Reply to the Editorial Decision Letter on "Openness to International Trade and Economic Growth: A Cross-Country Empirical Investigation" by Bülent Ulașan

Dear Jan Fidrmuc,

Firstly, I would like to thank you for your valuable criticism and comments. Second, I would like to inform you that I decide to revise the paper in accordance to your comments as well as to referee reports. However, I find that some of these comments are not appropriate. My detailed responses are as follows.

Comments 1 Following your comment, I have studied on principal components analysis (PCA) and read some paper constructing composite indices via this method. However, I have still some doubts on its suitability in order to measure trade openness in the current paper.

The PCA traditionally an econometric method used to reduce the dimensionality of (possibly a large number of) interrelated variables while retaining the variation in the data set as much as possible. This property of PCA gives us an idea such that we can apply PCA into a number of variables measuring different aspect of the same concept for accurate representation of that concept. More clearly, many concepts in economics, such as trade openness, institutional quality, quality of well-being, and so on are multidimensional, that is they have many different domains or attributes. That is why, we need a composite or aggregate indicator encompassing all of these different attributes in order to represent the concept of the interest accurately. In this respect, PCA can be used in order to capture various attributes of a variable or concept because each principal component is a linear combination of the original attributes where weights are the variance of these individual attributes. The resulting summary or composite indices may be more informative and better measure for the concept (or variable) of interest than the single indicators representing only one or some attributes of that concept or than another composite index weighting each attribute equally or arbitrarily.

In light of this discussion, if we return your and the first referee's comment about summarizing the measures of openness in a single indicator via PCA, I feel that this comment is not applicable the openness variables for each category, except the direct trade policy measures. As noted in the paper, I classified existing openness measures under four different categories. In the first category different measures of trade volumes defined as the fraction of exports plus import to GDP are used as an openness measure. I employ seven different indicators for this measure. It is clear that each of these indicators measure the same variable, trade volume across countries, but in one or another way. In other words, they do not measure distinct domains or different attributes of the trade volume. Therefore, aggregating these indicators under a single composite index via PCA or another method does not seem to be economically meaningful and reasonable.[1]

The same thing is more likely to be true for the other two categories of openness in the paper, namely deviation measures and subjective measures. As indicated in the paper, the openness variables classified under these two categories, such as the Sachs and Warner (1995) openness dummy, the fraction of openness years, the Frankel-Romer predicted trade shares, outward orientation index by Syrquin and Chenery (1989), the constructed openness measures from the trade model in the paper and so on, already aim to measure all aspects of trade openness, but they do this in different ways. In other words, these indicators attempt to measure the same concept, namely trade openness rather than representing the different aspects of openness. It is fair to say that these openness measures are in essence alternative, not complimentary to each other. Therefore, it seems to me that combining

[1]Nevertheless, I applied PCA to this data set consisting of seven different trade volumes and I conclude that the first PC explains 85 percent of total variation in the data. The first, second and third PCs account for 98 percent of variation. Moreover, the 7th eigenvalue is equal to 0 and 5th and 6th eigenvalues are very close to zero. This implies that there is exact multicollinearity in the data.

these different openness indicators via PCA or another method, with the hope of measuring the true degree of openness is not be meaningful and appropriate.

However, PCA can be applied to direct trade policy variables, namely tariff rates, non-tariff barriers (NTBs), and black market premium (BMP) in order to construct a composite openness measure. As noted in the paper, these policy measures are obviously represent different aspects of trade policy. Therefore, aggregation of these policy variables into a single indicator via PCA obviously captures the information contained in these variables and may measure the degree of openness across countries more accurately.

Table 1: Summary Statistics and Correlation Matrix of Trade Policy Measures

Variable	♯ of Obs	Mean	Std. Dev.	Min	Max
OWTI	104	0.1688	0.1630	0.0000	1.3190
OWQI	102	0.1858	0.2372	0.0000	0.8880
log (1+BMP)	121	0.3776	0.6716	-0.0044	5.4526
M_DUTY	117	0.1229	0.0888	0.0000	0.4645

Correlation Matrix

	OWTI	OWQI	log (1+BMP)	M_DUTY
OWTI	1.0000			
OWQI	0.4037	1.0000		
log (1+BMP)	0.1379	0.2463	1.0000	
M_DUTY	0.6895	0.3837	0.2137	1.0000

Note: **OWTI**: Own-import weighted tariff rates on intermediate inputs and capital goods over the 1983-1985 period; **OWQI**: Own-import weighted non-tariff frequency on intermediate inputs and capital goods over the 1983-1985 period; **log (1+BMP)**: Logarithm of one plus average of black market premium over the period 1960-1999. **M_DUTY**: The fraction of collected import duties to imports over the 1970-1998 period.

Before applying this method to direct policy measures, I would like to emphasise two points. First, it is useful to inspect pairwise correlation among variables because by construction PCA compresses the interrelated (collinear) variables in order to provide an adequate summary of data. Table 1 displays the correlation matrix of policy measures. As seen in the table, the pairwise correlation coefficients are less than 50 percent. The correlations between BMP and the other variables are particularly weak. Therefore, it is possible to conclude that trade policy measures are weakly correlated and this implies that application of PCA on this data set may not be appropriate.

Second, PCA is very sensitive to different units of measure. I standardise the variables to have means of 0 and variances of 1 in order to avoid this problem. In other words, the PCA here is based on the standardised variables.

The result of PCA for trade policy measures is given in Table 2. The first PC explains approximately 48 percent (less than half!) of the overall variation in the data set. As seen, the first PC gives relatively higher weights to tariffs and NTBs with respect to BMP and can be considered as a reasonable weighted average of policy variables. However, the second PC accounting for 33 percent of total variation is substantially dominated by BMP. Notice that both tariffs and NTBs have negative weights. Finally the last PCs gives a heavy weight to tariffs, a relatively small positive weight to BMP and a heavy negative weight to NTBs and captures only 19 percent of total dispersion.

Table 2: Principal Component Analysis for Trade Policy Measures

Variables	**PC1**	PC2	PC3	**Final Weights**
OWTI	**0.6665**	-0.3040	0.6807	**0.3532**
OWQI	**0.6958**	-0.0743	-0.7144	**0.1733**
log(1+BMP)	**0.2678**	0.9498	0.1620	**0.4695**
Eigenvalue	1.4450	0.9769	0.5781	
Proportion	0.4817	0.3256	0.1927	
Cumulative	0.4817	0.8073	1.0000	

While constructing (a) composite index(es) via PCA an important issue is deciding the number of PCs to retain the meaningful information in the data set. Several methods are suggested. The most common ones are the Kaiser's eigenvalue-one criterion, the scree plot, a specified proportion of the total variation accounted for by PCs (say, for instance, 80 percent or 95 percent), and the interpretability criteria. Applying these four criteria in sequence is often recommended to determine the

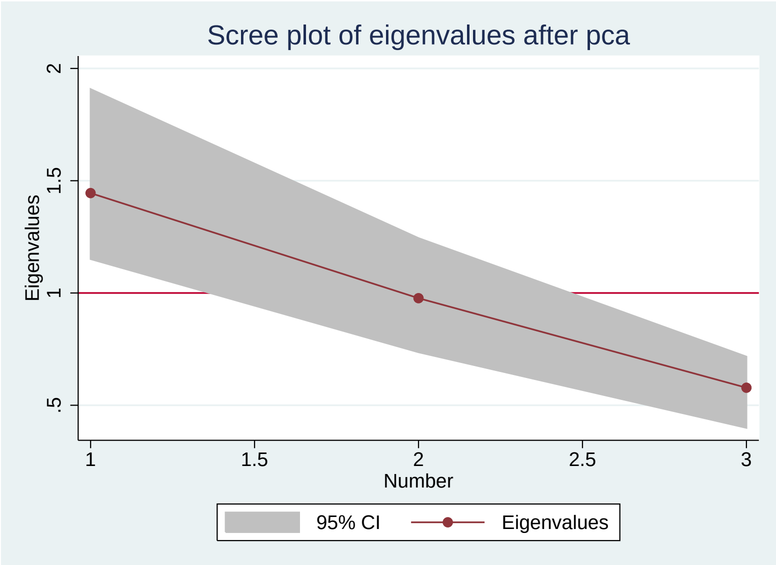

Figure 1: Scree Plot after the PCA for Direct Trade Policy Measures

optimum number of PCs. When we apply them to our PCA, we conclude that these criteria do not support each other. For instance, the eigenvalue-one criterion indicates only the first PC. However, as shown in Table 2, the eigenvalue associated to the second PC is 0.95. This makes the eigenvalue-one criterion ambiguous. Similarly, the scree plot depicted in Figure 1 is almost a straight line and there is no break between PCs. If we specify the proportion of total variance as 80 percent or more, this proportion captured by all PCs.

However, while determining the meaningful number of PCs the most popular approach is to use the first principal component if the objective is to construct a composite index capturing different attributes of a variable or concept. There are two important reasons for this. First, by construction the first PC accounts for the highest possible variation in the data set. Second, it is generally very difficult to interpret the other PCs in an economically meaningful way because weights of individual attributes have different signs. For instance, consider the second PC in our exercise. As seen in Table 2, the second PC gives positive weights to BMP while it assigns negative weights to tariffs and NTBs. This implies that both tariffs and NTBs affect the overall openness in opposite direction with respect to BMP. Furthermore, if all PCs measure more or less the same concept than it is reasonable to expect some correlations among them. However, by definition, all PCs are orthogonal to each other.Therefore, in practice most studies prefer to use the first principle component. In light of the first PC in Table 1 , we can compute the following composite index for openness.

$$Openness\ Index = 0.67OWTI + 0.70OWQI + 0.27log(1 + BMP)$$

Notice that the higher value implies high level of trade restriction because weights are positive. Thus, we expect a negative coefficient estimate in a growth regression if openness is positively associated with growth.

The key point here is, however, that the first principle component should represent the variation in variables adequately. Although there is no formal cutoff level, the common practice is that it should capture at least 80 percent of total variation. Since in our PCA, the first component account for only 48 percent of total variation, it is not informative as a summary index. Moreover, inserting this variable as an openness indicator into the basic growth regression does not yield statistically significant estimate (Table 3).

An alternative approach is suggested by Bo and Woo (2008) and Ang and McKibbin (2007). According to this approach, a composite index is constructed as the weighted averages of all PCs. The weights are determined according to the relative importance of PCs (the proportion of overall variation captured by PCs). For instance, in our example the first PC explains 48 percent of total variation and hence the weight of this component is 0.48. Similarly, the weights of second and third PCs are 0.33 and 0.19, respectively. By using these weights and also taking into account all PCs, we can compute a composite index for trade policy indicators. In light of weights associated to PCs, we can also calculate the final weights for individual variables. The final weights are shown in the last column of Table 2. Therefore, by using these weights we can calculate another composite index of openness as follows:

$$Openness\ Index = 0.35OWTI + 0.17OWQI + 0.47log(1 + BMP)$$

When we employ this composite index as an openness measure in the basic cross-country growth regression, we conclude that its coefficient estimate is negative and statistically significant at 10 percent level (Table 3). However, it is very difficult to asses this finding as an evidence

Table 3: Economic Growth and Composite Openness Indexes based on PCA for Trade Policy Measures: OLS Estimates†

	(1)	(2)
log of GDP per worker in 1960	-0.479	-0.500
	(6.74)	(7.44)
$\log(n_i + g + \delta)$	-1.373	-1.226
	(3.63)	(3.21)
log of Investment rate	0.368	0.349
	(3.06)	(2.92)
log of Secondary School enrolment	0.431	0.447
	(5.04)	(5.15)
Openness Index based on First PC	-0.038	
	(1.04)	
Openness Index based on All PCs	-	-0.165
		(1.87)
Constant	2.102	2.645
	(1.92)	(2.38)
Number of Observations	83	83
Adjusted R^2	0.60	0.61

Note: t-statistics based on heteroscedastic-consistent (White-robust) standard errors are in parenthesis. The variable, $(n_i + g + \delta)$ refers to sum of rates of population growth, technical progress and depreciation.

† Dependent variable is the log difference of real GDP per worker between 1960 and 2000.

for the claim that there is a negative relationship between trade barriers and growth. The reason is that the power of this index is as a result of high weight of BMP. As can be easily seen, the index assigns a substantial weight to BMP, a moderate weight to tariffs, and a relatively small weight to NTBs. There is no logical reason that BMP should be represented in a composite index of openness with a weight substantially higher those assigned to tariffs and NTBs. Therefore, it is more likely that this result indicates the negative correlation between BMA and growth, rather than the adverse relationship between growth and overall level of trade barriers. Given the substantial evidence on the fact that BMP is not a good proxy for trade policy, it is fair to say that the weights of the last index are not economically meaningful and thus the composite index is not appealing as a measure of openness.

As a sensitivity check, I replaced own-weighted tariff rates with the ratio of collected tariff revenues to imports in Table 4 and carry out a PCA with this data set (see the Appendix at the end of this note). Moreover, the scree plot of the second PCA is shown in Figure 2. As seen in Table 4, the results are very similar to the previous analysis. The only difference is that the first PC now explains around 52 percent (more than half) of total variation in the data set. Another difference is that this analysis assigns to BMP much more weight than those given by the previous exercise.

The first PC and the final weights in Table 3 yield the following two composite indexes for openness, respectively.

$$Openness\ Index = 0.0.61OWTI + 0.0.62OWQI + 0.50log(1 + BMP)$$

and

$$Openness\ Index = 0.34OWTI + 0.10OWQI + 0.51log(1 + BMP)$$

Employing these indexes as an openness measure in the cross-country growth regression concludes very similar results to those obtained from the first exercise. Again, the composite index based on the first PC is found to be negative and insignificant while the coefficient estimate of the second index based on all PCs is negative and significant (see Table 5 in the Appendix).

In summary;

- I believe that combining various measures of openness classified under each category via PCA does not produce an economically meaningful composite indicator. The reason is that these measures aim to capture all dimensions of openness and hence they are already openness indicators at aggregate level, except the direct trade policy measures.
- PCA can apply to direct trade policy indicators in order to capture different aspect of trade policy barriers. However, application of this method does not yield meaningful composite indexes because the indexes are dominated by BMP.

- Finally, aggregating various openness measures under a single indicator is not consistent with the aim of the paper because one objective of the paper is to evaluate the existing openness measures providing empirical evidence on how they are supported by the data over the 1960-2000 period.

Comment 2. As a complimentary analysis, I am going to carry out empirical investigation in panel setting in the revised version. For this purpose;

- I am planning to specify the cross-country growth regression (expressed in equation (1) in the paper) in panel form with 10-year-average over the 1960-2000 period. I prefer panel data model based on 10-year-averages since a 10-year-time period is more likely to represent the long-run growth dynamics and is less prone to business cycle effects than a 5-year time interval.
- I will employ dynamic panel models, notably the system GMM method suggested by Arellano and Bover (1995) and Blundell and Bond (1998) because the basic cross-country growth regression used in the paper includes the initial income level as a right-hand-side variable. This makes the panel growth model dynamic and thus fixed effects estimates suffers "dynamic panel bias" (also known as the Nickell bias). Nevertheless, I will also present the fixed-effect estimation results because these results with the single OLS estimates provide a good consistency check on the system GMM estimator (see, for instance, Bond et al. (2001)).
- Finally I want to note that the openness variables estimated in panel growth model will be considerably less than those employed in single cross-country growth regression. It is well-known fact that the RHS variables in panel model should have some variation within countries over the sample period. However, very few openness measures have this feature. These are current openness and real openness, BMP, exchange rate distortion index and fraction of open years based on the Sachs-Warner (1995) criteria. It is obvious that other openness variables, such as tariff rates, non-tariff barriers, composite trade policy indices are measured at less frequent time intervals, sometimes at only one point in the sample period and thus not appropriate for panel estimation.

Comment 3. As you note that dependent variable in the growth regressions measures the growth rate of GDP per worker over the period 1960-2000 and hence all right-hand-side (RHS) variables should enter the regressions as the averages of the same period. However, given the available cross-country growth data, measuring all RHS variables as period average is rarely possible, and thus we inevitably measure many growth related variables at over the shorter time intervals, sometimes at only one point in time. Of course, this is less problematic for the persistent and/or slow-changing variables, such as ethnolinguistic fragmentation index, cultural affiliates, geographical attributes. It is however a serious problem for the variables that considerably vary over time as in the case with trade policy related variables such as tariffs, trade volumes, black market premium (BMP).

Therefore and also following your comment, I will address this issue for the trade policy variables in the revised version of the current paper. To do so, I am planning to drop three openness indicators from the empirical analysis. These are i) the outward orientation index by Syrquin and Chenery (1989) covering only 1965-1980 period; ii) the Frankel and Romer (1999) predicted trade share calculated for only 1985; and iii) the Frankel-Romer predicted trade share provided by Dollar and Kraay (2003) and measured for the year 1995.

In connection to your concern about the regressions in Tables 8 and 9, I would like to emphasise a few points: First, I already present a cross-country growth regression on average BMP and all the other controls over the 1960-2000 period in the paper (see column 6 of Table 5 on pages 18-19) and conclude that the coefficient estimate of BMP is negative and highly significant. Whether this finding shows the trade restrictive effect of BMP on growth or indicates the negative relationship between growth and macroeconomic imbalances? In order to answer this question, I insert the average values of BMP in each decade continuously and separately in Table 8. By doing so my aim is to highlight which 10-year-average of BMP is much more correlated with growth over the sample period. As seen in Table 8, the only average black market premium in the 1980s is negatively and significantly associated with growth. It is obvious that the 1980s is a period from protectionist trade policies to more liberal trade regimes for the majority of developing countries. Therefore, it is possible to conclude that the negative association between growth and BMP is a result of macroeconomic imbalances rather than trade restrictive effect of BMP. In Table 9, I employ dummy variables for BMP (based on the 20 percent threshold level suggested by Sachs and Warner (1995)) in each decade and conclude that these dummies are continuously and separately negative and significant, except the BMP dummy in the 1960s. This finding implies two things. First, a high level of BMP is particulary harmful for economic growth. Second, while average values of BMP is found to be statistically insignificant in each decades except the BMP in the 1980, in the same decades the statistically significant coefficient estimates is obtained for only high levels of BMP. In other words, after a particular threshold level (20 percent), a significantly adverse correlation between growth and BMP is established. This can be considered as another evidence for that BMP reflects macroeconomic imbalances rather than its restrictive effect on international trade since it is more likely that a high level of BMP is a result of macroeconomic imbalances and distortions.[2]

Comment 4. The trade model used for the construction of policy indexes is simple and estimation results are not very precise as you rightly point out. My aim is, however, to obtain reasonable wights for combining tariffs, NTBs and exchange rate distortions while estimating this model. Although the coefficient estimates of trade policy related variables are not statistically significant in most cases, I believe that we can still use them as reasonable weights, at least approximately. There is no doubt a country's trade volume is determined by trade policy as well as other factors. In other words, trade policy barriers are important determinants of the trade flows across countries. That is why the coefficient estimates of these variables in a regression of trade volume show their relative importance on international trade and thus could be used as economically meaningful weights (even they are statistically insignificant). For instance, NTBs are very common trade policy measures in both developed and developing countries and the openness indexes in the paper give relatively higher weights to NTBs. On the hand, as mentioned previously it is highly likely that BMP is not a good proxy for trade policy and coefficient estimate of this variable is found to be negative, but very small in only one trade regression in which real openness is dependent variable.

Of course, I do not purport that the extent of trade openness is accurately and perfectly captured by these trade policy indexes. Like you, I believe that these indexes have some weakness and hence open to criticism. Yet, I also believe that the constructed policy indexes are finer and more informative measures of trade openness than the other existing openness variables. Nevertheless, I will try to improve these

[2] I have to confess that while writing the paper, I overlooked this last point.

indexes by adding other variables such as distance from major trade centres, foreign direct investment to trade model in the revised version.

As noted in the present paper and also you rightly argue that it would be better to obtain coefficient estimates of trade policy barriers, namely tariffs and NTBs from a gravity model of trade. However, this is obviously a challenging task and includes substantial difficulties. In this context, I would like to emphasise a few points here. First, as far as I know, the proper data on bilateral trade is available from UNCTAD, IMF's Direction of Trade Statistics data base and OECD and cover the only period 1990-2005. This time period is problematic for testing the effect of trade barriers on growth since the variability in the data on trade barriers (especially tariff rates) has been eliminated due to ongoing progress of trade liberalization. Second and equally importantly, we also need to bilateral tariffs and NTBs for gravity equation. Finally, it is obvious that estimation of such a gravity trade model requires a considerable amount of effort for collecting and organizing the data. Therefore, given the scope and objective of the present paper, it is more appropriate to deal with this challenging task in a future study.

Comment 5. The sensitivity analysis carried out in the paper is very common robustness checking in the empirical cross-country growth literature. In this context the major issue is selection of other control variables in the growth equation, as recently emphasised by Harrison and Rodríguez-Clare (2010). It is fair to say that my sensitivity analysis is superior in some aspects because it includes important growth theories, especially institutions and geography, two key growth theories that are neglected in most of the previous studies are included in my analysis. Furthermore, the sensitivity checking does not suffer from outlier effects.

Although the model specification for sensitivity analysis in the current paper is comprehensive, it is still subject to model uncertainty problem and one could reach different results by employing different growth variables and hence models, as you rightly point out. However, akin to the many studies in the literature, my aim while carrying out a sensitivity analysis is to provide more robust finding on the openness-growth nexus, not to deal with model uncertainty problem in a systematic way. In other words, employing relatively comprehensive growth model, I partly address the model uncertainty problem in the paper.

Indeed, I can expand this section by employing extreme bounds analysis (EBA) as in the study by Levine and Renelt (1992). However, EBA is too extreme and overstates the model uncertainty problem because it concludes a variable as fragile if the coefficient of that variable does not remain significant and/or changes its sign even in one regression. Therefore, given the result of sensitivity analysis in the paper, it is highly likely that all openness variables will be found fragile if one carry out an EBA. On the other hand Sala-i-Martin (1997) version of EBA can be found more reasonable because this analysis considers the whole distribution of variable of interest, and assign a level of confidence for the robustness test instead of labelling a variable as robust or fragile according to extreme bounds. However, the statistical properties of this approach, especially the weighting scheme of models, are unclear since they are not based on a formal statistical theory (as Barro and Sala-i-Martin (2004) point out).

In my opinion, the most promising solution of this problem is to integrate model uncertainty that is inherent in cross-country growth regressions into subsequent statistical inference by using Bayesian Model Averaging (BMA) technique. It is however obvious that applying BMA approach to cross-country growth regression is a difficult task, (especially assigning appropriate priors to models and their parameters is very challenging) and clearly subject of a different study.[3]

Finally, your concern about that the the effect of openness on growth may be different in different decades will be addressed by using panel growth model with 10-year averages over the 1960-2000 period.

Other Modifications. Following the comments of the first referee I am planning to make the following modifications.

- I will write a brief literature review on openness-growth nexus.
- I am planing to shorten the paper. To do so, I will drop the section 3.1 in which the trade volumes as openness measures empirically

[3]Frankly, in a different paper under review of another journal, I and my coauthor investigate the robustness of the relationship between trade openness and long-run economic growth over the sample period 1960-2000, utilising Bayesian model averaging techniques. In doing so we consider 8 different growth theories including openness and 26 different proxy variables measuring these theories. We measure openness by six different variables, namely the current openness, real openness, fraction of open years and three composite trade policy indices used in the present paper. Our findings indicate that trade oneness has the lowest posterior inclusion probability, implying it is not a robust growth determinant. However, we find that substantial evidence in favour of economic institutions and macroeconomic instability induced by high inflation and excess government consumption are key factors in explaining economic growth. As can be seen, the result of BMA exercise support the findings of the current paper.

tested from the paper since they are problematic measures of openness. As explained above, I am also planning to remove three more openness measures from the empirical analysis, namely the outward orientation index by Syrquin and Chenery (1989) covering only 1965-1980 period; the original Frankel-Rome predicted trade share; and the Frankel-Romer predicted trade share provided by Dollar and Kraay (2003). This means that the number of openness measures will be considerably less in the revised version of the paper.

- I will write a more compact conclusion.

Once again, I would like to thank you for reading my paper and for making such valuable criticism and comments.

Bülent Ulaşan

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Appendix

Table 4: Principal Component Analysis for Trade Policy Measures

Variables	PC1	PC2	PC3	**Final Weights**
M_DUTY	0.6054	-0.4203	0.6759	0.34
OWQI	0.6224	-0.2794	-0.7312	0.10
log(1+BMP)	0.4962	0.8633	0.0924	0.51
Eigenvalue	1.56965	0.816241	0.614109	
Proportion	0.5232	0.2721	0.2047	
Cumulative	0.5232	0.7953	1.000	

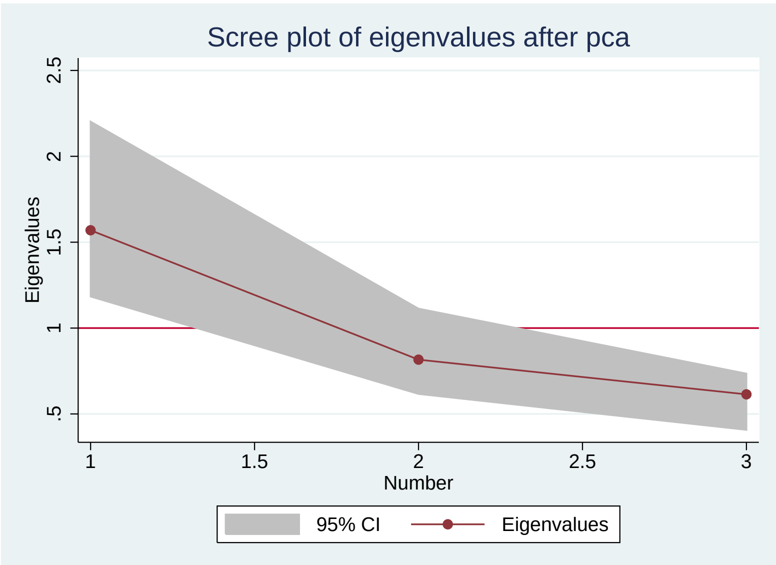

Figure 2: Scree Plot after the PCA for Direct Trade Policy Measures

Table 5: Economic Growth and Composite Openness Indexes based on PCA for Trade Policy Measures: OLS Estimates[†]

	(1)	(2)
log of GDP per worker in 1960	-0.479	-0.504
	(6.07)	(7.09)
$\log(n_i + g + \delta)$	-1.342	-1.153
	(3.46)	(3.04)
log of Investment rate	0.341	0.305
	(2.69)	(2.39)
log of Secondary School enrolment	0.429	0.447
	(5.11)	(5.27)
Openness Index based on the First PC	-0.049	
	(1.06)	
Openness Index based on all PCs	-	-0.183
		(2.27)
Constant	2.114	2.770
	(1.83)	(2.56)
Number of Observations	76	76
Adjusted R^2	0.56	0.58

Note: t-statistics based on heteroscedastic-consistent (White-robust) standard errors are in parenthesis. The variable, $(n_i + g + \delta)$ refers to sum of rates of population growth, technical progress and depreciation.

[†] Dependent variable is the log difference of real GDP per worker between 1960 and 2000.