

The evolution of world export sophistication and the Italian trade anomaly

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Abstract

This work provides an empirical assessment of the sophistication level of the Italian international specialization pattern from 1980 to recent years. In particular we present an original analysis which explores the intertemporal co-evolution of the newly proposed PRODY index of export sophistication (Hausmann *et al.* 2005, 2007) with standard measures of revealed comparative advantage. We argue that the results of this exercise can shed light on the Italian 'trade specialization anomaly' [**JEL Codes: C14, F14**].

Questo lavoro presenta un'analisi empirica del grado di sophistication delle esportazioni italiane per il periodo dal 1980 fino ad anni recenti. Proponiamo, in particolare, un originale tentativo di comparazione fra l'evoluzione della distribuzione settoriale dei vantaggi comparati rivelati, e la dinamica degli indici PRODY, recentemente introdotti nella letteratura che lega crescita economica e caratteristiche delle esportazioni (Hausmann *et al.* 2005, 2007). I risultati di questo esercizio fornisce alcuni nuovi spunti interpretativi sulle anomalie della specializzazione internazionale italiana.

1 Introduction

There is widespread consensus among economists and policy makers on the idea that economic growth of a country is to an important extent determined by its external performance. A number of theoretical models has also shown that the strength of this link heavily depends on the sophistication levels associated with the specialization pattern of a country (Kaldor, 1966; Thirwall, 1979; Pasinetti, 1981; Dosi *et al.*, 1990; Grossman and Helpman, 1991). This theoretical apparatus has been largely employed in the debate on the performance of the Italian economy, and often invoked to support the claim that one major difficulty for the country lies in its mis-directed pattern of specialization.¹ Indeed, it is very well known that Italy is characterized by a peculiar 'trade specialization anomaly' (Onida, 1999), consisting of *a*) strong comparative advantages in low-skilled and labor intensive sectors, implying that Italy, in terms of specialization, is much more similar to an emerging economy than to countries with comparable levels of per-capita income; and *b*) a remarkably high degree of persistence of such a peculiar structure of specialization (Epifani, 1999; De Benedictis, 2005; Monti, 2005).

The view that the sophistication content of the specialization pattern does matter for economic growth, despite theoretically well grounded, it is very difficult to test empirically. The results of the few studies attempting to do that strongly indicate that openness is not growth enhancing *per se*, but, rather, it is important to consider the type and the characteristics of the sectors which a country is specialized into. Dalum *et al.* (1999) convincingly show that the technological characteristics of the specialization pattern are important to explain growth differentials. Similarly, Feenstra and Rose (2000) find a strong relationship between what they call an 'advanced export structure', on the one hand, and higher productivity levels and faster growth rates, on the other.

¹For an opposite view see Faini (2004).

An important contribution to this line of research comes from the recent work by Hausmann *et al.* (2005, 2007), also developed in Rodrik (2006), where a new quantitative measure of sophistication of exports is presented. Specifically, they introduce an index – called PRODY – which returns, for each traded sector (product), a weighted average of the per-capita incomes of the countries which are exporting in that particular sector (product). Sectors are therefore ranked in terms of their productivity/income content, whence the name of the index. Based on this, a measure of the overall sophistication associated with the export vector of a country – called EXPY – is also computed, and shown to be a good predictor of subsequent growth.

This recent evidence, supporting that the specific type of products exported do matter for the growth records of a country, with more sophisticated sectors displaying higher growth enhancing potentials, turns particularly relevant when considering the Italian economy. Indeed, the most remarkable feature of the Italian 'specialization anomaly' is that Italy, notwithstanding its apparently misdirected specialization pattern, has for a long time enjoyed satisfactory growth records. The problem is that such positive link does not seem to characterize the country anymore. Why ? Can the evolution of world trade sophistication help explaining the trend observed in recent years ?

Our paper is an attempt to answer these questions. To do that, we structure the study into three steps.

The first contribution of the article is to pursue an analysis of the intertemporal evolution of the PRODY index. Extending the work by Hausmann *et al.* (2005, 2007) we highlight some crucial dynamic properties of this measure and then compute its value for three reference years, 1980, 1990, and 2000, over a sample of 90 countries and 777 traded products. We find evidence of significant changes occurred in the sectoral ranking of sophistication levels during the last twenty years, and

we argue that the entry of many low-medium income countries into international trade is largely responsible for the observed dynamics. Then, as a second step, we turn to Italy and describe the characteristics and the evolution of the specialization pattern of the country in between 1977 and 2004. The exercise is conducted with a finer level of sectoral disaggregation with respect to previous studies about Italy, but our results confirm much of the existing evidence: the structure of comparative advantages has been highly persistent and characterized by a pronounced bimodality. Finally, we present two complementary methodologies which are useful to evaluate the sophistication levels associated with the specialization pattern of a country. The first one is based on the EXPY index presented in Hausmann *et al.*(2005, 2007). The second represents our original contribution and consists of exploring the co-evolution of the sectoral PRODY indexes with a standard measure of sectoral specialization. Both the methods are then applied to Italy, allowing to provide a quantitative assessment of the evolution of export sophistication in this country over the period considered.

Overall, our findings suggest a possible answer to our initial questions. Ultimately, the evolution of world trade seems the very reason why the 'specialization anomaly' of Italy, which did not prevent to achieve sufficiently good growth performances in the past, has instead started to become a point of weakness for the economy in more recent years, since the late '90s at least. Indeed, while the changes occurred in the PRODY indexes reveal that, during the last two decades, the entry of new competitors (emerging countries in particular) as well as a vast world-wide redistribution of production have significantly changed the relative gains associated to exporting in each specific sector, Italy has remained stuck to its initial specialization pattern. A problem then arises because most of the sectors wherein Italy has persistently been, and still is, highly specialized, are characterized by an intertemporal decrease in the associated PRODY index, entailing a reduction in

their sophistication content as compared to the past.

The paper is organized as follows. In Section 2 we introduce the PRODY index and provide a theoretical discussion of its crucial dynamic properties. Section 3 presents a set of parametric and non-parametric exercises exploring the evolution of the index during the period 1980-2000. The evolution of the Italian specialization patterns is then analyzed in Section 4. Section 5 applies to Italy the two methodologies proposed to evaluate the sophistication associated with international specialization of a country, namely the EXPY index and our novel analysis of the co-evolution of the PRODY indexes with sectoral comparative advantages. Section 6 concludes and suggests directions for future research.

2 Measuring sophistication of exports: the PRODY index

In this section we introduce the PRODY index, discussing its use as a measure of sophistication of traded sectors, and we describe some of its dynamic properties.

Recently proposed in Hausmann *et al.* (2005, 2007), the index is defined as

$$PRODY_t = \sum_{i=1}^N s_{i,l} \cdot y_i \quad , \quad (1)$$

where y_i stands for the real per capita GDP of the i -th ($i = 1, 2, \dots, N$) country exporting in sector l , while the weight

$$s_{i,l} = \frac{RCA_{i,l}}{\sum_i RCA_{i,l}} \quad (2)$$

normalizes country i 's Balassa index of Revealed Comparative Advantage (RCA) with respect to those of all the countries exporting in the same sector (Rodrik,

2006).²

The PRODY index is thus a sectoral measure returning a weighted average of the levels of development (proxied by per-capita income) of all the countries producing and exporting in a given sector. By construction, sectors with high values of PRODY are those where high income countries play a major role in world exports. Therefore, under the reasonable assumption that high income/high wage countries display a strong presence in sectors wherein comparative advantages are determined by factors other than labor cost (such as know-how, technological content, intrinsic quality, and so on), then sectors with an high PRODY index are more sophisticated than sectors with a low value of the index. To the extent that such factors set the stage for non-perfectly competitive environments, an high value of PRODY in a given sector also signals that higher profit margins and, thus, greater growth opportunities are associated with producing and exporting in that sector.³

In the study of Hausmann *et al.* (2005, 2007) a static analysis is provided, computing a single value of each sectoral PRODY index as a three-year average for 1999-2001. We pursue a complementary dynamic perspective, and examine the evolution of the PRODY indexes over time. The idea is that intertemporal changes in both the value and the ranking of the indexes can reveal if significant mobility and transformations have taken place in world production and trade over

²Recall that the Balassa-RCA index is defined as:

$$RCA_{lit} = \frac{X_{lit}/X_{it}}{X_{lw}/X_w} \quad (3)$$

where X denotes the value of exports, l the sector, i the country, t the year considered, and w stands for the world economy. The index measures the importance (in terms of value) of sector l in the export bundle of country i with respect to the importance of sector l in worldwide export flows. If the index is bigger (smaller) than 1, then country i is said to be specialized (de-specialized) in sector l .

³On this interpretation see also Lall *et al.* (2006).

time. In addition, recalling the above mentioned relationship between sophistication and the growth enhancing opportunities stemming from exports, intertemporal changes in PRODY may also indicate whether the potential contribution to economic growth associated with trading specific goods has changed with time. Therefore, following the dynamics of the PRODY index should provide us with a quantitative assessment of these events.

In order to understand and interpret the observed intertemporal movements of the index it is however necessary to describe how the index responds to changes in its main determinants. These are *a)* the income levels and the extent of specialization of the countries involved in world exports of each sector; and *b)* the number of exporting countries in each sector, resulting from entry and exit dynamics. From the above definition 1, one can make the following statements. First, an increase (decrease) recorded in the per-capita income of one of the countries exporting in sector l increases (decreases) the value of the PRODY index of the same sector l , proportionally to the share of world exports of sector l which pertains to that country. Second, the effect on the PRODY index of sector l due to an intertemporal change recorded in the degree of specialization of one of the countries exporting in the same sector l depends in a non-trivial way on the simultaneous modifications occurring in the distribution of export shares across all the countries involved in world exports of sector l (see Di Maio and Tamagni (2007) for a derivation). Third, the way in which entry and exit of different exporting countries affect the value of each sectoral PRODY crucially depends on the relative income levels of the new as compared to the already exporting countries: the higher (lower) the per-capita income of the entrant country *vis a vis* the income level of the incumbents, and the stronger the increase (the decrease) which is expected in the index of a given sector.⁴

⁴See Proposition 1 in the Appendix for a precise statement and a formal proof of this property

The last consideration is particularly important for two reasons which are both closely connected with the dynamic perspective which we pursue here. First, because the property provide a guidance to attach an economic interpretation to the empirical evidence about the evolution of the PRODY indexes which we are going to present in the next section. Second, the peculiar effects of entry and exit of different exporting countries makes explicit that our attempt to follow the intertemporal evolution of PRODY indexes requires specific care in the construction of the dataset. Indeed, in order to avoid mis-measurement of each sectoral index over time, it is not enough to gather information on the largest possible number of countries. It is also essential to maximize the number of countries for which data are available and reliable over the *entire* sample period considered.⁵

3 Evidence on the dynamics of PRODY

In this section we present our empirical analysis of the evolution of the sectoral PRODY indexes, focusing on the dynamics observed across three reference years, 1980, 1990 and 2000. Exploring parametric and non-parametric exercises our main goal is to document the extent and the directions of the changes occurred.

We use Penn World Tables 6.2 for data on per-capita income, measured in 1996 US dollars, PPP adjusted. Trade data come instead from the UN Commodity Trade Statistics Database (COMTRADE). For each country present in the dataset, the latter reports detailed yearly figures on the value of exports in 777 sectors (SITC Rev.2 classification, 4-digit) and aggregate data on the economy wide level of exports.

of the index.

⁵See the data description section of the Appendix for a detailed explanation of the choices made in order to cope with these issues.

Table 1: PRODY index, descriptive statistics

	1980	1990	2000
Min.	200	92	123
1st Qu.	6,567	6,304	4,568
Median	10,051	9,882	8,172
Mean	9,582	9,904	8,591
3rd Qu.	12,860	13,441	11,740
Max.	20,740	20,571	24,420
SD	4,177	4,562	4,851

Values in 1996 PPP-adjusted USD per capita.

3.1 Descriptive statistics and average dynamics

Basic descriptive statistics, presented in Table 1, are already revealing of two empirical characteristics of the index. First, from a static point of view, the reported numbers testify that PRODY varies greatly across sectors: within each year the standard deviation (SD) is indeed quite high, and the index can take on values ranging from hundreds to tens of thousands of 1996 per capita USD. Second, considering the intertemporal dynamics of the index, one observes that significant changes have occurred over the considered years. On the one hand, the steadily increase registered in the SD suggests that the distance between minimum and maximum levels of sophistication has widened. On the other hand, the behavior of the other statistics seems to indicate a leftward shift in the distribution of the index, suggesting that the importance of sectors characterized by low PRODY has risen, especially in the second decade: the 1-st quartile and the median both decrease steadily, whereas the mean and the 3-rd quartile, after an increase in

Table 2: PRODY index, rank correlations

year	ρ	p-value
1980-1990	0.751	0.000
1990-2000	0.712	0.000
1980-2000	0.660	0.000

Spearman's ρ and associated robust p-values.

between 1980 and 1990, end up below their initial values in 2000.

Before entering a further investigation of the dynamics followed by the empirical distribution of the indexes, we present two exercises which look at average persistence over time.⁶

The Spearman's ρ coefficient of rank correlation provides a first, non-parametric, account of the degree of association between the values taken by the sectoral indexes in the different years. The estimates, displayed in Table 2, turn out to be all significant, and all lie well above 0.6, telling that a strong positive relationship is in place across time. Remarkably, the relationship is stronger on a 10 year basis (1980-1990 and 1990-2000) as compared to a 20 years time window (1980-2000), and possibly weakening during the second decade.

A standard Galtonian regression offers an alternative, parametric, method to get a synthetic measure of the average persistence of the index in between an initial year t and a final year $t + n$. Labeling the sector with l , the estimated equation takes the form

$$PRODY_{l,t+n} = \alpha + \beta \cdot PRODY_{l,t} + \epsilon_t \quad , \quad (4)$$

⁶If not else specified, the statistical exercises conducted in this work have been performed using *gbutils*, a package of programs for parametric and non-parametric analysis which is distributed under the General Public License, and freely available at www.cafed.eu/software.

Table 3: PRODY index, Galtonian regression.

	1980-1990	1990-2000	1980-2000
α	2215.29* (330)	1288.79* (270)	1386.96* (310)
β	0.802* (0.032)	0.737* (0.030)	0.752* (0.034)
Obs.	777	777	777
R_{adj}^2	0.539	0.480	0.418
F	909.1*	717.8*	559.3*

(*) Significant at 1% confidence level.

where the coefficient β captures what happens to the conditional average of the cross-sectoral distribution.

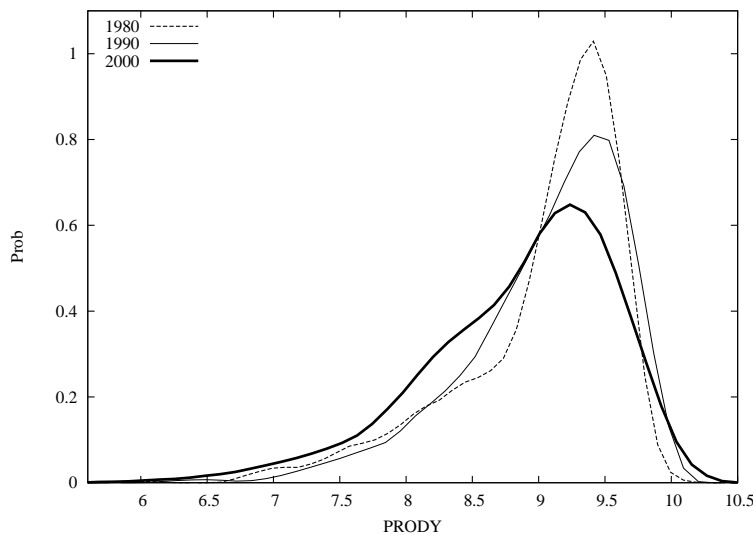
The estimates in Table 3 substantially mimic the results obtained with Spearman's ρ . The coefficient β is indeed significant, positive and high (above 0.7) in all the instances, confirming that, in general, a strong positive correlation is in place over time. Moreover we again observe that the strength of the relationship is decreasing as we move from a 10 years to a 20 years time window.⁷

3.2 Distributional dynamics

Focusing on average behavior of the PRODY indexes over time, although informative, presents some limitations, in particular for what concerns the so-called Galton-fallacy problem, discussed at length in the context of cross-country growth regressions (among the many, see Quah, 1996; Durlaf and Quah, 1999). This potential drawback can be overcome by focusing on the properties of the entire

⁷Robust standard errors are obtained via a standard "sandwich" estimator of the variance/covariance matrix.

Figure 1: PRODY index (logs), kernel densities in 1980, 1990 and 2000.

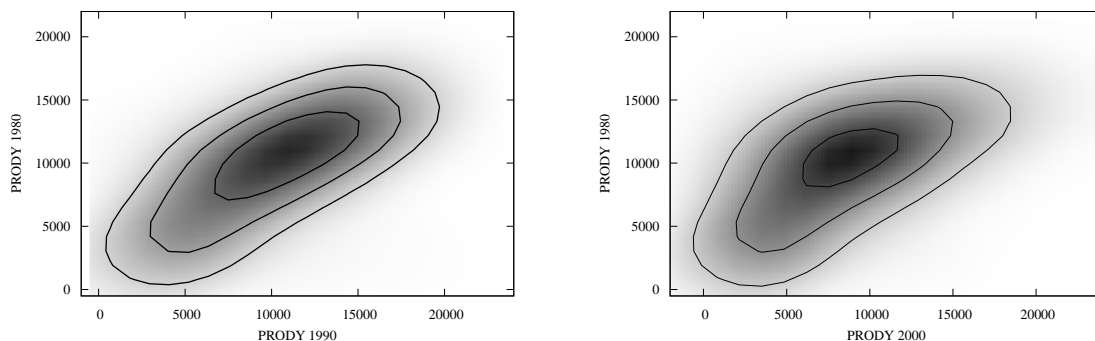


distribution of the indexes, at the same time providing a richer statistical characterization of the changes occurred during the period under consideration. To this end, we now present two complementary exercises, both based on non-parametric techniques. We first perform a univariate analysis, comparing kernel estimates of the density of the PRODY indexes in 1980, 1990 and 2000. Then, we explore the degree of association over time via an estimate of the bivariate joint probability density of the sectoral PRODY indexes between pairs of reference years.

Figure 1 shows the univariate exercise, reporting the estimated kernel densities of the empirical distribution of PRODY, in logs.⁸ Consistently with the statistics displayed in Table 1, the results suggest a shift of probability mass from the central part towards the tails of the density, more remarked in the lower tail, but present also in the upper tail. Indeed, two main patterns emerge. First, concerning the central part of the densities (approximately for the interval $[8.5, 9.5]$ on the x axis),

⁸Here, as well as in the rest of the paper, we use an Epanenchnikov kernel and set the kernel bandwidth according to the 'optimal routine' suggested in Silverman (1986).

Figure 2: Contour plots of the joint kernel density of PRODY in subsequent years: 1980-1990 (**left**) and 1980-2000 (**right**).



it is observed that, although the shapes and the location of the peaks are similar, the estimate for 1980 is much more concentrated around the modal value, while the height of the peak falls steadily in the two subsequent reference years. Second, looking outside the central part, both the tails are heavier in 2000 than they are in 1980, while the distance between the minimum and the maximum value of the support become wider as long as one moves from the initial to the final year.

Figure 2 tries to add some more information about the occurred movements. We estimate the joint probability that the PRODY index takes on a certain value y in a reference year and a value x in a subsequent year. Bivariate densities are again obtained via kernel techniques, and contour plots are reported, with darkest gray corresponding to areas where the estimated density is higher. Pairs (x, y) lying on an imaginary positively sloped bisector represent sectors for which the PRODY index remains unchanged in the two years, while points above (below) the bisector correspond to sectors where the index decreases (increases).

We first comment on the left panel, where we plot the relationship between 1980 and 1990. Consistently with Figure 1, we find that the sectoral distribution

of PRODY experiences substantial changes. Indeed, even if the contour surfaces are clearly positively sloped, confirming the positive association between the two years which was already uncovered by Spearman's ρ and Galtonian regression (see Section 3.1), much of the probability mass actually lies above an imaginary positively sloped bisector. This suggests that in 1990 the importance of sectors with low-medium levels of sophistication content has increased with respect to 1980. A similar conclusion holds looking at the comparison between 1980 and 2000, plotted in the right panel of Figure 2. The sign of the relationship is again positive, suggesting remarkable stability in the ranking of the sectoral indexes. But, in addition to that, one also observes a shift of probability mass towards the left-up corner, producing a further increase in the portion of density above the bisector. As compared to the left panel, this means that an even greater number of sectors have experienced a decrease in the index between 1980 and 2000.

3.3 Interpretation

Overall, the analyses of this section testify significant modifications in the PRODY indexes during the period under consideration: the values become more heterogeneous, with most of the sectors experiencing a reduction, and some, less numerous, characterized by an increase.

The dynamic properties of the index (discussed in Section 2) allows us to attach an economic interpretation to our findings. Recall, first of all, the above discussion concerning the effects induced on the value of PRODY by entry and exit of different countries in world exports of each sector. We argued that the PRODY index of a given sector is more likely to decrease when low-medium income countries start exporting in that sector. The clearcut left-swing of the probability mass observed between 1980 and 2000, as well as the decrease observed in the value of PRODY for many sectors, represent two findings quite consistent with this story.

This allows to read our evidence as robustly indicating that the important modifications occurred in world trade characteristics over the last two decades are largely attributable to the increased number of low-medium developed countries starting to export in many of the sectors considered. In addition, we also highlighted that the PRODY index of a given sector is increasing in the value of the per capita incomes of the countries already exporting in that sector. This helps explaining the increased distance between minimum and maximum values of the index, and it might also offer an interpretation for the increase observed over time in the weight of the upper tail. Two processes, non mutually exclusive, seem to be at work. Sectors whose PRODY indexes increase might either be sectors where high income incumbent countries are increasing their specialization over time, or they might represent markets where other high income countries become new exporters during the period.⁹

A straightforward and remarkable implication of the relevant changes characterizing the sophistication levels of traded sectors in between 1980 and 2000 is that what is sophisticated, and, thus, worth exporting in 1980 does not necessarily coincide with what is sophisticated in 2000. To the extent that sophistication of exports, as captured by the PRODY index, also represents a good proxy for the potential contribution to aggregate growth stemming from exporting in each particular sector, the main message we draw is that it is not irrelevant to ask whether the international specialization of a country has evolved towards one direction or another during the same period. A sort of dichotomy seems indeed emerging between a (small) group of sectors which steadily remain highly sophisticated over the years, and the vast majority of the other sectors, which become instead less

⁹Such interpretations get reinforced if one looks at entry and exit patterns in each sector. For specific and instructive examples, see the analysis in the Appendix, where we describe in greater detail the dynamics of the top 20 sectors in the yearly distribution of PRODY.

and less sophisticated, and, thus, less and less capable to sustain growth. This suggests that, in order to assess if the pattern of specialization of a country is sound, an interesting exercise can be performed through comparing the evolution of the PRODY index of each sector with the evolution of the comparative advantages in the same sector.

In the last part of the article we apply this idea considering the Italian case. Before coming to that, we investigate the basic characteristics of the Italian specialization pattern.

4 The evolution of the Italian pattern of specialization

In this section we characterize the specialization pattern of Italy by looking at the *symmetric* index of Revealed Comparative Advantage, which is a useful and widely used transformation of the classical Balassa-RCA index (Dalum *et al.* (1998), Laursen (2000), Brasili *et al.* (2000)).¹⁰ The symmetric RCA is defined as

$$\overline{RCA}_{i,l} = \frac{RCA_{i,l} - 1}{RCA_{i,l} + 1} \quad (5)$$

where, as before, l and i indicate the sector and the country, respectively.

As compared to the classical Balassa formulation, the \overline{RCA} index keeps the rank-ordering of the sectors unchanged, but takes on values in $[-1, 1]$, with 0 as demarcation value between specialization and de-specialization. While the standard Balassa index does not put any upper bound to the extent of comparative advantage of a sector, the merit of transformation (5) is to deserve equal emphasis

¹⁰Other studies applying \overline{RCA} to the Italian case are De Benedictis and Tamperi (2004) and De Benedictis (2005). Robustness of results was checked against the use of the traditional Balassa index, but we did not find any relevant variation in the main findings reported below.

Table 4: \overline{RCA} of Italy, rank correlations

year	ρ	p-value
1980-1990	0.807	0.000
1990-2000	0.853	0.000
1980-2000	0.723	0.000

Spearman's ρ and associated robust p-values.

to comparative advantages and disadvantages of a country.¹¹

We consider the period 1977-2004, the time window for which 4-digit trade data are available for this country from COMTRADE. In parallel with the analysis performed on the PRODY index, we first present evidence on the average dynamics of \overline{RCA} , and then focus on the characteristics of the entire distribution of the index.

The first exercise is presented in Table 4. Here we show the Spearman's rank correlations between the values of the \overline{RCA} indexes computed in our 'usual' reference years: 1980, 1990, and 2000. The displayed estimates are all significant and always lie above 0.7, giving a first hint that the structure of the Italian international specialization has been fairly persistent during the period under consideration. This result has been already documented for Italy, and is much in accordance with what it is commonly observed for other developed countries. What is more peculiar of the Italian case is that persistence has increased over time, as suggested by the higher coefficient estimated between 1990 and 2000.¹²

Next, we run a Galtonian regression of the form

$$\overline{RCA}_{l,t+n} = \alpha + \beta \cdot \overline{RCA}_{l,t} + \epsilon \quad , \quad (6)$$

¹¹For a deeper comparison between the classical Balassa-RCA index and the symmetric RCA index see De Benedictis and Tamberi (2001).

¹²For a cross-country comparison see De Benedictis and Tamberi (2004).

Table 5: $\overline{\text{RCA}}$ of Italy, Galtonian Regression

	1980-1990	1990-2000	1980-2000
α	-0.095* (0.011)	0.026* (0.011)	-0.037* (0.013)
β	0.754* (0.020)	0.852* (0.021)	0.736* (0.022)
N.Obs.	777	777	777
R^2_{adj}	0.646	0.684	0.580
F	1418*	1680*	1073.6*

(*) Significant at 1% confidence level.

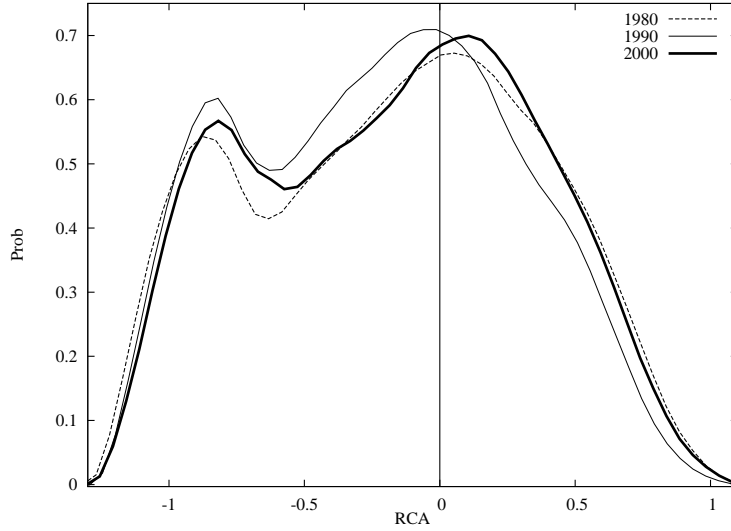
where l stands once again for the sector, while t and $t+n$ indicate the initial and the final year, respectively. The results for the 10 and 20 years time windows, reported in Table 5, confirm what already noted.¹³ Indeed, the value of the β coefficients are positive, significant and quite high, revealing considerable persistence in the average cross-sectoral level of specialization. In addition, we again observe that persistence is higher in the second period: the estimated value of $\beta_{1990-2000}$ is about 0.85, against an estimated $\beta_{1980-1990}$ of about 0.75.

Finally, changing the focus from the average behavior to the properties of the entire distribution of the $\overline{\text{RCA}}$ indexes, we estimate the kernel density for each year in the sample period.

A first remarkable finding concerns the high stability found over time: the main characteristics of the yearly distributions, such as width of supports and overall shape, remain substantially unchanged. Accordingly, Figure 3 reports only the estimates for 1980, 1990 and 2000, since these reference years are informative of

¹³Robust standard errors are obtained via a standard "sandwich" estimator of the variance/covariance matrix.

Figure 3: $\overline{\text{RCA}}$ of Italy, kernel densities over time



the results observed over the entire period considered. The most clearcut property is certainly represented by the strong bimodality appearing in all the years, with a first peak placed below the demarcation value $\overline{\text{RCA}} = 0$, and a second mode located above that threshold. This feature is broadly in agreement with the evidence reported in De Benedictis (2005), and reveals that the structure of Italian comparative advantages is characterized by the coexistence of two different groups of sectors: one group where Italy is and has steadily been highly specialized, and one where Italy is and has persistently been highly de-specialized.¹⁴

In order to add statistical precision to the graphical analysis, we investigate the presence of more than one mode in the distributions via a standard test (Silverman 1986). This procedure is based on the "critical smoothed bandwidth" of the kernel density estimator, $h(m)$.¹⁵ In practice, $h(m)$ provides a test statistic

¹⁴Despite the similarity of results, there are two differences with De Benedictis (2005). First, we use a larger sample of sectors, including non-manufacturing sectors. Second, we consider a finer level of sectoral aggregation.

¹⁵The "critical smoothed bandwidth" is the smallest possible value of the bandwidth param-

Table 6: $\overline{\text{RCA}}$ of Italy, test for m -modality

Year	H_0 : number of modes = m	$h(m)$	p -value
1980	$m = 1$	0.217	0.004
	$m = 2$	0.069	0.957
1990	$m = 1$	0.196	0.010
	$m = 2$	0.112	0.179
2000	$m = 1$	0.211	0.016
	$m = 2$	0.094	0.529

Critical bandwidth, $h(m)$, and associated bootstrapped p -values.

for the null hypothesis that a density has m modes, against the alternative that the number of modes is greater than m : a large value of $h(m)$ supports the presence of more than m modes, thus rejecting the null.¹⁶ Table 6 shows the critical bandwidths and the estimated p -values of the test for the three reference years of the analysis. As usual, the null hypothesis is rejected whenever the estimated p -value is smaller than standard levels of significance. Based on this, the presence of bimodality is accepted in all the instances, further corroborating the impression drawn from graphical analysis. Similar results obtained in the other years suggest

¹⁶In order to determine how "large" $h(m)$ should be to reject the null, a bootstrap test is employed. From the estimated density, N samples with replacement are drawn, and the critical bandwidth $h_n(m)$ ($n = 1, \dots, N$) consistent with m -modality is computed. An estimate of the p -value associated with the corresponding critical bandwidth is then given by $\#h_n(m) > h(m)/N$. Numbers reported in the Table are obtained with $N = 1000$ replications.

that bimodality is persistent over the entire sample period.

Summing up, our data confirms that the Italian pattern of specialization is characterized by two basic features: high (possibly increasing) degree of persistence and bimodality in the structure of comparative advantages.

5 Measuring the sophistication content of the Italian specialization pattern

The characteristics of the Italian comparative advantages, even if interesting *per se*, do not provide any information about the sophistication level associated with the specialization pattern of a country. Sophistication however represents a relevant issue, since it allows to establish a link with the growth enhancing opportunities possibly resulting from exporting in different sectors, thereby providing a quantitative basis to judge whether the specialization pattern of a country is 'sound'. To close this gap, in this section we perform two exercises, both exploiting the PRODY index as a measure of sophistication. We first follow Hausmann *et al.* (2005, 2007) and employ the PRODY indexes to compute for Italy a country-wide index, called EXPY, which is intended to capture the overall sophistication content associated with the export vector of the country. We then experiment our original contribution. We compare the evolution of the Italian comparative advantages in each traded sector with the evolution of the PRODY indexes in the same sector. In this way, we attempt to understand if, given the documented changes in world trade sophistication, the highly persistent structure of specialization of Italy has become more or less favorable to economic growth than in the past.

5.1 EXPY index of Italy

The EXPY index is defined as the weighted sum of the PRODY indexes of all the sectors wherein a country is exporting, with weights given by the share of each sector in the export vector of the country. Formally

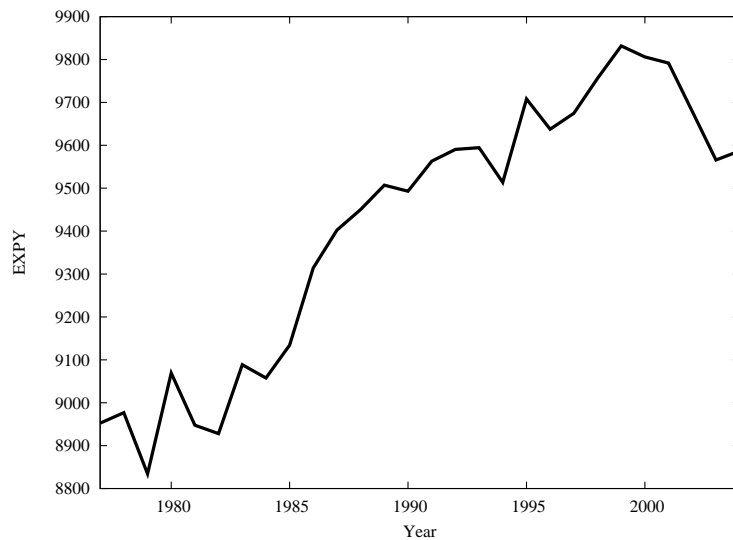
$$EXPY_{i,t} = \sum_l \left(\frac{x_{l,i}}{X_i} \right)_t PRODY_{l,T} \quad , \quad (7)$$

where $x_{l,i}$ is the value of country i 's export in sector l , X_i is the value of country i 's overall exporting activity, and T is a reference year in which each sectoral $PRODY_l$ is computed. The latter is fixed over time, so that an observed intertemporal change in EXPY only results from how the sectoral export shares change year by year.¹⁷

Taking a three-year average 1999-2001 as the reference year T for the value of PRODY, Hausmann et al. (2005, 2007) compute the evolution of the EXPY index for a large panel of countries during the 90's. They show that the index is highly correlated with per capita GDP and that countries with higher EXPY are those which also grow more rapidly, even after controlling for initial income per head, human capital levels, and time-invariant country-specific characteristics. One can therefore conclude that, *ceteris paribus*, rich (poor) countries tend to export goods which are exported by other rich (poor) countries, and that producing and exporting goods exported by richer countries represent an effective route to faster growth. In other words, it is what an economy exports that matters for growth, rather than its extent of specialization. Such beneficial effect of sophistication on the overall economic performance of a country also implies that, in general, an intertemporal increase in the EXPY index can be interpreted as a positive signal. Indeed, it means that a country is increasingly involved in the export of sectors with high

¹⁷The EXPY index is similar to the 'income level of exports' presented in Michaely (1984), and to the 'sophistication level of exports' proposed by Lall *et al.* (2006).

Figure 4: EXPY index for Italy, 1977-2004



values of PRODY, likely benefiting from reduced price competition and/or higher profit margins.

As said, trade data for Italy are available in COMTRADE for the period 1977-2004. We measure the EXPY index over this time window. Following Hausmann et al. (2005, 2007), computations are based on taking values of PRODY in the most recent available year as reference T , that is in 2000 in our case. This simply means that the sophistication content of the Italian export vector is evaluated, in each year t , on the basis of the sophistication of world exports as it stands in 2000. An increase in the EXPY would therefore register that the composition of the Italian export bundle is experiencing an increase in the shares of sectors with an high value of PRODY in 2000, i.e. those sectors which are supposed to be more capable to significantly contribute to overall economic growth given the characteristics of world trade in 2000.

The pattern depicted in Figure 4 reveals that Italy has been, in general, a well performing country. Indeed, the Italian EXPY displays an overall increase during

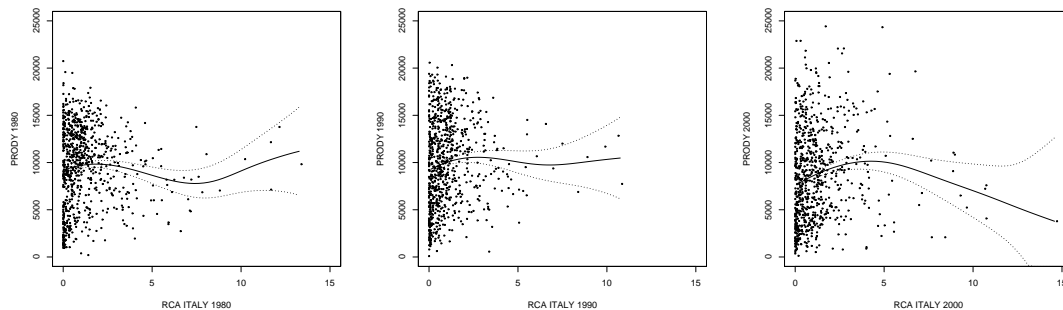
the period, passing from 8900 per capita USD in 1977 to around 9600 per capita USD in 2004. However, the dynamics from 1999 onwards display a reduction which brings the sophistication content of the Italian export bundle back to the values taken at the beginning of the 90's. Since changes in the EXPY reflect changes occurred in the composition of the export vector, the general finding is that a virtuous redistribution of export shares, with highly sophisticated sectors increasing their importance, has taken place in Italy only until the end of the 90's. In the most recent years, instead, the weight of sectors associated with low-medium levels of sophistication has become more relevant, enough to cause a sharp break in the evolution of the index.¹⁸

5.2 Dynamics of the PRODY index and the evolution of the Italian comparative advantages

We now propose a different and novel way to use the information provided by the PRODY indexes. While the EXPY index gives a measure of overall sophistication content of the export vector of a country, taking the PRODY indexes fixed in time, our idea is to exploit the information coming from computing the PRODY indexes in different years. The basic intuition is the following. Given the intertemporal changes in the PRODY indexes discussed in Section 3, it is quite likely that sophistication levels has changed for many traded goods during the years considered: sectors with high (low) PRODY in 1980 are not necessarily sectors where PRODY is high (low) in 2000. Thus, one might want to understand if the extent of specialization of a country in each different sector has evolved consistently with

¹⁸Of course, one could also construct the EXPY index taking the PRODY indexes of 1980 or 1990. This simply changes the benchmark year against which one is comparing the evolution of export sophistication of a country. The main result that EXPY of Italy has performed better in the past than in recent years is however not affected by these alternative choices.

Figure 5: Italian RCA vs PRODY, non parametric regression for 1980, 1990 and 2000.



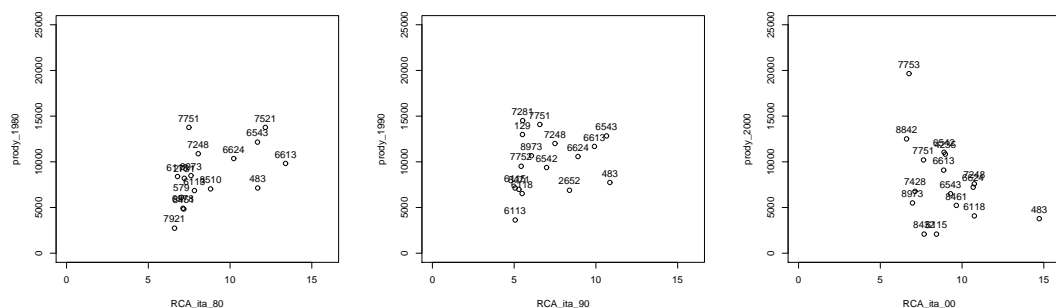
the changing sophistication associated to the same sector. This naturally leads to investigate the intertemporal co-evolution of the PRODY indexes with standard measures of sectoral specialization. We apply this idea to Italy, performing simple, but revealing, exercises which take the classical Balassa-RCA index as a measure of specialization.

As before, we focus on 1980, 1990 and 2000 to give an idea of the intertemporal dynamics. In the three panels of Figure 5 the x -axis shows the Italian RCA in the 777 sectors covered by the available dataset, computed for each of the reference years and plotted against the corresponding value of the PRODY index. We also present the result of a non-parametric regression exploring the shape and the strength of the relationship between the two variables.¹⁹

Since, as repeatedly argued, sectors with high PRODY are likely to be sectors wherein comparative advantages are determined by factors other than labor cost (high quality or high technological content, for instance), thereby entailing higher margins per unit of output sold and higher growth opportunities for the countries

¹⁹The estimates are obtained with *R* (see <http://www.r-project.org>), using the standard settings of the *sm* and *kernsmooth* packages. We also report the confidence bands, giving a measure of the statistical significance of the estimate.

Figure 6: The 15 sectors with higher RCA index and the associated PRODY in 1980, 1990 and 2000.



exporting in those sectors, the preferred pattern in terms of the exercise shown in Figure 5 would be a situation where *a*) a positively sloping fit is obtained in each year, meaning that specialization is higher in sectors of higher sophistication; and *b*) the relationship between the two variables becomes steeper over time, meaning that specialization increases in sectors whose sophistication is also increasing.

In the case of Italy, the comparison of the graphs in Figure 5 reveals that the relationship between RCA and PRODY has experienced significant changes, especially in the sectors wherein the country is highly specialized. Indeed, the estimated shape is almost flat (or slightly 'inverted-U' shaped) for sectors with low-medium RCA, no matter for the year considered. Instead, if one focuses on sectors with very high RCA (say for $RCA > 5$), a positive relationship is observed in 1980, which then flattens in 1990, and turns negative in 2000. A major source of possible misalignment between the Italian specialization patterns and the PRODY indexes seems therefore characterizing those sectors wherein Italy is highly specialized.²⁰

To corroborate this conjecture we focus on the 15 sectors which recorded the highest RCA in 1980, 1990 and 2000. These are plotted in Figure 6 against their

²⁰Nonetheless, note that variability band are larger for high RCA sectors since there are fewer observations in that region.

Table 7: The 15 sectors with higher RCA in 2000: evolution and associated PRODY index in selected years

Sector	1980		1990		2000	
	PRODY	RCA	PRODY	RCA	PRODY	RCA
0483	7,133	11.7	7,737	10.9	3,784	14.7
6118	8,393	6.8	6,529	5.5	4,079	10.8
6624	10,359	10.2	10,579	8.9	7,222	10.7
7248	10,885	8.1	12,004	7.5	7,590	10.7
8461	8,177	6.2	3,321	0.0	5,232	9.7
6543	12,154	11.7	12,835	10.7	6,505	9.3
4235	6,516	2.8	9,046	4.2	10,836	9.0
6542	9,594	4.5	9,376	7.0	11,044	8.9
6613	9,822	13.4	11,685	9.9	9,088	8.9
8432	5,086	3.0	5,713	1.8	2,089	7.7
7751	13,768	7.5	14,088	6.6	10,204	7.6
7428	12,234	3.5	11,314	3.8	6,770	7.1
8973	8,491	7.6	10,666	6.1	5,500	7.0
7753	15,818	4.1	16,858	3.6	19,651	6.8
8842	9,958	3.1	7,250	3.7	12,510	6.6

PRODY is measured in 1996 PPP-adjusted US dollars

corresponding PRODY indexes. The patterns of Figure 5 are obviously confirmed, with a positively sloped cloud of points in 1980 which ends up negatively sloped in 2000. What is however noticeable here is that most of the sectors remain present in all the three graph. This suggests that the high persistence recorded in the top tail of the Italian specialization structure is the reason why the PRODY-RCA relationship has turned negative in 2000: Italian RCA indexes have remained steadily high in sectors associated with declining sophistication.

The tendency is confirmed when looking in more details at the dynamics ex-

perienced by some of these sectors. In Table 7 we take the 15 sectors displaying higher levels of specialization in 2000, and follow the “history” of their RCA and PRODY indexes back in time, over the usual reference years. As expected sectors with high and stable RCA are sectors wherein Italy is known to exhibit traditionally high comparative advantages, such as in sector 483 (*Pasta and Similar Products*), in sector 6118 (*Leather, specially dressed or finished*) and in sector 6624 (*Non-refractory Ceramic Bricks, Tiles, Pipes and Similar Products*). In all of these instances the RCA steadily increases, while the associated PRODY falls significantly. Other sectors follow a similar pattern. In sector 7751 (*Household Type Laundry Equip.*) the *RCA* is stable, but *PRODY* decreases from 13768 to less than 10204 per capita USD. Sector 6115 (*Sheep and Lamb Skin Leather*) and sector 8432 (*Suits and Costumes for womens, of Textile fabrics*) are particularly instructive: the RCA more than doubles over time, while the PRODY index in 2000 is less than one half of its value in 1980. Obviously, there are also cases wherein increased or stable specialization occurs in sectors recording an increase in their PRODY index. Yet, the above regressions seem to offer a reasonable approximation: the top tail of the Italian structure of specialization is characterized by an inverse relationship between the dynamics of world export sophistication in a given sector and the evolution of the extent specialization in the same sector.

6 Conclusion and further research

This paper provides an empirical characterization of the sophistication of the Italian specialization pattern and of its evolution from the early 80’s to recent years, with the goal to propose original evidence on useful to evaluate the well-known Italian ‘trade specialization anomaly’.

To this end, we employ a number of measures and methodologies. We begin

exploring the inter-temporal dynamics of the PRODY index, a newly proposed measure of sophistication of traded goods. Extending the original work of Hausmann *et al.* (2005, 2007), we investigate the dynamic properties of the index and gather novel empirical evidence on its evolution over time across 1980, 1990 and 2000. Our findings show that sophistication levels have changed with time, signaling that sectors characterized by higher sophistication content at the beginning of the sample period might well have become less sophisticated in more recent years, and viceversa. This implies that each country, in order to enjoy the growth enhancing opportunities associated with exporting in sophisticated sectors, must continually adapt its positioning in international markets, trying to pursue a close consistency with the evolution of world trade sophistication. Our analysis also gives some indication of the possible causes lying behind the observed changes. In particular, the evolution of the empirical distribution of the index over the period considered seems largely resulting from the increasing role played by low-medium developing countries in many sectors, as well as from the increasing 'leadership' of rich countries in more sophisticated sectors.

The second contribution of the paper is to suggest that, in order to evaluate whether the specialization pattern of a country is well directed or not, one can fruitfully compare the evolution of the sectoral PRODY indexes with the evolution of standard measures of sectoral specialization. The application of this methodology to Italy reveals that, by the late 90's, the sectors where the country has been, and still is, highly specialized, are characterized by an intertemporal reduction in the value of the associated PRODY index. The implications for a further qualification of the Italian 'trade specialization anomaly' are relevant. Our analysis indeed shows that, even if the highly persistent specialization pattern of Italy does not need to represent a problem *per se*, the worries about the Italian 'anomaly' are justified. While world trade is rapidly evolving, Italy is stuck with its tradi-

tional structure of comparative advantages, characterized by strong specialization in sectors which, in the last years, have become less and less sophisticated, and, thus, less and less capable to sustain growth.

The present work could be extended in various directions. We sketch here some of the developments which are left for future work. In this work we computed RCA measures, and, consequently, the PRODY indexes, using world-wide trade flows. It could instead be interesting to consider specific sub-groups of countries. For instance, one could compute RCA and PRODY only considering OECD export flows, or, alternatively, split the analysis into two parts, distinguishing developed *vis a vis* low-medium income countries. One could also think of changing the sample of sectors considered by the analysis. Indeed, while keeping a fine level of sectoral aggregation is important for many purposes, 'aggregating back' the data could help identifying common patterns across sectors which share specific characteristics. Grouping sectors by Pavitt classes or by labour *vs.* capital intensive sectors, would for instance allow to link sophistication with innovation and technology dynamics. Finally, it could be interesting to replicate our analysis of the RCA-PRODY co-evolution with other countries. Such an attempt would indeed provide a test of the proposed methodology, and it would also offer a basis to identify similarities and differences in the observed patterns of specialization. In turn, this international comparison may also suggest some useful hints to understand *why* the Italian specialization pattern has been accompanied by decreasing sophistication levels in recent years. Indeed while our analysis documents this fact, it is beyond the aims of this paper to discuss which may have been its cause(s). Many of these factors, likely to require a study of micro data at firm level, might in fact be specific of the Italian case and do not need not affect other countries. Think about questions like, have the numerous exchange rates depreciation episodes reduced the incentives for the firms to upgrade their products (De Nardis and Traú,

2005) ? Or, moving to more indirect causes, is there little behavioral inclination on the part of the Italian firms to translate productivity and profitability into higher growth (Bottazzi *et al.*, 2008) ? Have labour market reforms implemented in the second half of the nineties pushed to much attention on cost saving policies, instead than favoring productivity growth (Saltari and Travaglini, 2006) ? Have credit markets failed to sustain the best performing firms (Fagiolo and Luzzi, 2006; Angelini and Generale, 2008) ? All of these issues have possibly been relevant. Further research is needed, because the symptoms described in this paper certainly call for a careful diagnosis as well as for an appropriate cure.

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Appendix

Proposition 1 (*Effect of entry on the dynamics of the PRODY index*)

The probability of observing an inter-temporal increase (decrease) in the PRODY index of a sector is higher the higher (lower) the per-capita income of the entrant countries as compared to the per-capita incomes of the already exporting countries. Indeed, assuming that country A and country B are already exporting a given good l at time t , while country C is a new exporter entering the market in $t + 1$, then it is possible to show that

$$\Delta PRODY_l > 0 \Leftrightarrow y_C > -\frac{\Delta RCA_{A,l}}{RCA_{C,l}} \cdot y_A - \frac{\Delta RCA_{B,l}}{RCA_{C,l}} \cdot y_B \quad , \quad (8)$$

with $\Delta X = X_{t+1} - X_t$.

Proof. The variation of the PRODY index depends on changes in both per-capita incomes and RCA of the countries involved. Suppose, for simplicity, that the incumbents' per-capita incomes remain constant (that is, $\Delta y_A=0$ and $\Delta y_B=0$), and assume that the same happens with the value of their exports in all the sectors (l included). Under the latter condition, the entry of country C produces an increase in sector l 's share in world exports, entailing a decrease in RCA_l of both country A and country B ($\Delta RCA < 0$), while an obvious increase from zero to a positive number is recorded in the specialization of the entrant country ($\Delta RCA_{C,l} > 0$). Now define

$$\Delta S = \sum_i RCA_{i,l,t+1} - \sum_i RCA_{i,l,t} \quad (9)$$

and suppose that country C enters with an RCA_l relatively high with respect to the incumbents, so that

$$RCA_{C,l} > |\Delta RCA_{A,l}| + |\Delta RCA_{B,l}| \quad (10)$$

and, thereby, $\Delta S > 0$. Ask then under which conditions the entry of country C entails an increase in PRODY_l . With some simple algebra one has that, given condition (10), the inequality

$$\Delta \text{PRODY}_l = \frac{\Delta \text{RCA}_{A,l}}{\Delta S} \cdot y_A + \frac{\Delta \text{RCA}_{B,l}}{\Delta S} \cdot y_B + \frac{\text{RCA}_{C,l}}{\Delta S} \cdot y_C > 0 \quad (11)$$

is satisfied whenever

$$\text{RCA}_{C,l} > \underbrace{-\Delta \text{RCA}_{A,l}}_{>0} \cdot \frac{y_A}{y_C} - \underbrace{\Delta \text{RCA}_{B,l}}_{>0} \cdot \frac{y_B}{y_C} \quad , \quad (12)$$

or, alternatively, whenever

$$y_C > \underbrace{-\frac{\Delta \text{RCA}_{A,l}}{\text{RCA}_{C,l}}}_{>0} \cdot y_A - \underbrace{\frac{\Delta \text{RCA}_{B,l}}{\text{RCA}_{C,l}}}_{>0} \cdot y_B \quad (13)$$

which are both more likely to hold if y_A and y_B are smaller than y_C . ■

In words, the effect induced by a new country starting exporting in a given sector l on the PRODY index of the same sector crucially depends on the development levels of the countries involved. The more developed the entrant countries vis a vis the already exporting ones, the higher is the likelihood of observing an intertemporal increase in PRODY_l . Viceversa, an intertemporal reduction of the index is more plausible when the entrant countries are less developed as compared to the already exporting ones.

Data description

Our trade data come from the UN Commodity Trade Statistics Database (COMTRADE). For each country present in the dataset during the period under consideration, it contains detailed yearly figures on the value of exports in 777 sectors (SITC Rev.2 classification, 4-digit) and aggregate data on the economy wide level of exports. To compute the RCA indexes we also need the time series of the value

of world exports in each single sector, as well as the figures about the overall value of world exports. Both the series are available in COMTRADE. The major caveat concerns the number of countries included, which varies from year to year, for reasons going from simple non-reporting to processes of integration and separation, changes of name, and so on, occurred during in the period considered. The same happens also with the Penn World Tables 6.2, from which we get the data about *real* per-capita GDP. This fact represents a potential drawback for our specific purpose of following the evolution of the PRODY indexes over time. Indeed, as mentioned in the text (and suggested by Proposition 1), a careful construction of the index would require non-missing observations on a large panel of countries over the entire sample period considered, so that observed changes in each sectoral index truly results from actual trade and income dynamics, rather than from a mere loss of data in a particular year.

To cope with this point, a first choice we made was to restrict the attention to three years (1980, 1990 and 2000), as reference for inter-temporal comparisons. Then, one would be tempted to consider only those countries for which *both* trade and income data are available in these years. Yet one can follow a better strategy allowing to fully exploit the trade data. To understand how just consider the definition of the index (see equation 1 in the text) and recall that $s_{i,l}$, the weights assigned to the per-capita GDP of each country, are computed considering the RCA of all the countries exporting good l in each year. Take, for instance, the hypothetical situation where only two countries, say the US and Bangladesh, export in sector l , and imagine that income data for all the years are available from Penn World Tables for the US only.²¹ Further, suppose that Bangladesh, given

²¹Incidentally, note that this is likely to be the typical situation which one has to face in practice, since non-reporting rates (actually for both trade and income data) are usually much higher among low-medium income countries, especially at the beginning of the time period.

its relatively un-differentiated export bundle, is highly specialized in commodity l , while the US have a moderate RCA_l , implying that $s_{i,l}$ is very high for Bangladesh (say 0.9) and very low (0.1) for the US. Now, excluding Bangladesh *tout court* from the sample only because its income data are not reported in all the years would assign a weight $s_{i,l} = 1$ to the US, resulting in a value of $PRODY_l$ artificially high and equal to the per-capita income of the US. Therefore, we proceed in two steps. We first compute the $s_{i,l}$ using export data of all the countries present in the COMTRADE dataset in each single reference year, no matter whether the same countries are present in the Penn World Tables in the same years.²² It is only after this step that we worry about which country can be included in the balanced panel needed for a correct computation of each sectoral PRODY index. At this point, in order to keep inter-temporal comparability under control as much as possible, one cannot do much better than simply focusing on those countries for which per-capita GDP is available in *all* of the three reference years. Whenever possible, we try to "save" as many countries as we can, keeping track, in particular, of unification or separation processes, as well as of changes in the official name of the states.²³ In the end, we are left with 90 countries.

²²Of course not all the countries do export in all of the 777 sectors, and when a zero is reported in COMTRADE one has simply to assume that it is precisely because that particular country is not exporting in that particular sector.

²³For instance, COMTRADE reports exports data for Benelux in 1980 and 1990, but for Belgium and Luxembourg, separately, in 2000. Our choice is to keep the two countries together into a fictitious aggregate entity, attributing to it the sum of the two countries' per-capita GDP, divided by two. The same we do with Slovak Republic and Czech Republic, reported as Czechoslovakia in 1980, before they split.

The dynamics of the PRODY index: four sectoral examples

To offer additional understandings of the evolution of the PRODY indexes over time, we perform an instructive albeit simple investigation. In Table 8 we report the values of PRODY for the 20 best ranked sectors in each of the three reference years. Then, we go back to the rough export-income data and identify which countries are involved in world exports of these sectors in each year, and reconstruct the evolution of the associated $s_{i,l}$, the normalized RCA appearing in the definition of PRODY. This exercise allows to give a flavour of the various dynamics present in the data.

The most common are well exemplified by 4 sectors. The first interesting pattern emerges in Sector 6733 (*Angles, Shapes, Sections and Sheet Piling of Iron or Steel*), ranked first in 2000. This provides an example of a sector displaying an high value of PRODY simply because one of the countries with the higher per capita income in 2000, namely Luxembourg, exhibits a very high normalized RCA in this sector (approximately 0.45).²⁴

²⁴Note that sector 6733 is not in the top 20, neither in 1990, nor in 1980, apparently in contrast with one might expect, given a certain degree of stability the observed in the ranking. The reason for this evidence is particularly interesting, as it shows how sensitive the index is with respect to data constraints. Indeed what happens here is simply that, as mentioned above, for 1980 and 1990 we only have export data about Benelux, rather than about Belgium and Luxembourg separately, so that we need to build a fictitious "aggregate country" attributing to Benelux the sum of per capita GDP of Belgium and Luxembourg, divided by two. Thus, the extent of specialization in this sector in 1980 and 1990, presumably very high for Luxembourg alone, is mitigated by the low specialization of Belgium, resulting into a normalized RCA for Benelux as a whole which is much lower than that for Luxembourg alone. The same happens with per capita incomes: aggregating the two countries fictitiously lowers the income of the -presumably- most specialized actor in this sector, Luxembourg. Both the effects are clearly likely to be responsible for the disappearance of sector 6733 from the list in 1980 and 1990. Haven't we coped with these data driven problems, 6733 would have probably had an high index also before 2000.

Table 8: The 20 sectors with highest PRODY index, selected years.

1980		1990		2000	
Sector	PRODY	Sector	PRODY	Sector	PRODY
3415	20,740	451	20,571	6733	24,420
6880	19,580	7268	20,320	121	24,329
7268	19,488	9510	20,048	6812	22,886
7187	18,406	2860	19,394	6880	22,879
2226	18,188	8996	19,313	6631	22,080
7245	17,917	7741	19,302	5147	22,069
5147	17,885	2120	19,147	5156	21,835
7129	17,811	7251	19,099	6647	21,557
7126	17,366	8744	19,011	8813	21,130
7911	17,266	121	18,981	7251	20,544
6812	17,239	6642	18,937	5332	20,364
7252	16,884	7259	18,875	6644	19,977
8996	16,753	7252	18,844	7268	19,962
5163	16,739	7423	18,671	5827	19,797
7264	16,587	5827	18,670	7753	19,651
7412	16,556	6411	18,635	6572	19,609
7434	16,545	8851	18,556	6412	19,560
5411	16,535	5411	18,457	7213	19,479
7784	16,521	7931	18,402	7412	19,387
7246	16,473	7264	18,376	6418	19,160

Values in 1996 PPP-adjusted US dollars

Instructive dynamics are also followed by sector 121 (*Bacon, Ham and other Dried, Salted, Smoked Meat*), second in 2000. We have here an example of a sector where the PRODY index moves together with the GDP of the countries which display a stable leadership in world exports of this sector, and ends up ranking well exactly because the main exporters are rich countries. Indeed, in all of the reference years considered, Denmark is the most specialized country, with a normalized RCA of about 0.45 in 2000 and 0.5 in the previous periods, while Italy, Luxembourg and The Netherlands represent substantially all the remaining part,

with $s_{i,l}$ varying between 0.1 and 0.2. Thus, it is not surprising that the PRODY index follows the increase characterizing the incomes of Denmark and of the other main players: out of the top 20 in 1980 (PRODY \simeq 12000 per capita USD, not reported in the Table), the sector moves to the tenth place in 1990 and ends up second in 2000.

Sector 6812 (*Platinum and Other Metals of the Platinum*), ranked third in 2000, provides a clearcut example of a falling PRODY due to low-medium developing countries entering world exports. Indeed, although the UK is also important in this sector (with $s_{i,l} \simeq 0.2$), Switzerland is the main responsible for the high ranking in 2000, since its normalized RCA is approximately 0.6 and its GDP per capita is one of the highest in this year. The sector is well positioned (12th) also in 1980, when very few countries, and mainly rich (Switzerland and the UK) are significantly specialized in the export of this industry. On the contrary, the value of the index falls dramatically to approximately 9500 per capita USD (around the 400th place) in 1990. The reason for this decline is that many countries enter the market in 1990, and they are all countries with low-medium levels of per-capita income. Accordingly, though the extent of specialization of the rich countries active in the sector (Switzerland and the UK) remains similar to that of 1980, the weights $s_{i,l}$ assigned to their per-capita incomes in the computation of the index are much lower. What happens with Switzerland is particularly striking, with $s_{i,l} \simeq 0.04$ in 1990. This kind of pattern is what Figure 1 suggest to have likely occurred over time in many industries: the entry of low developing countries during the years considered has likely produced a widespread reduction in the values of PRODY. Then, if rich countries take again the leadership, or at least a prominent role in terms of relative weight (this is the case for Switzerland in 2000) the index becomes high again. If instead low-medium income countries keep a strong presence, the index continues its fall. This latter evolution is well exemplified by the dynamics

in Sector 3415 (*Coal Gas, Water Gas, Producer Gas and Similar Gases*). Ranked first in 1980, when Switzerland has a very high normalized RCA, this sector goes out of the top 20 in the following years, when Switzerland is becoming less and less present (s_i almost zero in 2000), while low income countries (Zimbabwe, Chad and Qatar) acquire the highest shares by the end of the sample period.