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IDENTIFYING THE DIRECTIONS OF THE RELATIONSHIPS OF ASSOCIATION BETWEEN THE CONSTRUCTS AND THEIR INDICATORS: AN EMPIRICAL CASE

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Abstract: There are two types of models for measuring a construct. A construct is a latent variable when the measurement indicators are influenced by it. In this case, the indicators are called reflected or effect indicators. On the other hand, a construct can be called a composite variable when it is the indicators that condition its behavior. These indicators are called formative or causal. There is disagreement in the literature about the nature of indicators for measuring various constructs. Furthermore, in most empirical work, indicators are assumed to be reflective. The direction of the linear relationship between indicators and their constructs influences the parameter estimates of structural models. An empirical study with categorical data is used to assess the direction of linear relationships. Although the theoretical framework of some constructs used advocates the use of causal indicators, tests of statistical significance pointed out that all indicators in the model are reflected.
Keywords: Confirmatory tetrad analysis, causal indicators, reflective indicators, composite variable, latent variable.

INTRODUCTION

Initially, it presents a synthesis of the two types of indicators, namely, reflected or effect, and formative or causal. The initial step consists of your conceptualization. Then, the dissent in the literature regarding the classification used in empirical studies will be discussed. Later, some heuristics will be presented to identify the nature of the indicators. In the following topic, an empirical model used in this article will be exposed, and the procedures adopted for the analysis of association relationships will be shown. Finally, the conclusions inferred from the model used will be presented.

CONCEPT

Structural equation models originate from studies of multiple linear regressions and factor analysis. Factor analysis is characterized by the measurement of a construct – corresponding to an abstract concept, such as intelligence, attitude, personality, technological innovation, satisfaction with concessionaire companies – through observational variables called reflected indicators. This designation results from the fact that the intensity of the construct, in this case called the latent variable, reflects on the observational variables used to measure it. In summary, the indicator reflects the behavior of the construct. In other words, a causal relationship is assumed between the latent variable and the reflected, reflexive, or effect indicators, in which it conditions the level of the measurement scale of the indicators used for its estimation.

In structural equation models composed of latent variables, the scale validation process and the accuracy of the estimation of the values (scores) of the construct is inferred from statistical criteria of measurement validity and reliability. These methodological criteria are inherited from the classical measurement theory, in which latent variables are defined based on the variance of their reflected indicators (BOLLEN and LENNOX, 1991; DIAMANTOPOULOS, 2006; EDWARDS and BAGOZZI, 2000; MacKENZIE et al., 2005; ROSSITER, 2002).

Otherwise, there are constructs in which this relationship is not observed, that is, the construct does not condition the intensity verified in the measurement scale of the observational variable. Rather, it is the observational variables that determine the measurement of the construct. In this case, we say that the constructs are composites formed from the linear combination of observational variables, plus a disturbance term referring to its estimation error. These manifest variables are then called formative or causal indicators, as they condition the construct score, whereas this construct is called a composite variable.

Having made this conceptual and terminological differentiation, how, then, is it possible to distinguish, with greater assertiveness, these two types of measurement models, that is, latent variables and reflected indicators, on the one hand, and composite variables and formative indicators, on the other?

AMBIVALENCES OF CAUSAL MEANING DETERMINATION

In order to show a bias arising from the reasoning of the classical theory of factor analysis and to demonstrate the difficulty in correctly categorizing the construct, several examples of scientific works are cited, whose nature of the constructs has been questioned and criticized.

There is a hegemony for the constitution of reflected indicators and, ipso facto, of latent variables. As an example, we present some constructs originally constituted as latent variables, but which were questioned as to their nature. They are: job satisfaction, professional performance, organizational commitment, leadership, socioeconomic status, exposure to discrimination, exposure to stress, social interaction, and service quality (BOLLEN and LENNOX, 1991; BORSHOOM et al., 2003; MacKENZIE et al., 2003; MacKENZIE et al. al., 2005; McDONALD, 1996; ROSSITER, 2002). By way of illustration, Bollen (1989) cited the examples of race and sex as formative indicators of the exposure to discrimination factor. He also illustrated divorce, unemployment, and promotion as causal indicators of the stress exposure factor. He also added income, education, and occupational prestige as conditions for socioeconomic status. However, this question remains controversial. As an example, Edwards and Bagozzi (2000) defend the reflected nature of the indicators of the organizational commitment, socioeconomic status and stress constructs.

On the other hand, the classification of some constructs as latent variables is pacified, such as, for example, self-esteem, intelligence, fear of negative evaluation, mental abilities, emotional states, and personality traits, which manifest themselves, eg, in the form of attitudes, feelings and mental activities (BOLLEN and LENNOX, 1991; BORSSBOOM et al., 2003; FAYERS and HAND, 2002; MacCALLUM and BROWNE, 1993; ROSSITER, 2002). Edwards and Bagozzi (2000) observed that the subjective states corresponding to cognition, emotion, attitude, and other states of mind – ethos of psychology – are more associated with latent variables. On the other hand, behavior-related phenomena, such as personal performance, tend to be measured as composite variables.

IDENTIFICATION OF THE NATURE OF THE INDICATOR

In this item, a set of principles that must be observed when trying to specify, initially, the structure of the measurement relationships between a construct and its meters, that is, whether the measurement model consists of reflected or formative indicators, is elaborated.

The first consists of identifying whether the indicators are measuring characteristics or manifestations of the construct. If they capture manifestations of the construct, they will be reflected. On the other hand, if they express a set of characteristics capable of explaining the meaning of the construct, the indicators will be formative. The following question must be asked: will changes in the construct lead to changes in the meters (reflected indicators) or, on the contrary, are changes in measurements that cause changes in the construct (formative indicators)?

The second criterion corresponds to the

replacement level of the indicators. Reflected indicators capture much of the essence of the construct and are therefore more interchangeable than formative indicators. The latter measure unique and representative aspects of the conceptual domain of the construct and must be exhaustive in the sense that all indicators that express characteristics of the construct must be included in the model.

Third, one must prospect whether the indicators present covariance with each other. Since the reflected indicators share a common cause – construct manifestations – it is predictable that they will correlate with each other. Distinctly, if it is not possible to make predictions about the existence of mutual correlations between the meters, these will be formative indicators. These indicators can even be correlated with each other, however, the verification of this evidence cannot be made a priori (BOLLEN and LENNOX, 1991; BORSBOOM *et al.* 2003; EDWARDS and BAGOZZI, 2000; MacKENZIE *et al,* 2005).

An additional way to identify the nature of the indicator – whether reflected or causal – is through the interpretation of temporal precedence. Bollen (1989) suggested the use of 'mental experiments' due to the impossibility of directly measuring the constructs. Initially, an attempt must be made to imagine changes in the factor to subsequently identify whether there would be changes in the measurement variables. Continuously, the opposite is done, that is, one imagines whether changes in the indicators will influence the factors. The finding of the initial experiment would correspond to reflected indicators and the second, to causal indicators.

However, the author pointed out that, although the mental perception of temporal precedence between events is the most effective way of identifying the causal relationship, the mental experiment does not always allow the clear identification of the primary event. This perception becomes even more obscure when it is not possible to estimate the period between the occurrence of phenomena or events. In these cases, the relationships can be reciprocal or non-recursive. As an illustration, Bollen (1989) mentioned the difficulty of identifying the temporal precedence – and, consequently, causal – between a company's financial health and the price of its shares on the stock market.

Causal indicators have implications for traditional assessments of meter validity and reliability. The classical test theory that supports the reliability criterion does not conceive the existence of this type of indicator. The use of the multiple correlation coefficient (R2) as a reliability estimator has serious limitations. This is because this coefficient does not express the effect of the causal indicators on the factors, but the opposite. Furthermore, since causal indicators are exogenous variables, this coefficient will be zero, as the origin of possible associations between them is external to the analyzed structural arrangement. Therefore, existing reliability estimates are not applied for the analysis of causal indicators. On the other hand, since validity expresses the adherence – or direct structural relationship – of a meter to the concept, this measurement criterion remains valid for the reflected indicators.

ANALYSIS PROCEDURES

The pictorial model used in this work and the original structural model are presented below, conceived from theoretical and empirical literature on firm resources and capabilities, channels of mediation of national entrepreneurs – exogenous variables; public foreign trade policies, export behavior and export performance of the firm – endogenous variables. The conceptual, theoretical and empirical exposition of these fields of knowledge is beyond the main objective of this work.

In the Appendix of this study, the latent variables of the first and second order, or constructs, and the respective indicators of the structural model constituted from the specialized literature are presented.

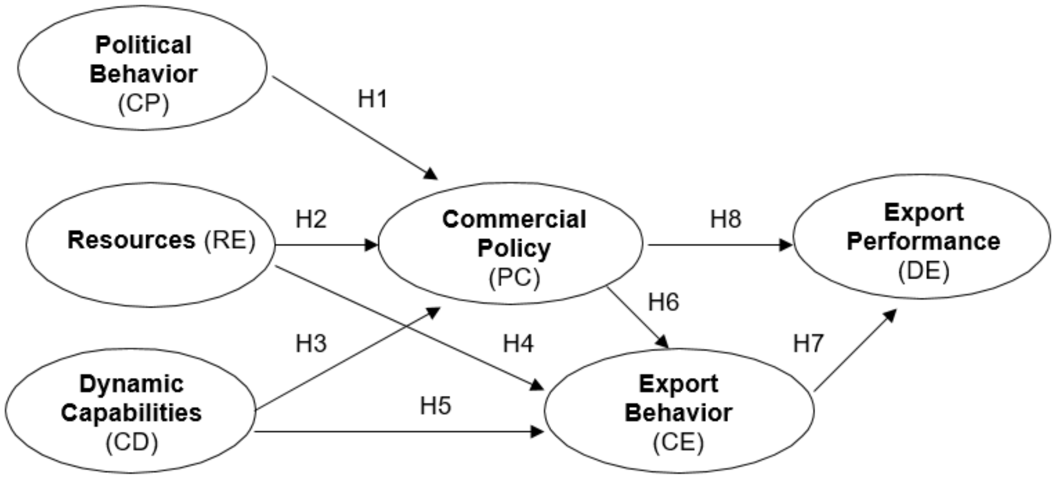

FIGURE 1 – Simplified analysis model of Brazilian trade policy.

The following hypotheses are naturally derived from the proposed research model, and must be tested with a view to validating the model:

H1: the firm's political behavior positively conditioned the use of commercial policy instruments;

H2: the firm's resources positively conditioned the use of trade policy instruments;

H3: the firm's dynamic capabilities positively conditioned the use of trade policy instruments;

H4: the firm's resources positively conditioned its export behavior;

H5: the firm's capabilities positively conditioned its export behavior;

H6: State trade policy instruments positively conditioned the firm's export behavior;

H7: the firm's export behavior positively conditioned the performance of its exports; and

H8: State trade policy instruments positively conditioned the firm's export performance.

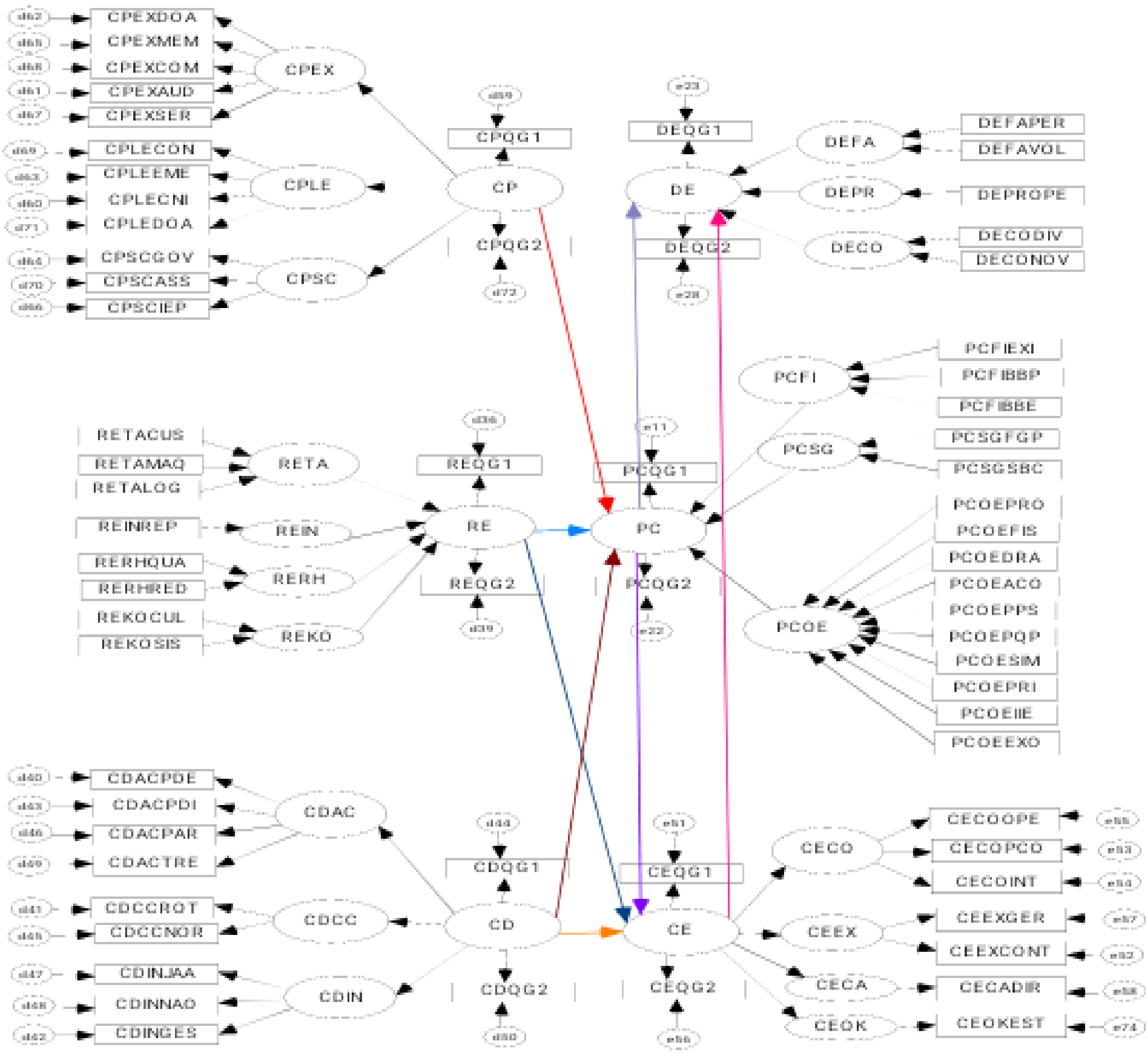

FIGURE 2 – original structural model

SENSE OF THE ASSOCIATION RELATIONSHIP OF INDICATORS

In this topic, the meanings of the relationship of measurement indicators are analyzed. It seeks to determine whether the manifest variables (indicators) of the different factors are reflected indicators, in which the factor conditions the measurement of the variable, or whether they are causal, when, then, the variables determine the measurement of the factor.

The original theoretical model, shown in Figure 2, corresponds to the unfolding of the pictorial model of the constructs illustrated in Figure 1. It is the Full Version of the initial theoretical model in which all manifest variables of each of the first and second order constructs (factors) are presented. From it, a set of analyzes is carried out with the objective of obtaining the final model. In this sense, the practical and statistical significance of each of the parameters of the developed models is evaluated.

The thought experiment is used, which corresponds to the aprioristic definition of the meaning of the causal relationships of the construct measurers (BOLLEN, 1989).

During the elaboration of the analysis model, it was concluded that three measurement models would be of a reflected nature: political behavior, dynamic capabilities, and export behavior. The remaining three would be composed of causal indicators, namely, resources, trade policy, and export performance. In the first case, the constructs are latent variables, while in the second, composite variables.

In order to corroborate the meaning of the relationships between the indicators and the constructs, we seek to identify the nature of the indicators using two different statistical analyses. The initial procedure does not feature statistical tests for the causal relationship. It allows the analysis of the model's adjustment indicators, and the verification of the statistical significance of its parameters. It consists of carrying out confirmatory factor analysis of each of the measurement models. In this case, all indicators were directly associated with constructs or second-order factors, that is, the dimensions or categories (first-order factors) of the construct did not make up the measurement models.

The second procedure, unlike the previous one, emphasizes the statistical validation of the causal sense, through chi-square statistics (χ^2), at the expense of practical significance. Corresponds to the method named *confirmatory tetrad analysis* – CTA (BOLLEN e TING, 2000; TING, 1995). According to this method, if the set of covariances of a group of 4 indicators (tetrad) is close to zero, the indicators will be causal; otherwise, they will be reflected. In the syntax of this statistical test, case the statistic χ^2 is significant (p value < 0.05), the indicators will be causal; otherwise, if the statistical test is non-significant (p value ≥ 0.05), the indicators will be reflected.

The statistics used in both procedures are summarized below:

- *p value*: the probability of a value – p value, as the name expresses itself, is the statistical probability that the estimate of a parameter is within the confidence interval for its occurrence. It is used to express the existence of statistical significance in the estimation of a parameter, in the relationship between parameters, or in the comparison of models, e.g., factor loading, structural coefficient, correlation between factors, chi-square test of structural models.

- Chi-square distribution (χ^2): used to estimate the fit of a structural model, it provides chi-square estimators to test the null hypothesis. (H_0) that $S = \Sigma(\theta)$, that is, given that S is the covariance matrix of observational variables,and θ is the set of structural parameters of the model, the null hypothesis is that all residuals are equal to zero. If the value χ^2 is high, the model will not fit the empirical data and the null hypothesis will be rejected. In general, the chi-square distribution presents the following representation: $\chi^2 = (N - 1). F (gl, \alpha)$; where N is the sample size, and F corresponds to the chi-squared distribution function, whose parameters are the number of degrees of freedom (df) and the significance level of the test (α). The statistic: χ^2 is heavily influenced by sample size. The lack of statistical significance suggests that the model is not rejected for: *p value* > α.

- Multiple correlation coefficient (R^2): examines statistical significance, that is, the proportion of the variance of the dependent variables that is explained by the independent variables. As discussed above, it is not an appropriate reliability estimator for estimating the association between causal indicators of factors, being, therefore, used only for the reflected indicators. Parameters with p value > 0.05 are eliminated if the relationship is not theoretically substantive.

- λ (lambda): is the measurement model statistic that corresponds to the factor loading, or regression coefficient, between the latent variables and their indicators.

- TLI (*Tucker-Lewis index*): is a statistic used to compare alternative models or the proposed model from a more restrictive model (*baseline model*); TLI > 0.90.

- CFI (*comparative fit index*): also, it is a comparative statistic that measures the level of improvement of the centrality obtained by a new embryonic model of a previous one; CFI > 0.90.

-RMSEA (root mean square error of approximation): it is a statistic used for the general adjustment of the model that is determined from the estimation of a distribution: χ^2 uncentered, where the value of the uncentered parameter is compared with the value of the centered distribution; RMSEA < 0.08.

- WRMR (weighted root mean square residual) is a statistic calculated by Mplus for categorical variables; WRMR < 1.

From now on, the first procedure will be used, that is, the practical significance analysis of the indicators will be carried out, reconciled with their statistical significance. The following table summarizes the results in terms of model fit statistics.

Construct	χ^2	gl	p value	CFI (> 0,90)	TLI (> 0,90)	RMSEA (<0,08)	WRMR (< 1,000)
Political Behavior							
Causal	**5.379**	**7**	**0.6138**	**1.000**	**1.286**	**0.000**	**0.493**
Reflected	134.130	20	0.0000	0.922	0.965	0.191	1.189
Resources							
Causal	**5.290**	**5**	**0.3815**	**0.993**	**0.982**	**0.019**	**0.524**
Reflected	65.635	11	0.0000	0.878	0.889	0.178	1.094
Dynamic Capabilities							
Causal	**13.617**	**7**	**0.0584**	**0.763**	**0.560**	**0.078**	**0.805**
Reflected	70.148	17	0.0000	0.881	0.937	0.141	0.892
Commercial Policy							
Causal	**10.660**	**9**	**0.2998**	**0.937**	**0.874**	**0.034**	**0.601**
Reflected	268.295	18	0.0000	0.881	0.914	0.298	2.159
Export Behavior							
Causal	**14.066**	**5**	**0.0152**	**0.822**	**0.573**	**0.107**	**0.794**
Reflected	13.124	12	0.3601	0.978	0.971	0.024	0.504
Export Performance							
Causal	**8.596**	**3**	**0.0352**	**0.884**	**0.691**	**0.109**	**0.817**
Reflected	10.963	3	0.0119	0.886	0.734	0.130	0.799

TABLE 1 – Statistics of measurement models for causal and reflected indicators

The table above highlights, in bold, the nature of the indicators that was inferred from the data adequacy indices (CFI, TLI, RMSEA and WRMR), also called model adequacy criteria or adjustment indices, which correspond to meters of the level of adequacy of the model to the sample data. It is observed that the analysis of the indicators was inconclusive, given the non-observance of valid values for adjustments for all statistics, for the measurement models, dynamic capabilities and export performance, a conclusion denoted by the absence of bold marking.

The following table presents an analysis of the causal sense of the measurement models under a different dimension from the one presented above (level of adjustment of the data to the model). The statistical significance of the parameters of the indicators, that is, their factor loadings (λ) is presented together with the significance of the multiple correlation coefficients (R^2). These coefficients are determined only for reflected models.

The columns preceding the p values (second and fourth) add the indicators that did not show: λ and R^2 statistically significant, that is, p values > 0.05, while the last column (remaining variables) lists those that have statistical validity, that is, whose p values were ≤ 0.05 for both λ and the same to R^2. It is emphasized that Mplus does not present the calculation of R^2 for causal models, as the classical theory of measurement of non-observational variables only measures the adherence of indicators to the behavior recommended by the factor, that is, when the indicators are dependent variables of the factor.

It is observed that the statistics presented below come from confirmatory factor analysis of each of the model's measurement models.

Construct	Variable (λ)	p value (> 0.05)	Variable (R^2)	p value (> 0.05)	Remaining variables
Political Behavior					
causal model	CPEXDOA CPEXMEM CPEXSER CPEXCOM CPLECNI CPLEEME CPLECON CPLEDOA CPSCIEP CPSCASS	0,676 0,104 0,415 0,998 0,294 0,645 0,153 0,292 0,452 0,488	n.d.[(1)]		CPEXAUD CPSCGOV
reflected model	Nihil		nihil		all variables
Resources					
causal model	RETACUS REINREP RERHRED REKOSIS RETALOG	0,146 0,266 0,333 0,194 0,057	n.d.		RETAMAQ RERHQUA REKOSUL
reflected model	Nihil		nihil		all variables
Dynamic Capabilities					
causal model	CDACPDE CDCCROT CDCCNOR CDACPAR CDINJAA CDACTRE	0,491 0,200 0,386 0,108 0,074 0,216	n.d.		CDACPDI CDINNAO CDINGES
reflected model	Nihil		nihil		
Commercial Policy					

causal model	PCFIEXI PCFIBBP PCFIBBE PCSGFGP PCOEPRO PCOEDRA PCOEACO PCOEPQP PCOESIM PCOEPRI PCOEEXO	0,336 0,548 0,351 0,398 0,514 0,273 0,905 0,761 0,099 0,219 0,671	n.d.		PCSGSBC PCOEFIS PCOEPPS PCOEIIE
reflected model	Nihil		nihil		all variables
Export Behavior					
causal model	CECOINT CEOKEST	0,184 0,139	n.d.		CECOOPE CECOPCO CEEXGER CEEXCONT CECADIR
Construct	**Variable (λ)**	**p value (> 0.05)**	**Variable (R^2)**	**p value (> 0.05)**	**Remaining variables**
reflected model	CECOINT CEOKEST	0,052 0,480	CECOINT CECOOPE CEEXGER CECADIR CEOKEST	0,286 0,107 0,078 0,107 0,718	CECOPCO CEEXCONT
Export Performance					
causal model	DEFAPER	0,219	n.d.		DEFAVOL DEPROPE DECODIV DECONOV
reflected model	Nihil		nihil		all variables

Note.: (1) n.d.: not available

TABLE 2 – Factor loadings for causal and reflected indicators

There is an apparent paradox between the analyzes summarized in the two previous tables. In the first, all adjustment indices indicate that causal indicators are more appropriate for the following measurement models: political behavior, resources, and trade policy. On the other hand, the reflected indicators are adequate for the export behavior. The constructs of dynamic capabilities and export performance did not converge for all adequacy indices.

Otherwise, in the second table, most of the supposed causal indicators turned out to be statistically insignificant. In light of the substantive meaning and the theoretical framework, that is, according to the practical significance, these results are ambiguous. As an example, in the causal model of the construct related to political behavior, only the indicators CPEXAUD – audiences with Ministers of State and/or Secretaries of their ministries – and CPSCGOV – participation in employers regulated by the government – showed statistical significance. All other observational variables from the executive dimension and civil society, as well as all those from the legislative dimension, did not show statistical validity. This inference is not supported by the theoretical literature on which the model was based and which guided the formation of categories and the selection of indicators. So there is an ambivalence between statistical significance and practice. The use of statistically valid indicators will only make the practical meaning of this model thin.

Results that were antagonistic to the theoretical body were also found in the causal models of the constructs related to resources and trade policy. With regard to resources, although the three remaining indicators each represent one of the categories of that construct, there is no consonance with the theoretical framework. For example, the RETAMAQ indicator – acquisition of machinery, equipment, and industrial software – does not express the representation of tangible resources. Elements such as economy of scale, logistics system, and corporate systems find ample support in the theoretical body of resource theory.

Finally, trade policy is restricted to four elements only when we assume the causal meaning of the indicators. By way of illustration, only one of them is commented. The variable manifests PCSGSBC – SBCE insurance – has statistical significance. However, according to the existing analyses, this instrument has a less significant relevance than the export financing sponsored by BNDES – BNDES-Exim, and by Banco do Brasil – PROEX.

In turn, the reflected model of the export behavior construct showed greater convergence. In terms of factor loadings, both the causal and the reflected models presented the same non-significant variables. However, when the analysis is extended to multiple correlation coefficients – which, by definition, are not estimated for independent variables, that is, for causal models – only two variables – CECOPCO and CEEXCONT – remained in the reflected model.

This partial analysis concludes with two observations. First, the sample size is relatively small and, ipso facto, the sample may not be representative of the population. Therefore, indicators whose parameters did not show statistical significance but on the other hand maintain solid practical significance can be maintained in the model. Second, the statistics generated by the structural equation models reflect the disjunction between the search for the best fit of the model's parameters - which is led by the adequacy indicators - and the best estimates of the association relations - regressions and covariances - between the observational variables and latent of the model. Thus, the antinomies highlighted above are cogent of structural models. Finally, a commonality between the general adjustment of the model, the statistical significances of the relationships between the variables, and the practical significances derived from the theoretical framework present in all stages of the model's conception must be sought.

Next, the second procedure for determining the meaning of the relationships between the indicators and their constructs is developed. This analysis will be complemented with the carrying out of tests of confirmatory analysis of tetrads (CTA) at a significance level of 5%, according to the formulations proposed by Ting (1995) and Bollen and Ting (2000). A Version of the indicators adopted in the so-called hybrid model will be used to identify the causal or reflexive nature of the indicators associated with the constructs. In this configuration, observational variables (indicators) of other factors that have theoretical relevance with the analyzed indicators were included in the measurement models composed of less than four indicators.

This model (hybrid) is a gradient of the complete model, the latter consisting only of measurement indicators. The hybrid model has composites (linear combination of indicators) and was developed for methodological purposes only, with the objective of reducing the number of observational variables of a factor and, therefore, improving the adjustment indicators and the parameter estimation process. The composition of the composites is presented at the end of the Appendix of this work.

In the hybrid model, the political behavior and export performance constructs kept their first-order factors. However, as the indicators of the first-order dimensions of export performance were not composed of four variables – for the application of the confirmatory tetrad analysis (CTA) it was decided to associate them directly with the main construct (second-order factor). An attempt was made to preserve the measurement model of the political behavior factor, elaborated from theoretical material, with the purpose of enabling a more comprehensive analysis of the channels of political mediation used by exporting companies. The maintenance of the original scales of the export performance factor was done naturally, since, according to the proposed model, this is the main construct to analyze the contribution of trade policy to exports.

The table below summarizes the results of the CTA obtained using the hybrid model.

Construct	Indicators used	χ^2	*p value*	Type
CPEX	CPEXAUD, CPEXDOA, CPEXSER, CPEXCOM, CPEXMEM	4,89	0,4295	reflective
CPLE	CPLECON, CPLEEME, CPLECNI, CPLEDOA	8,86	0,0119	causal
CPSC	CPSCGOV, CPSCASS, CPSCIEP, CPQG1	8,16	0,0168	causal
RE	RE_TANG, RE_INTAN, RE_RH, CD_ACUM	10,29	0,0058	causal
CD	CD_ACUM, CD_CONV, CD_INOVA, RE_INTAN	0,60	0,7403	reflective
PC	PC_FIN, PC_SE_GA, PC_INDIR, PC_PINT, PC_INVES, PCOEFIS, PCOEPRI	27,33	0,0174	causal
DE	DEFAPER, DEPROPE, DECODIV, DEFAVOL, DECONOV	6,86	0,2309	reflective
CE	DEFAVOL, DEFAPER, CE_COMPR, CE_EXPER	9,14	0,0104	causal

TABLE 3 – Tetrad analysis of the hybrid model measurement models

Once the types of indicators have been determined from the CTAs, the following table compares the results arising from the mental experiments with the indicators of adequacy of the measurement models and with the CTA.

<table>
<tr><th>Construct</th><th>Experiment</th><th>Adjustment Indices</th><th>CTA</th></tr>
<tr><td>CPEX</td><td>reflective</td><td rowspan="3">causal</td><td>reflective</td></tr>
<tr><td>CPLE</td><td>reflective</td><td>causal</td></tr>
<tr><td>CPSC</td><td>reflective</td><td>causal</td></tr>
<tr><td>RE</td><td>causal</td><td>causal</td><td>causal</td></tr>
<tr><td>CD</td><td>reflective</td><td>non-adequacy</td><td>reflective</td></tr>
<tr><td>PC</td><td>causal</td><td>causal</td><td>causal</td></tr>
<tr><td>DE</td><td>causal</td><td>non-adequacy</td><td>reflective</td></tr>
<tr><td>CE</td><td>reflective</td><td>reflective</td><td>causal</td></tr>
</table>

Framework 1 – Summary of procedures for identifying the nature of the indicator

It appears that the measurement models used in the column of adjustment indices do not present, exactly, the same nature as the indicators used in the CTA. The models related to the adequacy indices used all indicators and correspond to the complete model. In turn, the CTA was calculated for the so-called hybrid model, which shares original and composite indicators. It must be noted that the analysis expressed in the column of adequacy indicators was carried out with the direct association between all indicators and the main construct. Therefore, the CPEX, CPLE, and CPSC constructs are consolidated in the political behavior construct, whose adjustment indicators converged to the causal model.

One can observe ambivalences in the results obtained. The results for the three criteria presented were congruent only for the factors related to resources (RE) and trade policy (CP), highlighted in bold. However - as noted in Table 2 above, when the significance of factor loadings and multiple correlation coefficients of the indicators of these factors are analyzed, the variables that are statistically significant have low practical significance, that is, the its meaning is not theoretically expressive.

It is possible that these divergences are due to the measurement scale used. Ting (1995) asserted that the residuals of tetrad calculations are influenced by the measurement scale. All dimensions of the constructs were measured using the Likert scale. This scale is suitable for capturing the respondent's opinions, perceptions and feelings. On the other hand, the calculation of the tetrads' residuals may be involved by model adjustment problems that go beyond the causal direction.

Finally, a model containing causal indicators and reflected simultaneously is configured, with the purpose of analyzing its level of adjustment to the sample data. The commercial policy (CP) and resources (RE) factors were composed of causal observational variables, as they presented converging results in the three criteria for identifying the nature of the indicator (highlighted in bold in Framework 1), while the others, by reflective variables. For the estimation of PC, all 5 indicators corresponding to the official export promotion mechanisms (PCFIEXI, PCFIBBP, PCFIBBE, PCSGFGP, and PCSGSBC) were used, regardless of their being statistically significant. All other indicators used presented significant l and/or R2 statistics, that is, they corresponded to those in the last column of Table 2, above.

The results of the adjustment indexes obtained are in the following table 4.

χ^2 / gl (*p value*)	CFI	TLI	RMSEA	WRMR
228,041 / 89 (0,0000)	0,870	0,874	0,100	1,335

TABLE 4 - Model fit statistics with causal and reflected indicators

All factor loadings of the reflected indicators were statistically significant. The same was verified with the resource indicators. However, no trade policy indicator, the other factor composed of causal indicators, was significant, as shown by the p values of the parameters related to their factor loadings, shown in the table below (Table 5).

PCFIEXI	PCFIBBP	PCFIBBE	PCSGFGP	PCSGSBC	PCOEFIS	PCOEPPS	PCOEIIE
0,304	0,483	0,993	0,621	0,273	0,301	0,163	0,806

TABLE 5 - P values of factor loadings of trade policy (causal indicators)

Finally, the structural regression coefficients and their respective p values (in parentheses) of the hybrid model are (Table 6).

CP □ PC	RE □ PC	CD □ PC	RE □ CE	CD □ CE	PC □ CE	PC □ DE	CE □ DE
0,187 (0,012)	0,060 (0,376)	0,092 (0,335)	0,605 (0,000)	0,877 (0,000)	0,287 (0,515)	0,903 (0,059)	0,565 (0,000)

TABLE 6 - Model regression coefficients with causal and reflected indicators

This analysis ends with a preliminary conclusion. The use of causal indicators compromises all practical validation and does not find shelter in the epistemology that must underlie the choice and application of any method. In the present case, the use of these indicators atrophies most of the theoretical body used for the constitution of the constructs and for the definition of their indicators.

The values contained in the tables of adjustment indices and regression coefficients (Tables 4 and 6) will be reproduced below for comparison with the general model in which all manifest variables are reflexive, when the decision about the meaning will then be presented of the relationships between measurement indicators and their respective constructs.

FINAL ANALYTICAL MODEL

Initially, the model will be composed with all the indicators that measure the different dimensions of the constructs, obtained from theoretical and empirical literature. Based on the analysis undertaken above, it will be considered that all indicators are reflected. The software used in this step was Mplus Version 5, and the discrepancy function adopted was WLSMV.

In order to facilitate cross-references throughout this work, the final Version obtained from the use of all indicators is called the complete model. Figure 3 below is similar to Figure 2, which corresponds to the original structural model, but all indicators are considered reflected. From statistical tests and practical significance, the manifest variables (reflected indicators, in this case) will be gradually eliminated – giving rise to new versions of the complete model, until obtaining the final complete model.

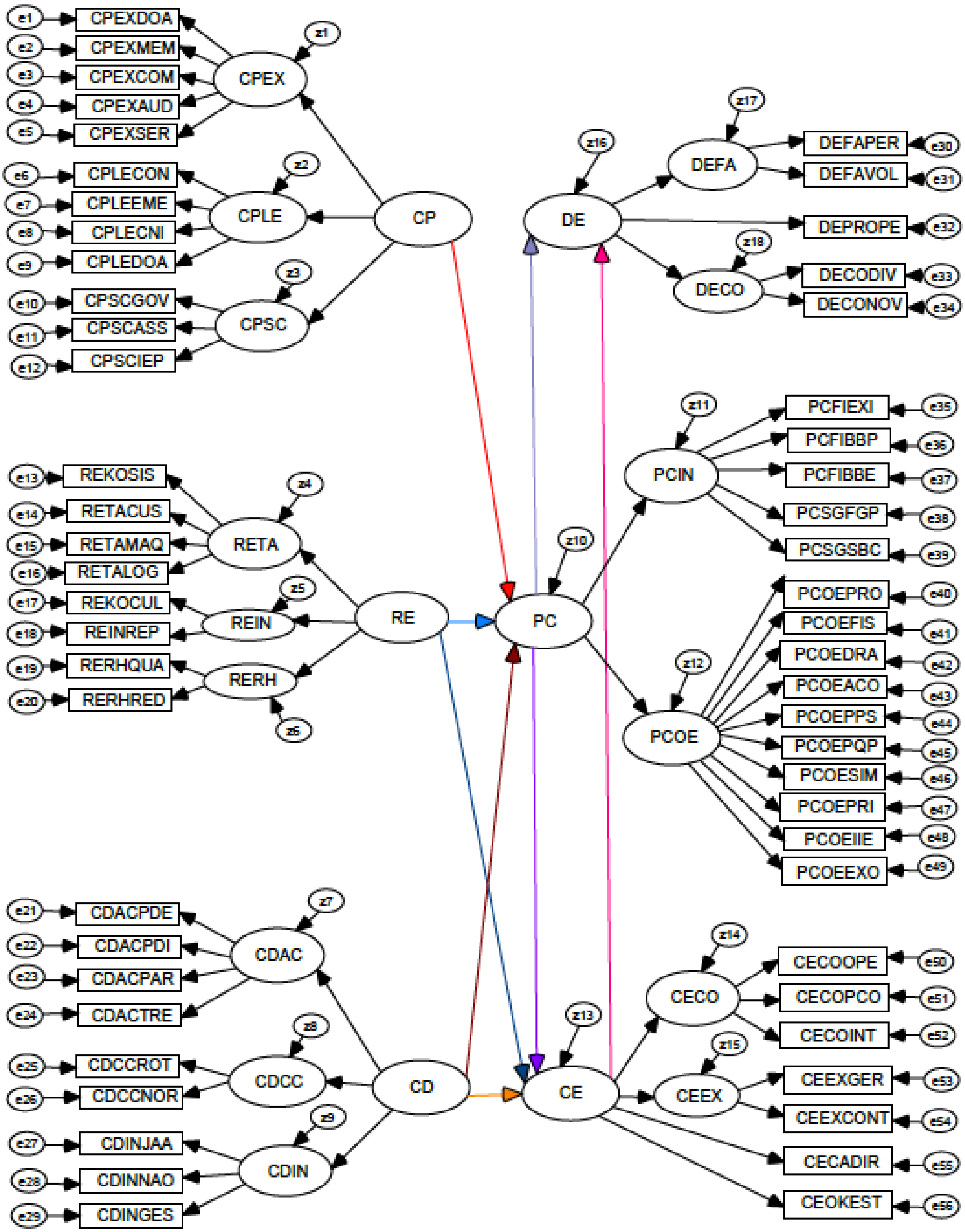

FIGURE 3 - Complete model (reflected indicators only)

An evolutionary chart is presented below, which summarizes the different versions of the model until obtaining the final model. The measurement indicators discriminated in the 'Parameters' and 'R2' fields were eliminated from the model, as they presented non-significant p values (broken down in parentheses) at a significance level of 5% and, in parallel, do not have substantive theoretical meaning.

Aiming at preserving the initial theoretical configuration, the general questions relating to each construct were sometimes introduced – duly mentioned in the table below. If the incorporation of these questions did not change the statistical significance of an indicator's parameter, they were removed together with the less representative metrics, in the subsequent Version. As an example, the factor 'export behavior' is mentioned, which, in the original Version, presented 4 indicators with non-significant R2 (p values ≥ 0.05). Therefore, in 'Version 1', only one indicator was excluded, and general questions were included in order to maintain the measurement suggested by the theoretical framework.

	Initial version	**Version 1**	**Version 2**	**Version 3**	**Version 4**	**Final version**
χ^2 / gl (*p value*)	201,702/89 (0,000)	208,808/89 (0,000)	193,317/86 (0,000)	185,203/85 (0,000)	182,884/83 (0,000)	178,872/80 (0,000)
CFI	0,937	0,932	0,940	0,944	0,945	0,947
TLI	0,952	0,948	0,954	0,957	0,958	0,960
RMSEA	0,090	0,093	0,089	0,087	0,088	0,089
WRMR	1,168	1,193	1,174	1,148	1,149	1,141
Parameters	CEOKEST (0,223)	-	-	-	-	-
R^2	CECOPCO (0,182) CECOINT (0,094) CEEXGER (0,091) CEOKEST (0,536)	CECOPCO (0,215) CECOINT (0,089) CEEXGER (0,085)	CECOINT (0,078) CEEXGER (0,090)	CECOINT (0,079) CECADIR (0,594)	CECOINT (0,080)	-
Modifications to the next Version	Deletion of CEOKES. Inclusion of general CE questions	Exclusion of CECOPCO	Exclusion of CEEXGER	Exclusion of CECADIR	Exclusion of CECOINT and general CE issues	

TABLE 7 - Full Model Statistics

The parameters of structural relationships - structural or regression coefficients between exogenous and endogenous factors (γ) and among the endogenous factors (β) these versions of the general model are shown below. Values in parentheses correspond to p values.

	Initial version	Version 1	Version 2	Version 3	Version 4	Final version
CP □ PC	0,282 (0,004)	0,264 (0,006)	0,262 (0,000)	0,263 (0,000)	0,263 (0,000)	0,273 (0,000)
RE □ PC	-0,321 (0,033)	-0,282 (0,040)	-0,269 (0,019)	-0,275 (0,020)	-0,277 (0,020)	-0,290 (0,020)
CD □ PC	0,298 (0,033)	0,269 (0,039)	0,259 (0,018)	0,261 (0,018)	0,263 (0,018)	0,270 (0,019)
RE □ CE	0,415 (0,000)	0,371 (0,000)	0,371 (0,000)	0,675 (0,000)	0,677 (0,000)	0,654 (0,000)
CD □ CE	-0,060 (0,457)	-0,017 (0,814)	-0,009 (0,897)	-0,010 (0,935)	-0,017 (0,889)	-0,081 (0,448)
PC □ CE	0,158 (0,023)	0,115 (0,021)	0,086 (0,065)	0,110 (0,177)	0,121 (0,145)	0,118 (0,230)
PC □ DE	-0,348 (0,086)	-0,272 (0,084)	-0,206 (0,175)	-0,156 (0,286)	-0,170 (0,247)	-0,164 (0,319)
CE □ DE	2,220 (0,000)	2,250 (0,000)	2,208 (0,000)	1,221 (0,000)	1,229 (0,000)	1,292 (0,000)

TABLE 8 - Regression coefficients of the complete model

Finally, the pictorial representation of the final complete model is shown below (Figure 4).

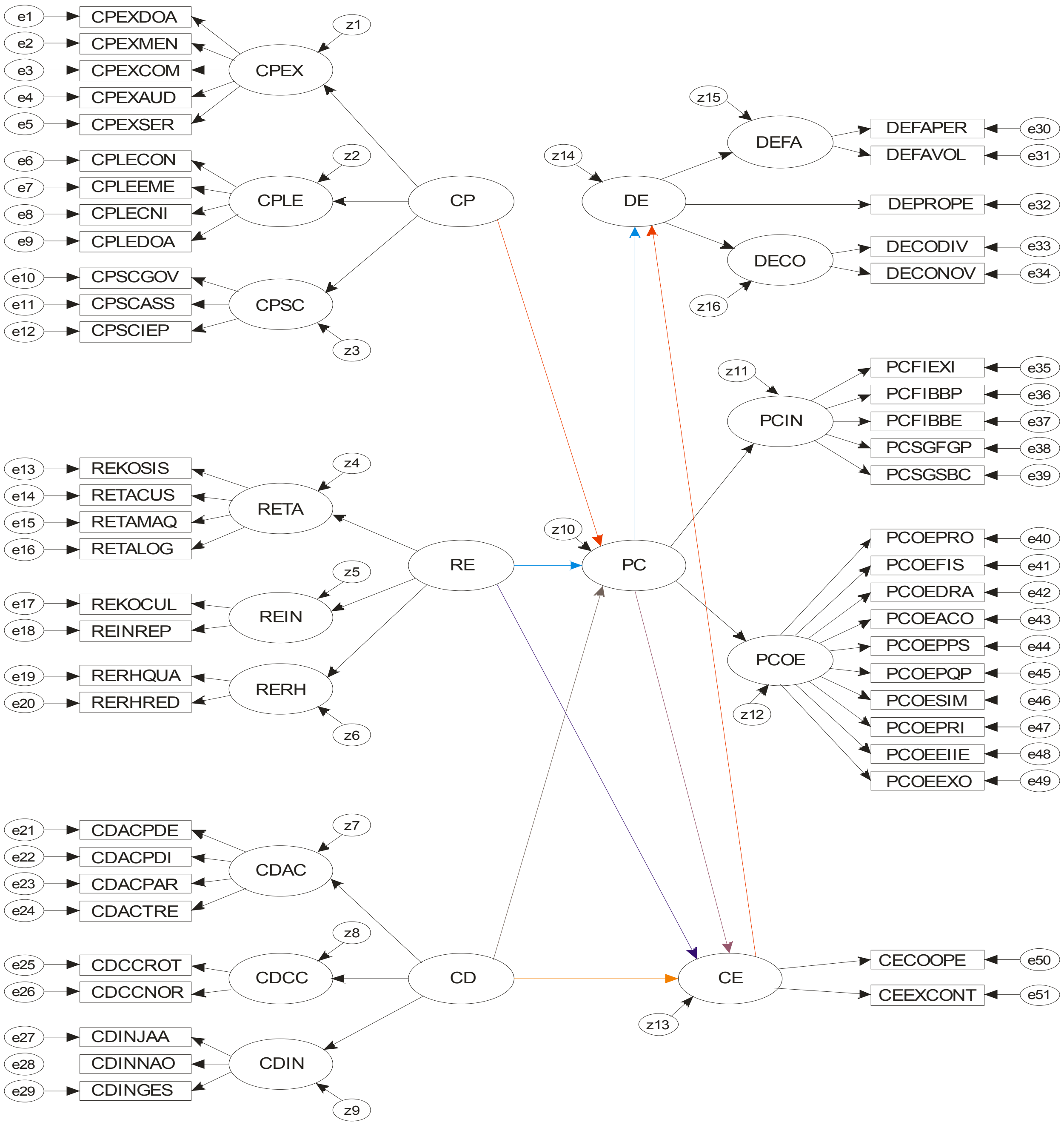

FIGURE 4 – Final complete model

CONCLUSION

The adjustment statistics and structural regression coefficients obtained in the final version (final complete model) are reproduced below – in which all indicators are reflected (last line) – together with the values obtained in Tables 4 and 6, presented previously, when the manifest variables of the factors PC and RE were considered causal (second line).

	χ^2 / gl (*p value*)	CFI	TLI	RMSEA	WRMR
PC and RE with causal indicators	228,041 / 89 (0,0000)	0,870	0,874	0,100	1,335
All reflective indicators	178,872 / 80 (0,000)	0,947	0,960	0,089	1,141

TABLE 9 – Full model fit statistics

	CP □ PC	RE □ PC	CD □ PC	RE □ CE	CD □ CE	PC □ CE	PC □ DE	CE □ DE
PC and RE causal indicators	0,187 (0,012)	0,060 (**0,376**)	0,092 (**0,335**)	0,605 (0,000)	0,877 (0,000)	0,287 (**0,515**)	0,903 (**0,059**)	0,565 (0,000)
All reflective indicators	0,273 (0,000)	-0,290 (0,020)	0,270 (0,019)	0,654 (0,000)	-0,081 (**0,448**)	0,118 (**0,230**)	-0,164 (**0,319**)	1,292 (0,000)

TABLE 10 – Regression coefficients of the complete model

Regarding the model's adequacy indicators (CFI, TLI, RMSEA and WRMR), all the statistics of the model composed of reflected variables were superior to those of the model with causal indicators. Furthermore, in the model with causal variables, the regression coefficient between the two factors that were constituted by the indicators, namely RE and PC – use of causal indicators, instead of reflective ones, did not show statistical significance (0.376).

Finally, the analysis of the nature of the relationships between the indicators is concluded. The general model that presents constructs – or factors – composed of causal indicators does not have statistical support. All of its adjustment indicators were lower than those estimated by the model composed only of reflected indicators. Furthermore, as observed after analyzing the data contained in Tables 1 and 2, the causal indicators lack substantive theoretical representation, which, therefore, frustrates any analysis of the practical significance of the model. Due to the better results in terms of statistical and practical significance, it is suggested to adopt reflective indicators for all analyzes contained in the model presented.

The results of the mental experimentation, the confirmatory factor analysis of each construct, and the confirmatory tetrad analysis did not converge to the empirical model used. Some measurement models showed better indicators of adequacy when the variables were causal. However, in these cases, most of the parameters of factor loadings and multiple correlation coefficients were not significant. It is possible that these inconsistencies were influenced by the Likert-type measurement scale. Finally, it must be noted that there is a paucity of empirical studies that analyze the causal sense, that is, the causal or reflected nature of the indicators of a factor in a measurement model.

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ADDENDUM

Constructs, categories and measurement variables used in the original structural model.

Attribute	Categories	Indicators
Political Behavior (CP)	Executive Dimensions (**CPEX**)	Campaign financing (**CPEXDOA**), participation in councils (**CPEXMEM**), participation in delegations (**CPEXCOM**), audiences and political contacts (**CPEXAUD**), hiring consultants (**CPEXSER**)
	Legislative Dimension (**CPLE**)	Campaign financing (**CPLEDOA**), contacts with members of political parties (**CPLECON**), participation in parliamentary commissions (**CPLEEME**), participation in the formulation of the legislative agenda within the National Confederation of Industries (**CPLECNI**)
	Civil society entities (**CPSC**)	Participation in employers (**CPSCGOV**), in industry associations (**CPSCASS**), and in study and research institutes (**CPSCIEP**)
	General Inquiries (**CPQG**)	Importance of political contacts (**CPQG2**), satisfaction with the means of articulation (**CPQG1**)

Attribute	Categories	Indicators
Resources (RE)	Tangible resources (**RETA**)	Size (**RETACUS**), technology (**RETAMAQ**), logistics (**RETALOG**)
	Intangible resources (**REIN**)	Company reputation (**REINREP**)
	Human resources (**RERH**)	Management qualification (**RERHQUA**), relationship network (**RERHRED**)
	Organizational capital (**REKO**)	Organizational culture (**REKOCUL**), corporate systems (**REKOSIS**)
	General questions (**REQG**)	Fulfillment of expectations by the resources (**REQG1**), satisfaction with the use of resources (**REQG2**)

Attribute	Categories	Indicators
Dynamic Capabilities (CD)	Knowledge acquisition (**CDAC**)	R&D contracting (**CDACPDE**), internal R&D activity (**CDACPDI**), partnership and cooperation agreements (**CDACPAR**), training and experimentation (**CDACTRE**)
	Knowledge ConVersion (**CDCC**)	Operational routines and procedures (**CDCCROT**), coding and standardization (**CDCCNOR**)
	Innovation activities (**CDIN**)	Existing product and process projects (**CDINJAA**), new product and process projects (**CDINNAO**), strategic and organizational changes (**CDINGES**)
	General issues (**CDQG**)	Competitive advantage of innovations (**CDQG1**), satisfaction with acquisition and diffusion of tacit knowledge (**CDQG2**)

Attribute	Categories	Indicators
Commercial Policy (PC)	Export Financing (**PCFI**)	BNDES-Exim (**PCFIEXI**), PROEX-post-shipment (**PCFIBBP**), PROEX-Equalization (**PCFIBBE**)
	Credit guarantee and insurance (**PCSG**)	FGPC (**PCSGFGP**), SBCE (**PCSGSBC**)
	Other intervening elements (**PCOE**)	Promotion (**PCOEPRO**), tax incentives (**PCOEFIS**), drawback (**PCOEDRA**), sectorial policies (**PCOEPPS**), trade agreements (**PCOEACO**), administrative procedures (**PCOESIM**), infrastructure investments (**PCOEIIE**), productivity and technological training programs (**PCOEPQP**), private credit system (**PCOEPRI**), exogenous factors (**PCOEEXO**)
	General issues (**PCQG**)	Access to official trade policy instruments (**PCQG2**), satisfaction with credit and insurance instruments (**PCQG1**)

Attribute	Categories	Indicators
Export Behavior (CE)	Commitment to exports (**CECO**)	Operational features (**CECOOPE**), entry into new markets (**CECOPCO**), tradeoff with the domestic market (**CECOINT**)
	Experience with exporting activities (**CEEX**)	Functional experience (**CEEXGER**), number of personal contacts (**CEEXCONT**)
	Export Channels (**CECA**)	Direct export (**CECADIR**)
	Origin of equity capital (**CEOK**)	Participation of external capital in the decision-making process (**CEOKEST**)
	General issues (**CEQG**)	Importance of commitment and business experience (**CEQG1**), satisfaction with exporting behavior (**CEQG2**)

Attribute	Categories	Indicators
Export Performance (DE)	Billing (**DEFA**)	Relationship between exports and total sales (**DEFAPER**), growth in exported volume (quantum) (**DEFAVOL**)
	Productivity (**DEPR**)	Productivity of production factors (**DEPROPE**)
	Competitiveness (**DECO**)	Production scope (**DECODIV**), market diversification (**DECONOV**)
	General issues (**DEQG**)	Competitiveness in the international market (DEQG1), satisfaction with export performance (**DEQG2**)

Composites of the Resources, Dynamic Capabilities, Commercial Policy and Export Behavior factors used in the hybrid model

Composites	Indicators
Resources	
RE_TANG	RETACUS, RETAMAQ, RETALOG, REKOSIS
RE_INTAN	REINREP, REKOCUL
RE_RH	RERHQUA, RERHRED
Dynamic Capabilities	
CD_ACUM	CDACPDE, CDACPDI, CDACPAR, CDACTRE
CD_CONV	CDCCROT, CDCCNOR
CD_INOVA	CDINGES, CDINJAA, CDINNAO
Commercial Policy	
PC_FIN	PCFIEXI, PCFIBBP, PCFIBBE
PC_SE_GA	PCSGFGP, PCSGSBC
PC_INDIR	PCOEPRO, PCOEDRA, PCOEPQP, PCOESIM
PC_PINT	PCOEACO, PCOEEXO
PC_INVES	PCOEPPS, PCOEIIE
Export Behavior	
CE_COMPR	CECOPCO, CECOINT, CECOOPE
CE_EXPER	CEEXCONT, CEEXGER