma_i^2 \overline{\left(\frac{S_c}{L_c}\right)} + \gamma_i^3 \Delta^t \left(\frac{K_c}{L_c}\right) + \gamma_i^4 \Delta^t \left(\frac{S_c}{L_c}\right) + \Delta^t \mu_{ic} \tag{10}$$

Where the differences are taken between 2000 and 1980, and the bars represent averages over that period. γ^1 and γ^2 represent the impact of relative endowments over changes in specialization over the period. For example, a (significant) positive value for γ^1 in an industry i implies that specialization (measured as growth in value-added share) in that industry was stronger in countries that on average have higher levels of capital per worker. γ^3 and γ^4 control for the Rybczynski effect of factor accumulation over industry growth.

I will estimate 10 using the data explained in past chapter[15] and then I will compare the results with the prediction of a model that interacts factor endowments and trade cost in a multi-country and multi-god approach.

[15] See Chapter 2, section 3.

3.2 A Model of Trade Cost, Endowments, and Specialization

As stated in the previous subsection, we need a model against which results can be compared. A tractable model linking factor endowments to trade cost and to both production and trade specialization occurs in Markusen and Venables [2007]. It deals with a multi-country world where countries differ in factor endowments and trade costs alike. In this scenario, there are two factors (Labor and Capital) and production has constant return to scale and is perfectly competitive. Unit cost functions for each good i are the same in all countries and depend on factor prices: $b_i(w, r)$. There are three produced goods, varying in factor intensities. Trade in these goods is subject to iceberg trade costs varying across countries but constant within any given country.

The equilibrium location of production satisfies a set of inequalities relationships. The lower boundary of unit cost is the export price, and each good will be produced in a country only if unit cost is less than or equal the import price: $p_i t \geq b_i(w, r) \geq p_i/t, \quad i = 1, 2, 3$

Under these circumstances, equilibrium is described numerically.[16] The authors assume that preferences and production of three goods are Cobb-Douglas (the latter with symmetric factor shares, being X_1 is the most capital-intensive), and that countries are uniformly distribute over the parameter space of factor endowments and trade costs, solving for world general equilibrium for all countries simultaneously.

The following graph (taken from their paper) shows the main findings:

The horizontal axis represents country's labor abundance (one minus capital abundance) and the vertical axis represents trade cost. A given country is a point on the graph. Higher trade costs are associated with a region of autarky. As trade costs fall, countries become more specialized, Under these conditions, capital scarce (i.e., labor-abundant) countries are first seen to produce goods 2 and 3 (that is, the less capital intensive ones) and further falling implies total specialization in good 3 for those same less capital-abundant countries. Countries with lower than the average capital abundance produces goods 2 and 3, and average countries specialize in good 2. Finally, relatively capital-abundant countries either produces goods 1 and 2 or exclusively good 1. A zero trade-cost situation is characterized by multiple cones of partial diversification bounded by regions of complete

[16] In the second part of the paper they characterize the different regimes of specialization analytically, showing how they depend on key parameters of the model.

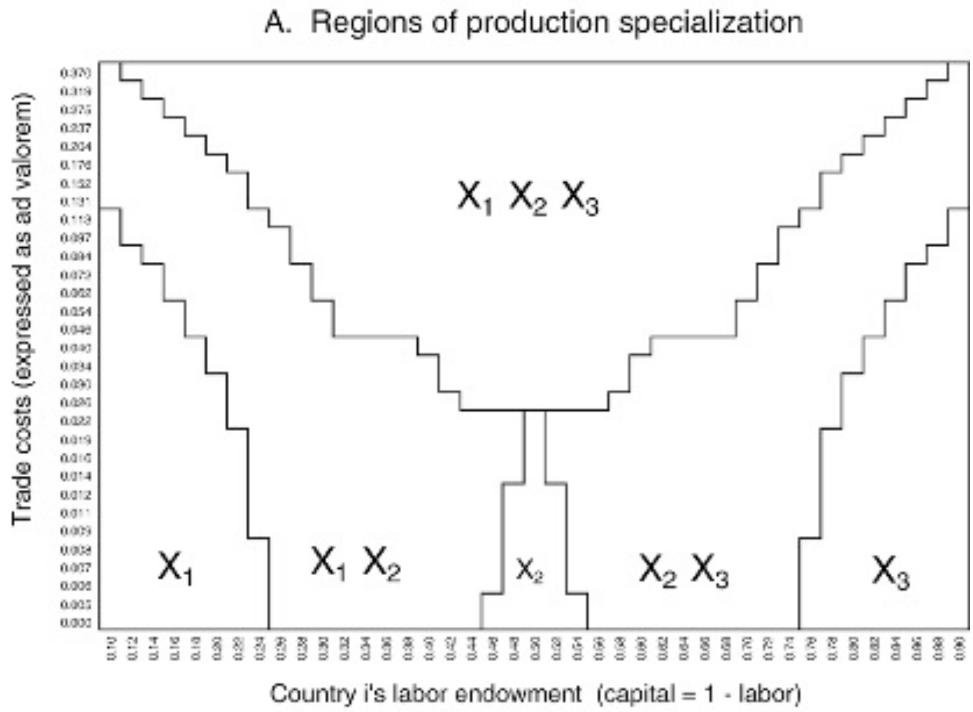

Figure 1: Regions of Production Specialization in Markusen and Venables [2007]

specialization.

Thus, according to the model, a trade liberalization reform that could be associated with a fall in trade cost would cause liberalized economies (typically those less capital-abundant than the average) to specialize in a subset of capital non-intensive goods. Within this range of countries and goods, Rybczynski effects will prevail. Thus, relatively more capital-abundant countries will produce relatively more capital-intensive goods (always excluding the most capital-intensive goods).

Having explained the main features of a model that links both trade cost and factor endowments to specialization, I will describe the main results of the regression analysis and how they relate to the main conclusion of the model.

3.3 Results and Discussion

The table 6 shows the results obtained for regressing 10 for each one of the twenty-four sectors in the sample of countries that liberalized their economies in the '80s and '90s. As comparable data on industrial value-added[17] from the beginning of the '80 and end of the century are needed, I provide data on twenty five countries.[18] Many countries have missing values in some sectors, and differences in shares have been considering over the same set of sectors.[19]

The table shows the standardized coefficients of the regression (for each sector) of variations in the sectoral value-added share between early 80's (on average data from 1980-1983) and the late '90s (average 1998-2001) with respect to averages and differences in capital per worker, and proportion of skilled over total labor. An explanation of how those variables were constructed, and the sources for the data is found in the previous chapter, section 2.3.[20]

Although initially it seems not much information can be extracted for the table, my contention is that the results (more especially those related to the average capital abundance of a country) are consistent with the main conclusions of the model presented in the previous sub-section.

To see that, first consider the relative capital abundance of the countries in the sample (i.e., those that opened their economies in the last quarter of the last century). Figure 2 shows the histogram of their capital abundance, measured as average capital per worker for the world and for the liberalized economies. It is clear that the sample of the latter (transparent bars) are located at the left tail of the distribution.

According to the Markusen and Venables [2007] model, capital-scarce countries do not specialize in products which are capital intensive. Instead, they specialize in less capital-intensive sectors as trade costs decrease, there being a positive relationship between relative capital abundance and capital intensity of goods (within that range of less capital-intensive goods). Thus, if we graph a scatter of γ_i^1 (the coefficient that relates specialization to capital abundance) and sector capital intensity, we should observe a positive relation for lower levels of capital intensity. We do not necessarily observe any kind of relationship for capital intensive-sectors, as none of the countries studied specialize in those sectors.

[17]Using production output gives like results. I prefer to work with value-added as it is the adequate theoretical measure of specialization

[18]This is the list of the countries: Argentina, Bangladesh, Bolivia, Cameroon, Chile, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, Ethiopia, Hungary, Kenya, Madagascar, Mexico, Panama, Poland, South Africa, Sri Lanka, Tanzania, Trinidad and Tobago, Tunisia, Turkey, and Uruguay.

[19]This means that if, for example, a country has data for one sector for the '80s but not for the '2000s, that sector is excluded, and total manufacturing value-added is computed summing the remaining sectors.

[20]It is important to recall, for example that skilled and unskilled workers are expressed in efficiency units.

Table 6: Regression Coefficients

Isic	Sector Name	Average $\frac{K}{L}$	Average $\frac{S}{L}$	$\Delta\frac{K}{L}$	$\Delta\frac{S}{L}$	R2	Obs
311	Food	.525**	.164	-.277*	-.054	.446	23
313	Beverages	.195	.104	-.16	.021	.076	23
321	Textiles	.392*	.316	-.148	-.072	.305	24
322	Apparel	-.542***	.308	.136	-.341	.289	22
323	Leather	-.207	-.13	-.033	.278	.072	21
324	Footwear	-.417*	.238	-.025	-.369	.247	20
331	Wood	.194	-.602	-.009	.211	.164	22
332	Furniture	-.435	.525	-.04	-.262	.14	24
341	Paper	.025	.055	-.112	-.17	.021	25
342	Printing	.228	.063	.085	-.129	.074	24
351	Ind.Chemichals	.13	.117	-.233	.12	.117	21
352	Other.Chemicals	-.13	.224	.101	-.013	.04	24
355	Rubber	-.412	-.092	.511*	.439	.209	21
356	Plastic	.418*	.122	.21	-.043	.348	24
361	Pottery	-.831*	.07	.356	.242	.347	21
362	Glass	.072	-.066	.172	.147	.049	24
369	Minerals	-.125	-.233	.175	.311	.039	21
371	Iron.Steel	.006	.126	-.157	-.173	.022	25
372	Metals	-.096	-.764**	-.069	.561*	.286	24
381	Metal.Products	-.124	.19	.576***	-.147	.344	21
382	Machinery	.414	.409	-.341	-.406	.182	21
383	Electrical.Mach	.191	-.424	.523	.191	.26	21
384	Transport	.191	-.091	.253	.369	.266	22
385	Scientific.Equipm	.228	.158	.079	-.203	.074	24

Standardized Coefficient. Dependent variable is $\Delta^t \tilde{s_{ic}}$, the growth in sectoral value added share in total manufacturing value added between the early '80s and late '90s. ***Significant at 1%, **5%, *1%. Significance obtained using robust standard errors.

Figure 3 confirm this intuition. The first column of table 6, showing standardized coefficient (γ_i^1 in 10) are plotted against sectoral capital intensity, measured as real capital per employee ratio expressed relative to the same ratio for US manufacturing as a whole. Broadly, sectors are divided into: capital-intensive (above-average ratios of of $\frac{K}{L}$), and intermediate and non-capital intensive (ratio lower than half the average).

High capital-intensive sectors have in general coefficients close to zero. For those sectors relatively less capital-intensive (i.e., below the average) there is a clear positive relationship between intensity and the coefficient linking endowment with specialization. In general, the less capital-intensive sectors have a negative coefficient (i.e., the more capital-abundant a country, the less it specializes in this sector), while intermediate capital-intensive sector generally have positive coefficients. The only sector that appears not to follow the rule would be Rubber (355). In the graphs,

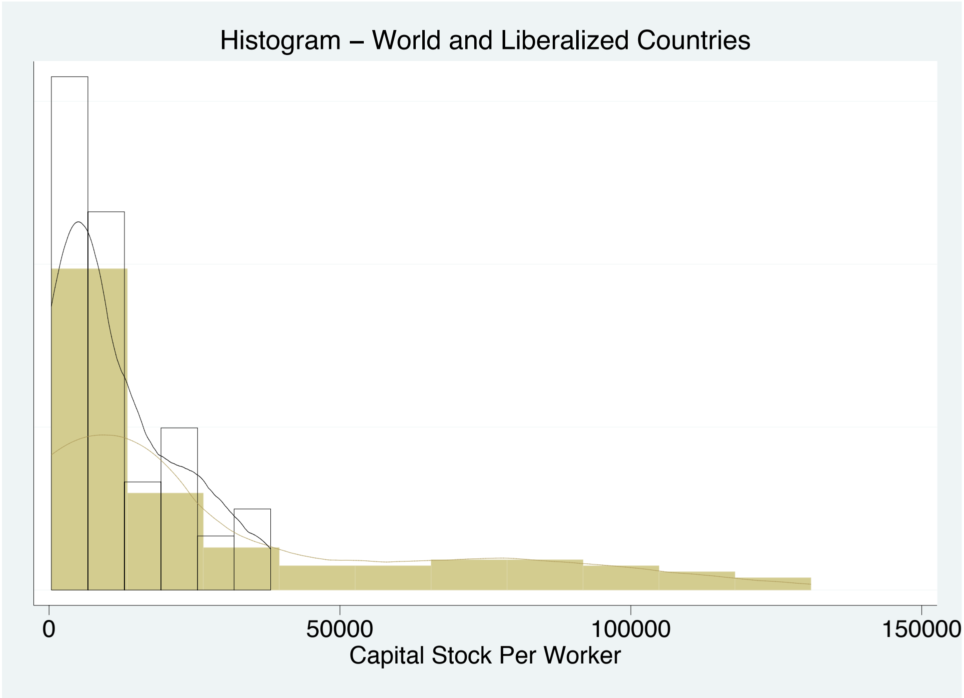

Figure 2: Histogram - Capital Stock per Worker

regression lines are computed only for those sectors with a below-average capital ratio.[21]

These findings are clearer if, instead of using the coefficient value, we graph the t statistic against capital intensity (Figure 4). Even tough the small sample size makes most of the coefficients being non-significant, there are some sectors with negative significance of the coefficients relating specialization to endowments at lower levels of capital intensity, and there are also some sectors with positive significance at sectors with intermediate levels of capital per worker ratio. No one sector with a ratio of capital per worker higher than the average has a significant coefficient, and in general, t statistics related to those sectors are close to zero.

Thus, the data would seem to indicate that there is indeed a positive correlation between capital abundance and specialization, and sector capital intensity, once one controls for the accumulation of factors. However, this relationship is to be found only in the relative non capital-intensive sectors. This is precisely what the model of Markusen and Venables [2007] predicts for those countries that experience a reduction in trade costs, a situation that I relate to the process of trade liberalization.

[21] Alternatively, one could work with other measures of capital intensity, like ratio of real capital to value-added. Results does not vary significantly, since the order in practically the same.

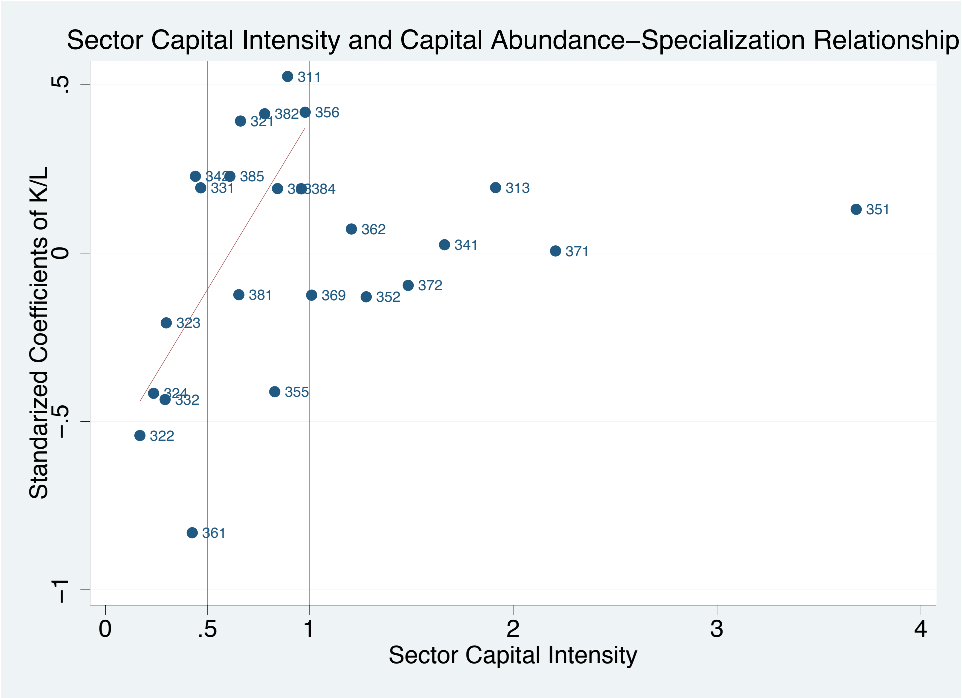

Figure 3: Scatterplot - γ_i^1 and sector capital intensity

Countries with a lower level of capital abundance specialize in non capital-intensive sectors such as Apparel, Footwear or Pottery, and intermediate capital-abundant countries (relatively speaking, the capital-abundant ones in the sample) specialize in intermediate capital-intensive sectors such as Food, Textiles or Plastic. There is simply no pattern whatever in capital-intensive sectors like Chemicals or Steel, because no country in the sample is capital-abundant relative to the rest of the world.

However, when one scatters the second coefficient of regression 10 (the one related with skilled-labor abundance) with a measure of sectoral skilled intensity (ratio of non-production workers over total employees), the results exhibit no clear pattern. Both skilled and non-skilled intensive sectors show a (non-significant) positive correlation between relative abundance and specialization. Clearly these results fit better when we analyze the relationship between specialization and relative capital abundance.

Finally, Figure 6 graphs the R^2 of the regressions in 10 against sectoral capital-intensity. The explanatory power of average levels, and of changes in endowments (capital and skilled labor)

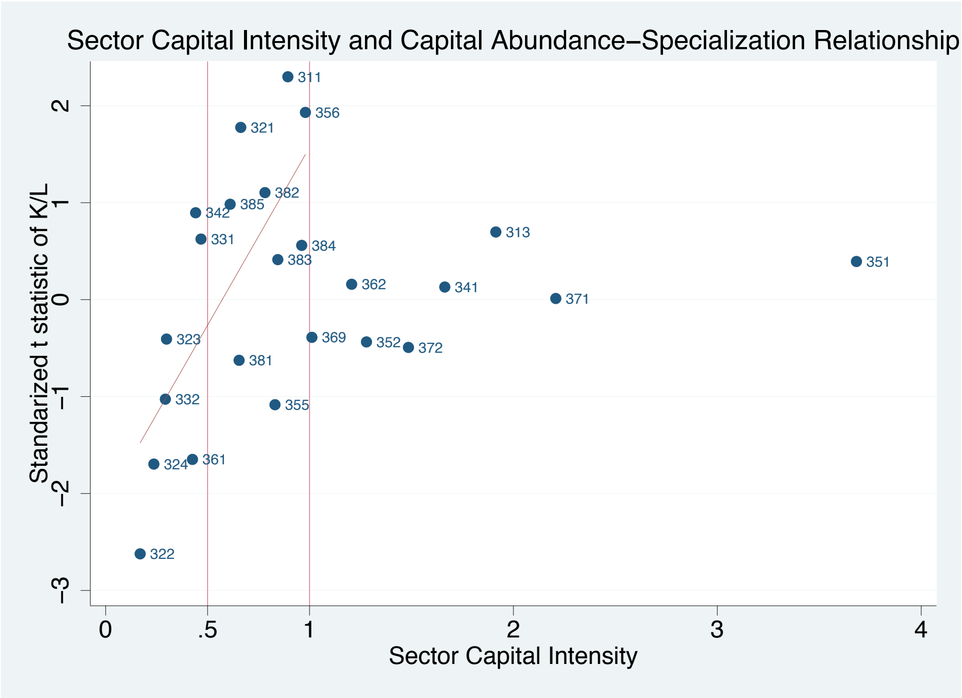

Figure 4: Scatterplot - $\frac{\gamma_i^1}{\sigma_{\gamma_i^1}}$ and Sector Capital Intensity

with regard to specialization is higher (for the sample of liberalized countries) in non capital-intensive sectors. Actually, in most of the capital intensive ones, R^2 is lower than .10, while in the rest of the sectors it averages 0.24. In summary, data seem to support the main prediction of a simple multi-country multi-good factor proportion model. For countries that reduced their trade cost significantly in the period, through a process of trade liberalization, there exists a positive relationship between capital abundance and specialization only in some set of sectors, those with lower levels of capital intensity. No relationship is found in capital-intensive sectors, as the countries in the sample did not specialize in those sectors. The relationship can be observed if we rank the sectors according to their capital-labor intensity, but not if we rank them according to their skilled or non-skilled labor intensity. Finally, the explanatory power of endowments (both levels and changes) with regard to specialization is higher in labor-abundant sectors.

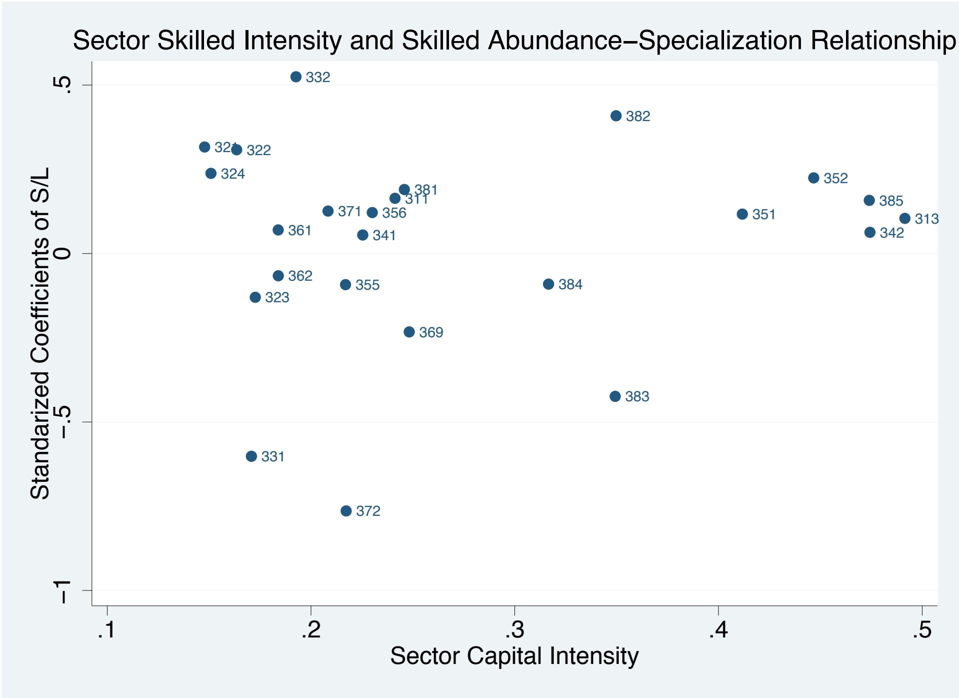

Figure 5: Scatterplot - γ_i^2 and sector skilled labor intensity

4 Conclusion

Considering that the massive trade-liberalization episodes at the end of the last century could help us to understand better some openness' effects on national economies, this paper has focused on the liberalization's effects on given countries' productive structures. Having twenty years of value-added data for a number of trade-liberalized countries, one can compare how the productive structure was before with respect to the situation existing several years after the reforms took place. Thus, I have been able to study the medium-run changes that compensate from those short-run adjustments that frequently biases the results of previous studies.

In particular, the paper had tried to answer two questions: a) do we observe major structural changes in the productive structure within countries after a process of trade liberalization? and b) do such changes in the productive structures conform to the pattern that classical trade theories would predict?

In order to resolve the first one, I have conducted a descriptive analysis using transition matrices

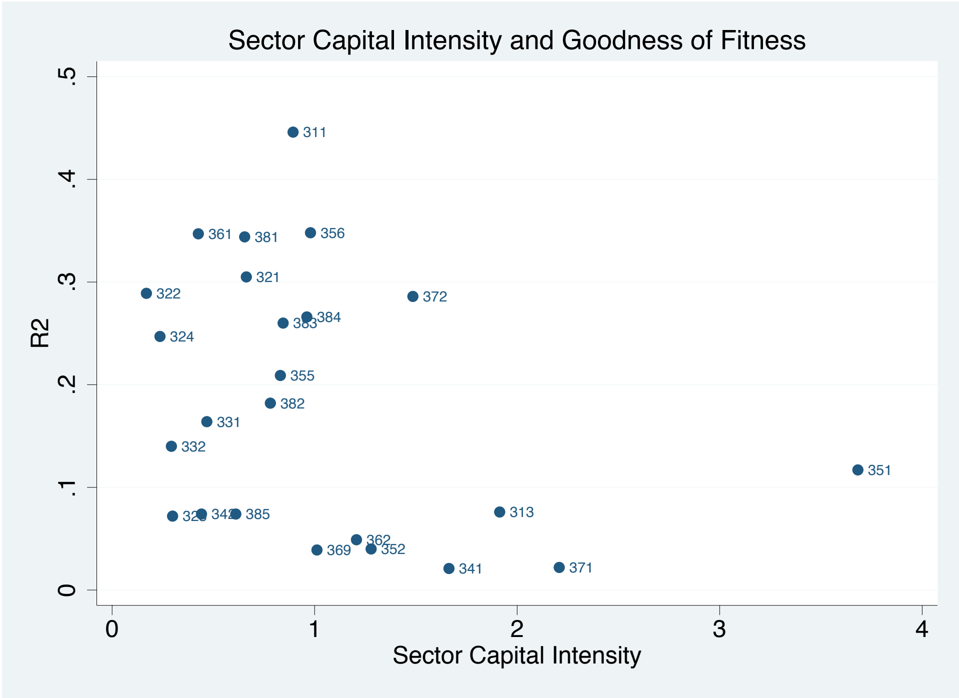

Figure 6: Scatterplot - R^2 and sector capital intensity

and a dynamic model of specialization. This has shown that, when one analyzes sufficiently large transition periods, mobility in liberalized countries is relatively high, in particular higher than in already open or non-liberalized economies.

To answer the second question, I based my regression strategy on a neoclassical model of production. Then I compare the results obtained with a multi-country multi-good factor proportion model showing the interaction of factor endowments and trade cost with production specialization. The data used have confirmed the basic intuition of the model: i.e., for relative capital-scarce countries, reduction in trade cost provokes specialization in a set of non capital-intensive goods, and (for this set of goods) there is an observable positive relationship between capital abundance and specialization. This relationship however, is not seen in the set of capital-intensive sectors, as none of the countries in the sample were specialized in that kind of activity.

Overall, we can not rule out the effects of trade liberalization on productive structure. Changes in such structure seem to be correlated with endowments, as classical theories predict, but this last finding is far from conclusive.

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