Koopman-Wang-Wei Decomposition Analysis of Global Value Chain

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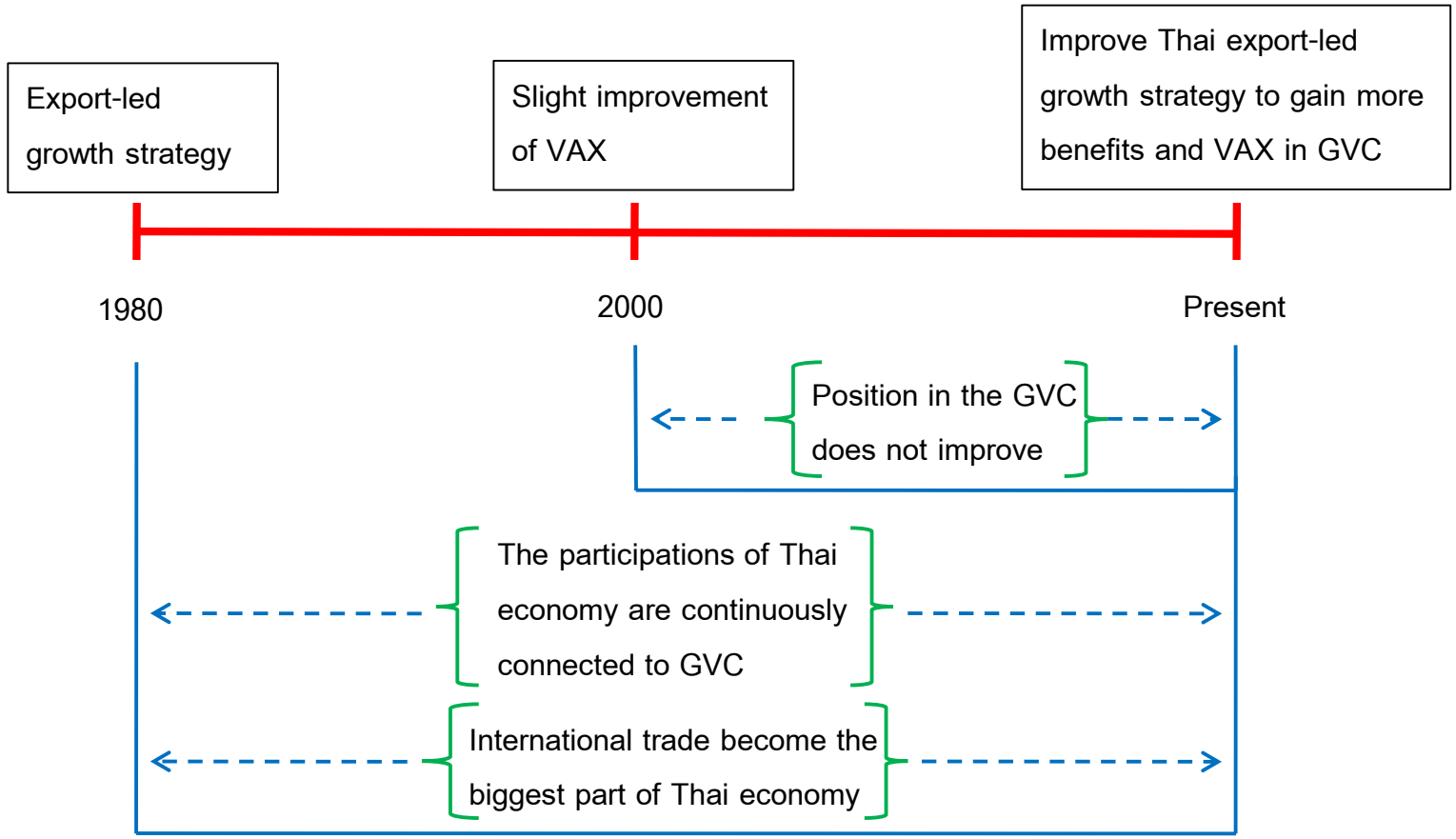
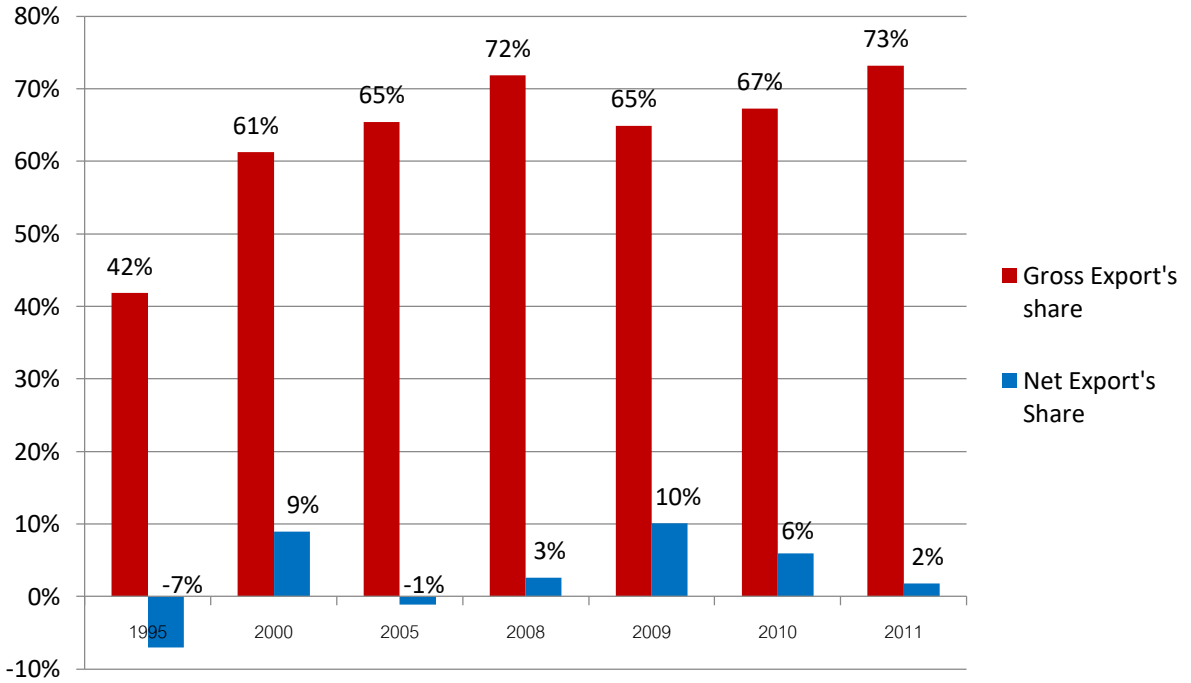
1. Introduction

1.1 Statement of the problem



1. Introduction

Share of Gross Export and Net Export to GDP for Thai Economy



Source: Author's calculation based on OECD

2. Review of Literature

2.1 Decomposition Analysis of Gross Export

Koopman et al. (2014) clarify that when any country exports products to the others, amount of gross export can be decomposed into 9 categories.

2.2 Misleading in Measuring Export Value

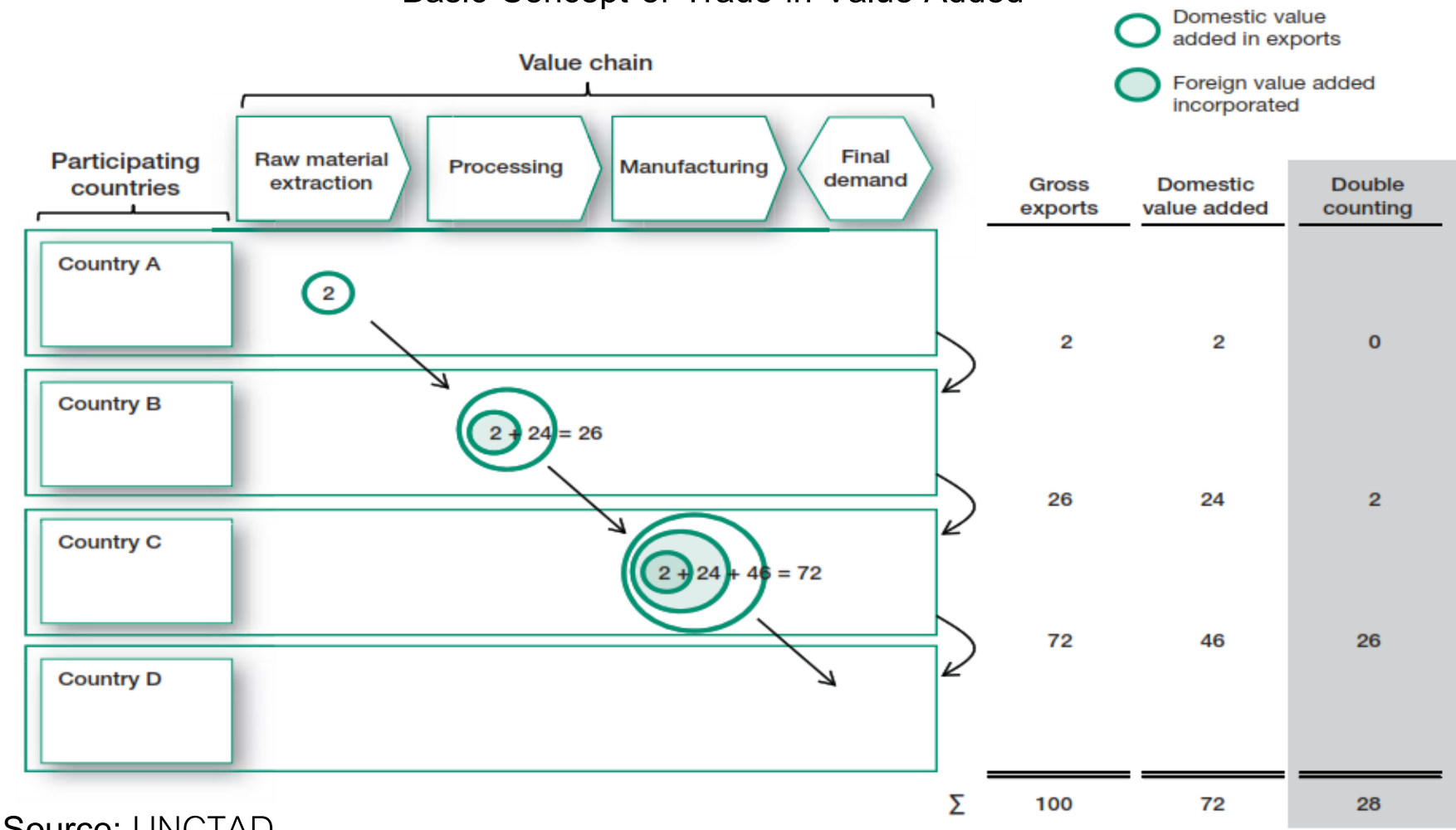
Johnson and Noguera (2012) employ the VAX method to correctly measure the actual value of export and prevent the misleading problem from trade in VS chain.

2.3 Concept of Vertical Specialization chain

Hummels et al. (2001) define the VS chain as the specialization of each country in particular stage that employs the imported intermediate input from other countries in global value chain to produce a country's export.

3. Theoretical Framework & Methodology

Basic Concept of Trade in Value-Added



Source: UNCTAD

3. Theoretical Framework & Methodology

3.1 Two Countries One sector Model

Two Countries One sector ICIO Table

Country	Intermediate Use		Final Demand		Total output
	S	R	y^s	y^r	
S	z_{ss}	z_{sr}	y_{ss}	y_{sr}	x_s
R	z_{rs}	z_{rr}	y_{rs}	y_{rr}	x_r
Value-added	v_s	v_r			
Total input	x_s	x_r			

Country	Intermediate Use		Final Demand		Total output
	S	R	y^s	y^r	
S	$a_{ss}\, x_s$	$a_{sr}\, x_r$	y_{ss}	y_{sr}	x_s
R	$a_{rs}\, x_s$	$a_{rr}\, x_r$	y_{rs}	y_{rr}	x_r
Value-added	v_s	v_r			
Total input	x_s	x_r			

Source: Adapted from OECD (2013)

3. Theoretical Framework & Methodology

3.1.1 Production sharing and trade in value-added

The gross output which is produced by country s (x_s) will be used for intermediate goods and final goods, at home and abroad. Thus, gross output of country s (x_s), can be specified as the following accounting relationship (Koopman et al. 2014):

$$x_s = a_{ss}x_s + a_{sr}x_r + y_{ss} + y_{sr}, \quad r,s = 1,2 \qquad (1)$$

Transforming equation (1) into matrix term as follows:

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} I - a_{11} & -a_{12} \\ -a_{21} & I - a_{22} \end{pmatrix}^{-1} \begin{pmatrix} y_{11} + y_{12} \\ y_{21} + y_{22} \end{pmatrix} = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \end{pmatrix} \qquad (2)$$

3. Theoretical Framework & Methodology

We can write the 2 × 2 value-added coefficient matrix as follow:

$$V = \begin{pmatrix} v_1 & 0 \\ 0 & v_2 \end{pmatrix} \tag{3}$$

The measurement of value-added shares by source of production is

$$VB = \begin{pmatrix} v_1 b_{11} & v_1 b_{12} \\ v_2 b_{21} & v_2 b_{22} \end{pmatrix} \tag{4}$$

The summation of each column has to equal one:

$$v_1 b_{11} + v_2 b_{21} = v_1 b_{12} + v_2 b_{22} = 1 \tag{5}$$

3. Theoretical Framework & Methodology

3.1.2 Accounting of Gross Export

The gross export of country 1 which involves final goods and intermediate goods exports can be specified as following equation:

$$e_{12} = y_{12} + a_{12}x_2 \tag{6}$$

Combining equations (1) and (6), we will get

$$\left.\begin{aligned} x_1 &= (1-a_{11})^{-1} y_{11} + (1-a_{11})^{-1} e_{12} \\ x_2 &= (1-a_{22})^{-1} y_{22} + (1-a_{22})^{-1} e_{21} \end{aligned}\right\} \tag{7}$$

3. Theoretical Framework & Methodology

$$e_{12} = y_{12} + a_{12}x_2 \quad (6)$$

$$\times$$

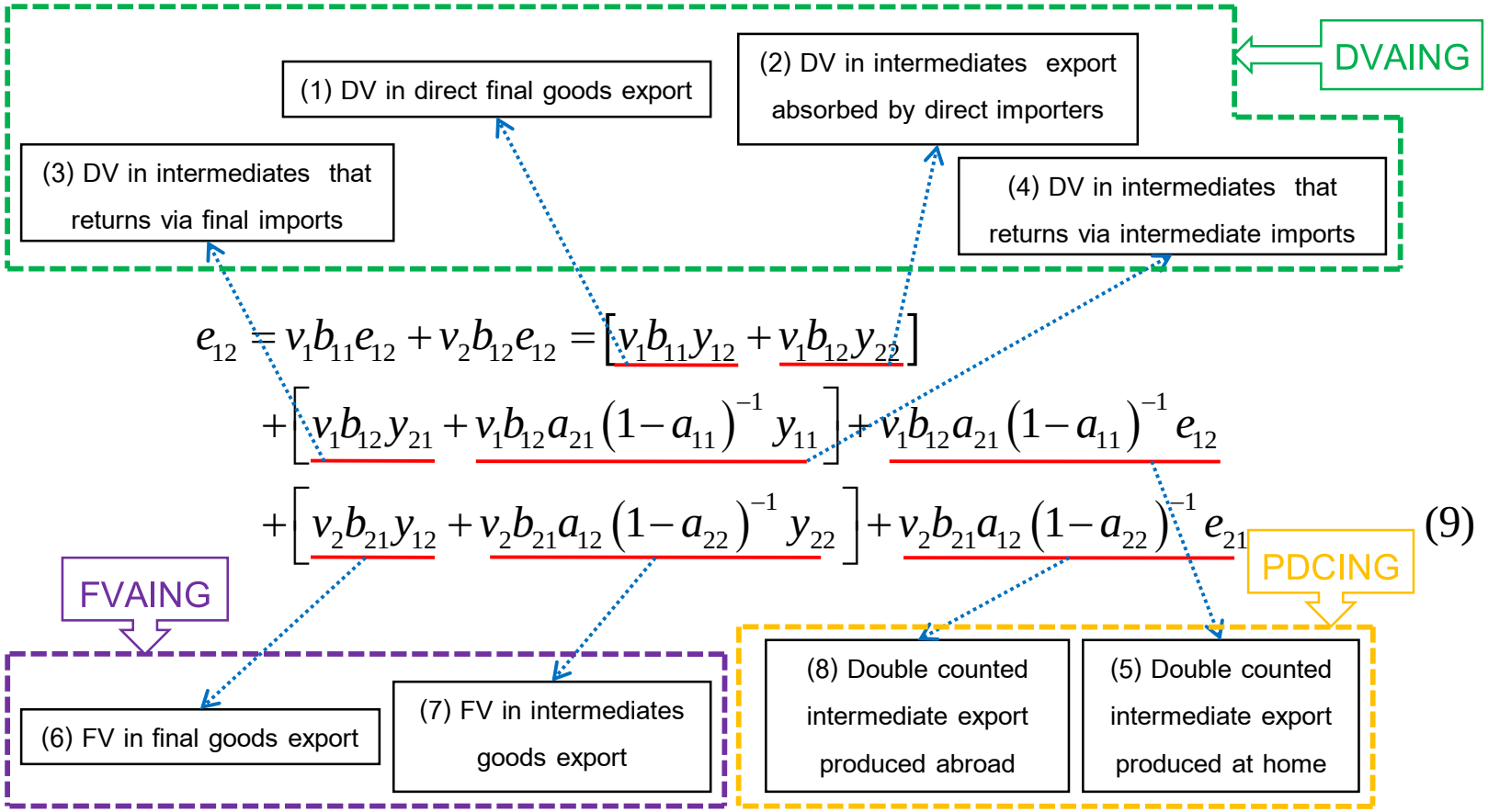
$$v_1 b_{11} + v_2 b_{21} = v_1 b_{12} + v_2 b_{22} = 1 \quad (5)$$

$$\left.\begin{aligned} x_1 &= (1-a_{11})^{-1} y_{11} + (1-a_{11})^{-1} e_{12} \\ x_2 &= (1-a_{22})^{-1} y_{22} + (1-a_{22})^{-1} e_{21} \end{aligned}\right\} \quad (7)$$

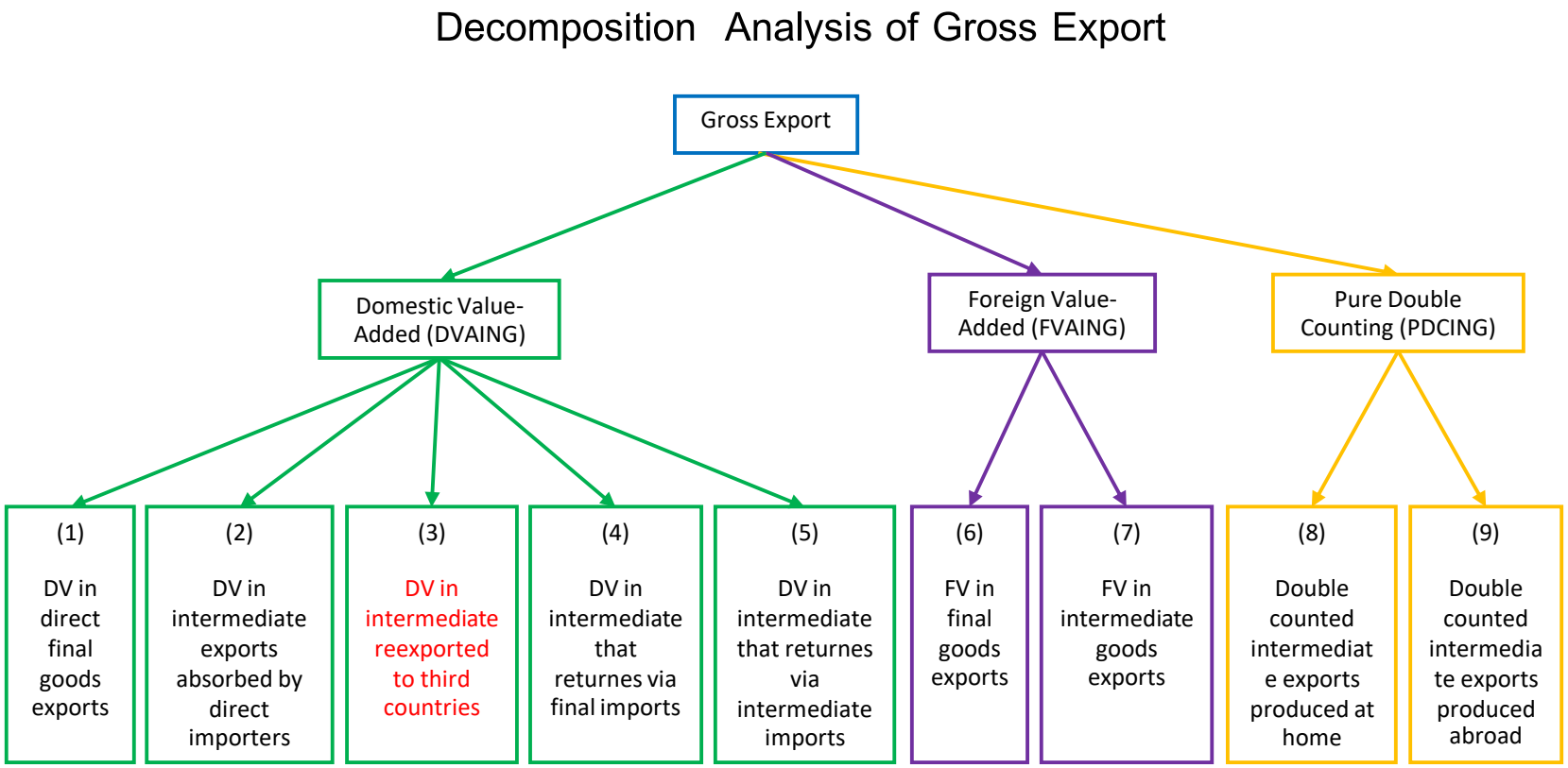
$$\begin{aligned} e_{12} &= v_1 b_{11} y_{12} + v_2 b_{21} y_{12} + v_1 b_{12} y_{22} + v_1 b_{12} y_{21} \\ &\quad + v_1 b_{12} a_{21} x_1 + v_2 b_{21} a_{12} x_2 \end{aligned} \quad (8)$$

Finally, we will get:

3. Theoretical Framework & Methodology



3. Theoretical Framework & Methodology

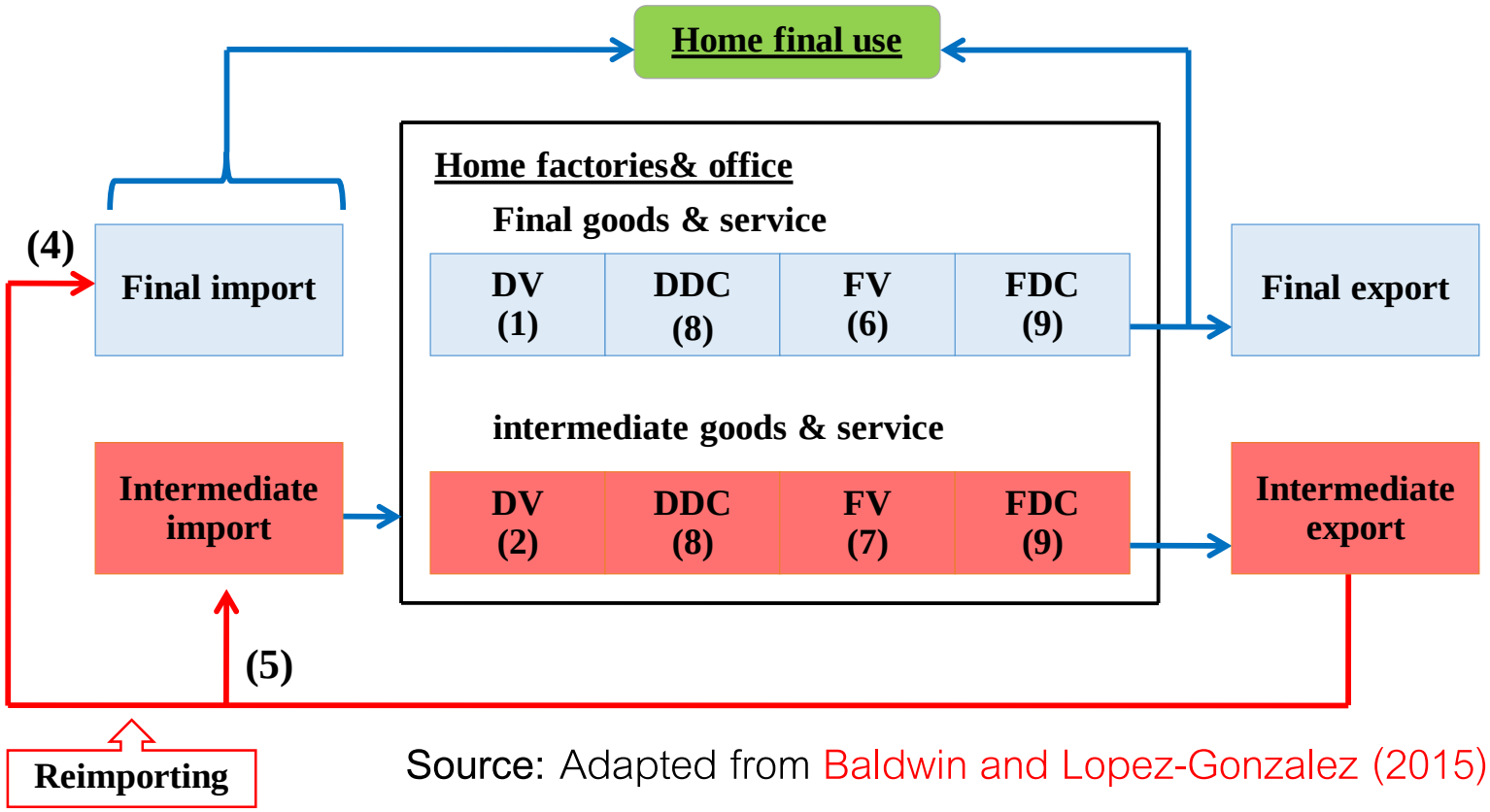


Source: Author based on Koopman et al. (2014)

3. Theoretical Framework & Methodology

The Schematic Diagram of

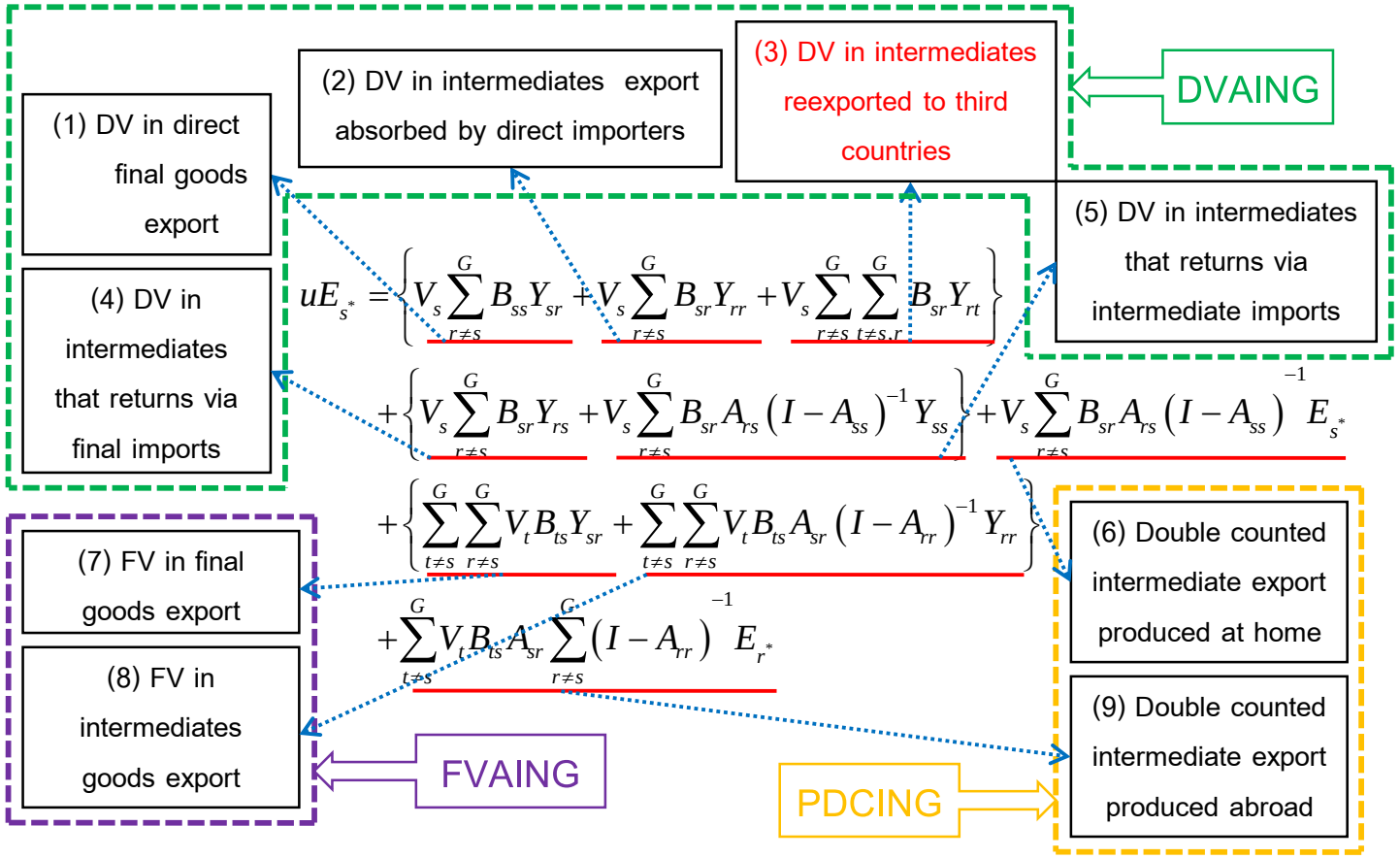
International Production Chain for Two Countries One Sector Model



Source: Adapted from Baldwin and Lopez-Gonzalez (2015)

3. Theoretical Framework & Methodology

3.2 General Case of G Countries and N Sectors Model

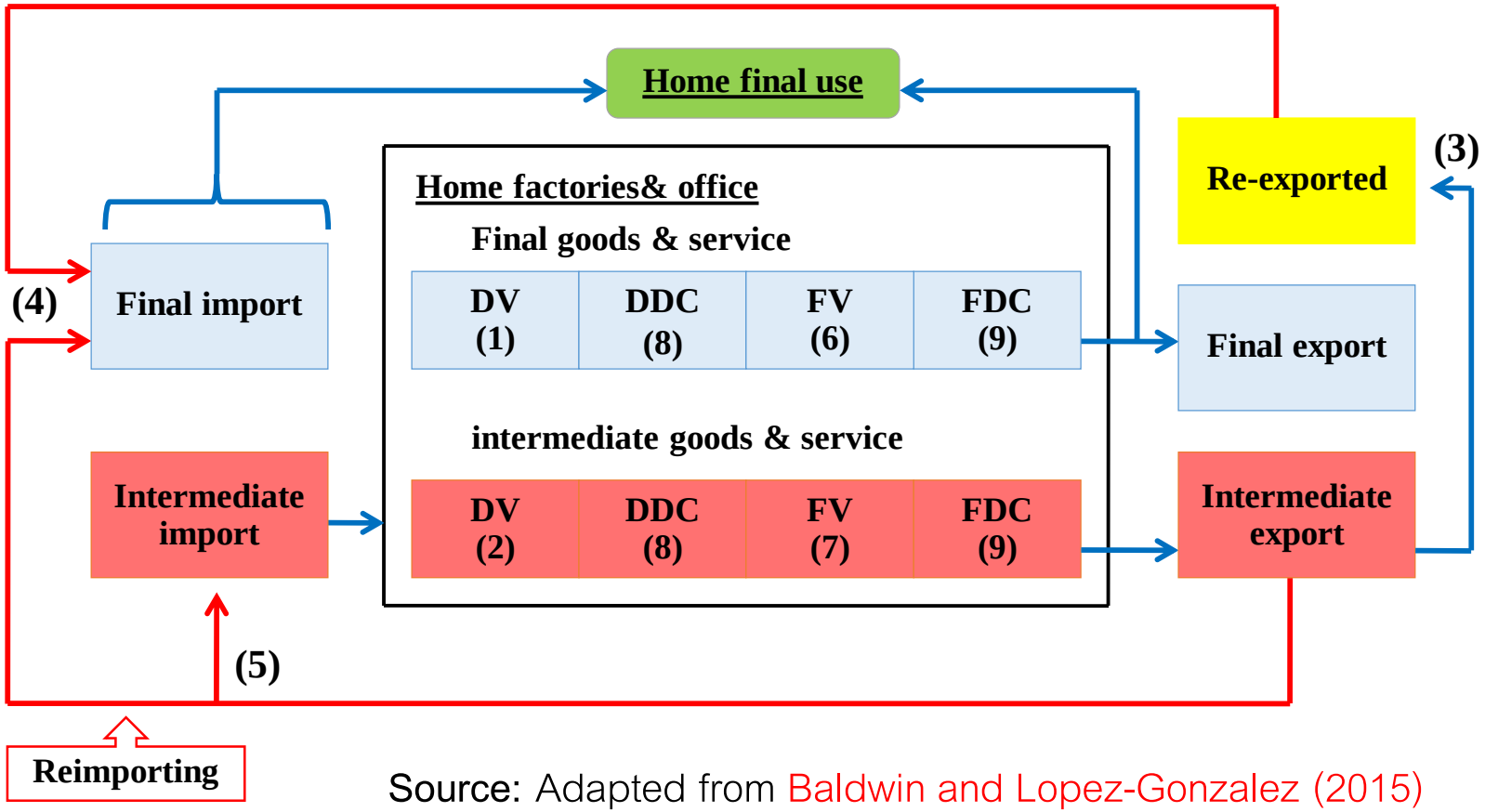


$$uE_{s^*} = \left\{V_s \sum_{r\neq s}^{G} B_{ss}Y_{sr} + V_s \sum_{r\neq s}^{G} B_{sr}Y_{rr} + V_s \sum_{r\neq s}^{G}\sum_{t\neq s,r}^{G} B_{sr}Y_{rt}\right\} + \left\{V_s \sum_{r\neq s}^{G} B_{sr}Y_{rs} + V_s \sum_{r\neq s}^{G} B_{sr}A_{rs}\left(I-A_{ss}\right)^{-1}Y_{ss}\right\} + V_s \sum_{r\neq s}^{G} B_{sr}A_{rs}\left(I-A_{ss}\right)^{-1}E_{s^*}$$
$$+ \left\{\sum_{t\neq s}^{G}\sum_{r\neq s}^{G} V_t B_{ts}Y_{sr} + \sum_{t\neq s}^{G}\sum_{r\neq s}^{G} V_t B_{ts}A_{sr}\left(I-A_{rr}\right)^{-1}Y_{rr}\right\}$$
$$+ \sum_{t\neq s}^{G} V_t B_{ts}A_{sr} \sum_{r\neq s}^{G}\left(I-A_{rr}\right)^{-1}E_{r^*} \qquad (10)$$

3. Theoretical Framework & Methodology

The Schematic Diagram of

International Production Chain for G Countries N Sector Model



Source: Adapted from Baldwin and Lopez-Gonzalez (2015)

3. Theoretical Framework & Methodology

3.3 The Comparison between Conventional Revealed Comparative Advantage (RCA) and New Revealed Comparative Advantage (NRCA) Indices

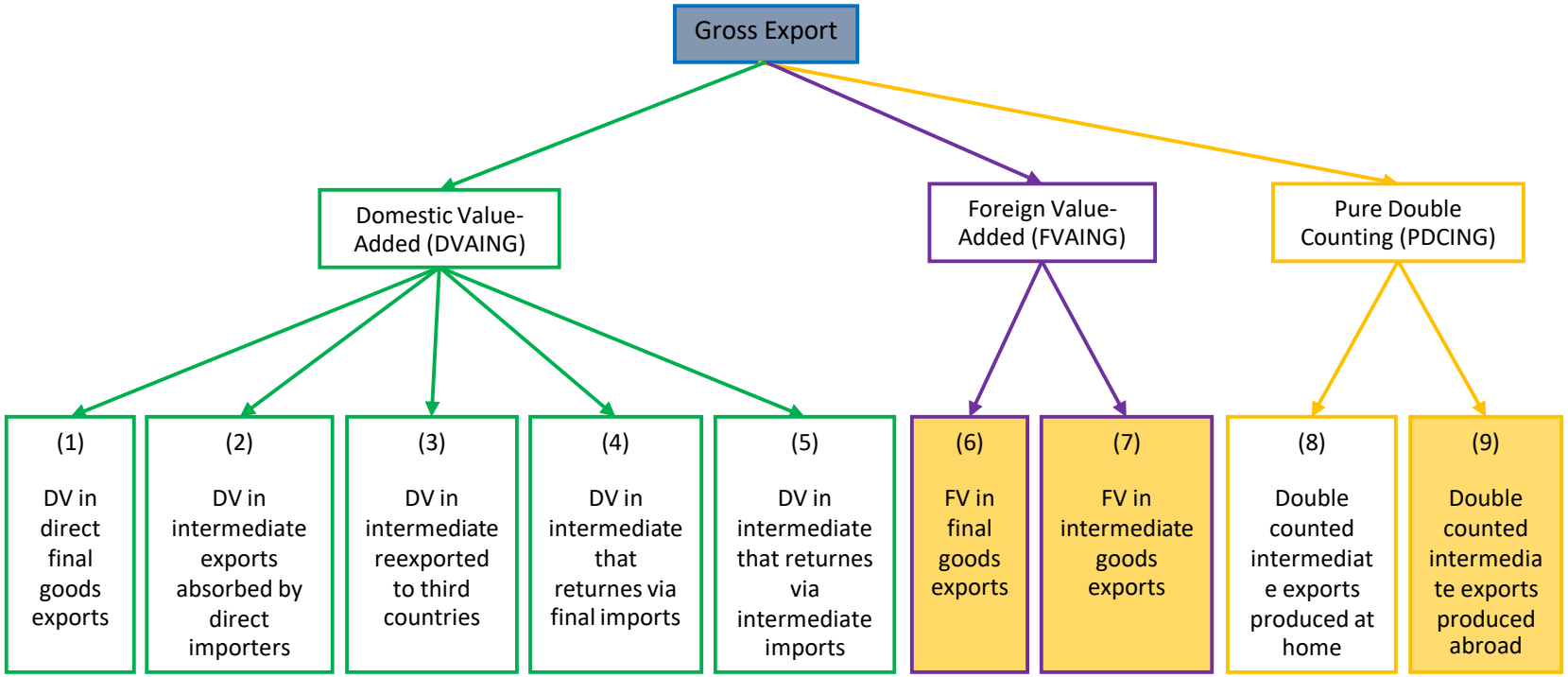
$$TRCA_i^r = \frac{E_i^{r^*}}{\sum_{i=1}^{n} E_i^{r^*}} \Bigg/ \frac{\sum_{r}^{G} E_i^{r^*}}{\sum_{i}^{n}\sum_{r}^{G} E_i^{r^*}} \tag{11}$$

$$NRCA_i^r = \frac{DVAING_i^r}{\sum_{i=1}^{n}\left(DVAING_i^r\right)} \Bigg/ \frac{\sum_{r}^{G}\left(DVAING_i^r\right)}{\sum_{i}^{n}\sum_{r}^{G}\left(DVAING_i^r\right)} \tag{12}$$

3. Theoretical Framework & Methodology

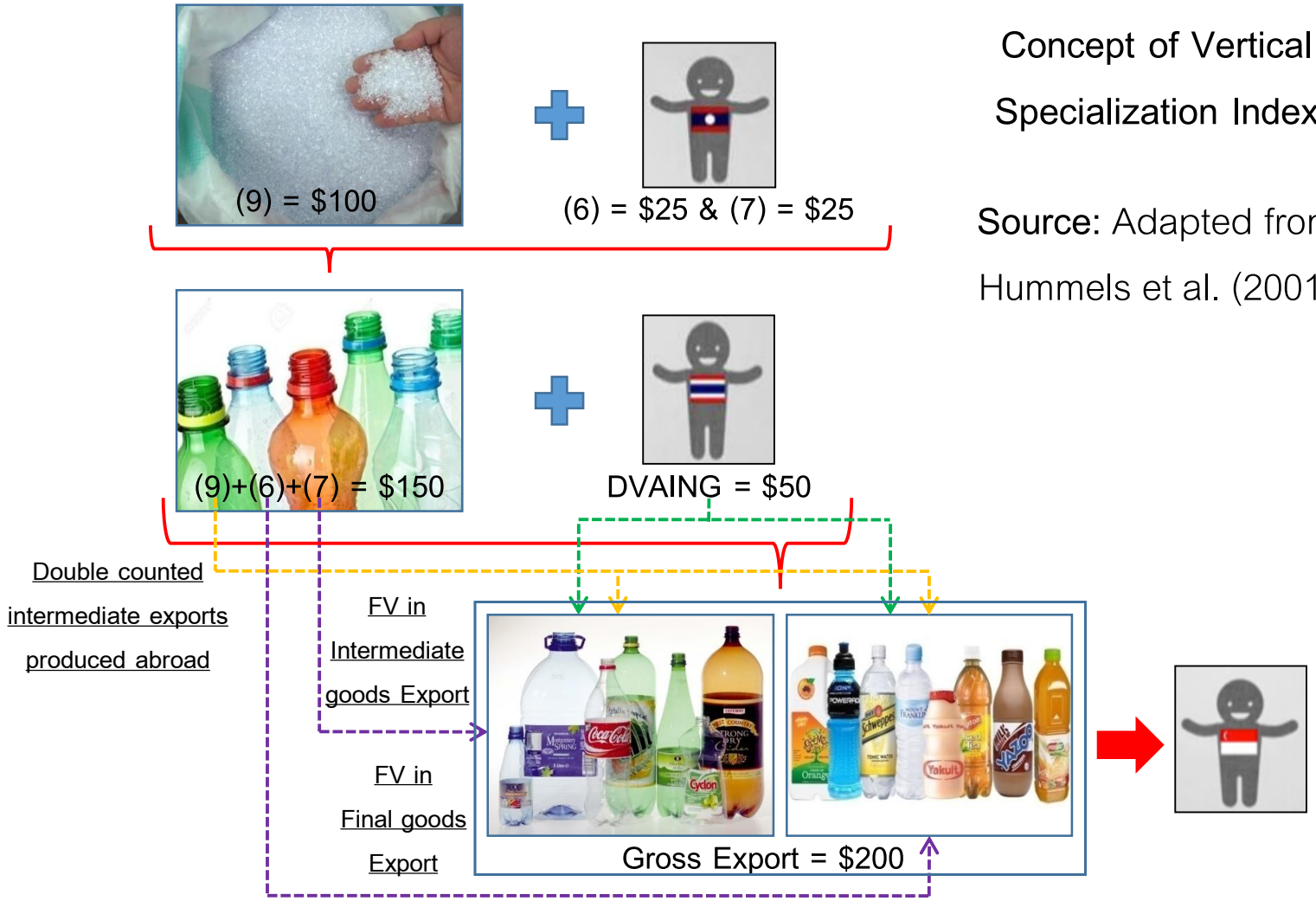
3.4 Linkage of Industries in Global Value Chain

3.4.1 Vertical Specialization Index (VS Index)



Source: Author based on Koopman et al. (2014)

3. Theoretical Framework & Methodology



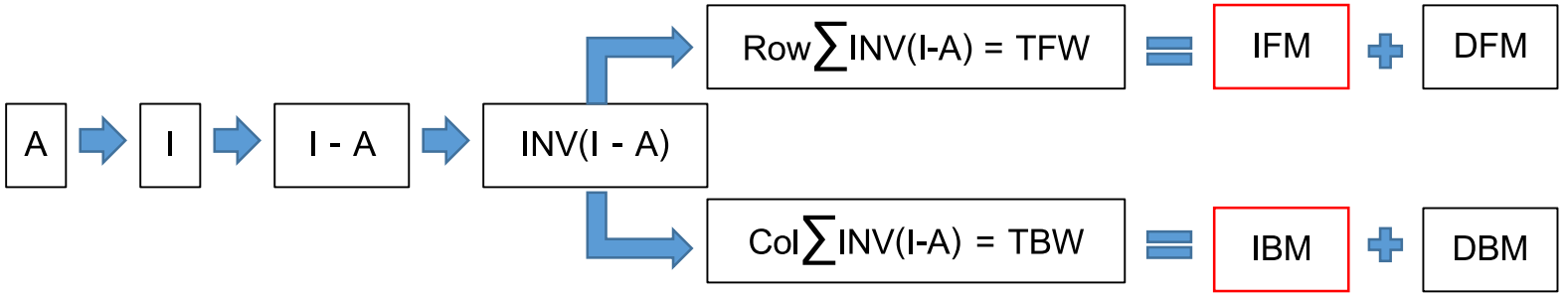
Concept of Vertical Specialization Index

Source: Adapted from Hummels et al. (2001)

3. Theoretical Framework & Methodology

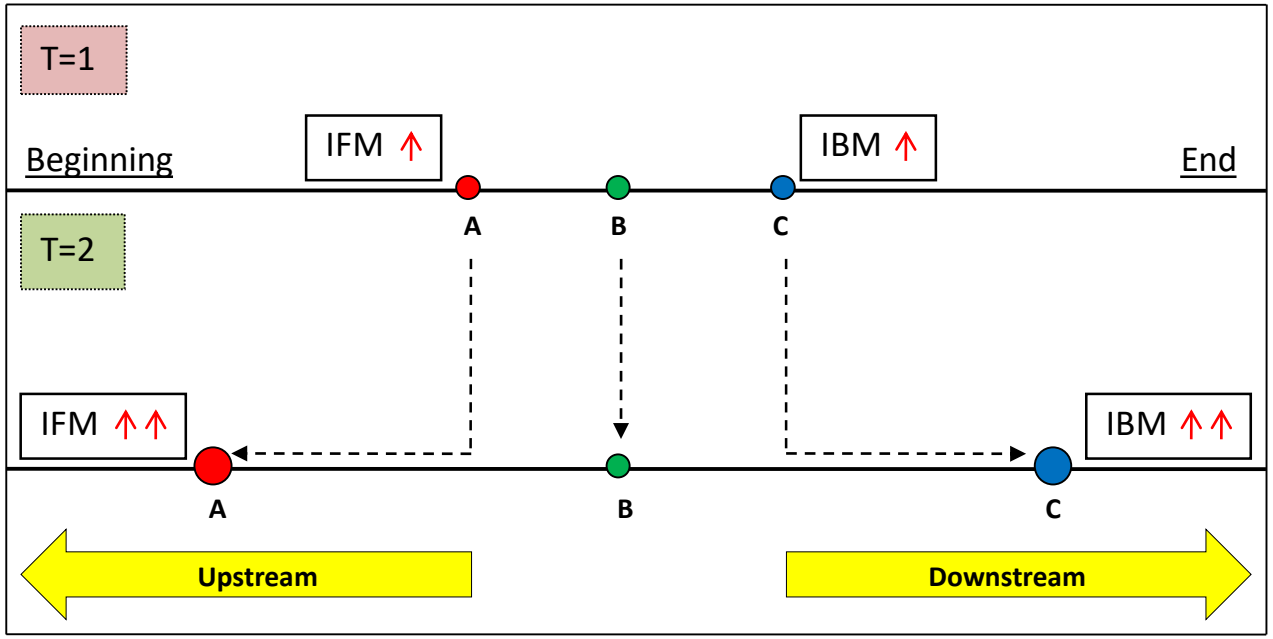
3.4.2 International Forward and Backward Multipliers

The International Forward and Backward Multipliers tell us about the degree of a particular sector's impact on its downstream and upstream, respectively, as well as the position in global value chain. These multipliers can be calculated by using 5 steps of matrix algebra based on OECD Inter-Country Input-Out (ICIO) tables, 2015.



3. Theoretical Framework & Methodology

Downstream and Upstream Linkages



Source: Adapted from Inomata (2011)

3. Theoretical Framework & Methodology

3.5 Regression Analysis Based on Export-led Growth Strategy

Export-led Growth in Bivariate Model		
➢ Overall Effect	$LnY_{it} = \beta_0 + \beta_1 LnEXP_{it} + \varepsilon_{1it}$	(13)
➢ Partial Effect	$LnY_{it} = \beta_0 + \beta_1 LnDVAING_{it} + \varepsilon_{2it}$	(14)
	$LnY_{it} = \beta_0 + \beta_1 LnFVAING_{it} + \varepsilon_{3it}$	(15)
	$LnY_{it} = \beta_0 + \beta_1 LnPDCING_{it} + \varepsilon_{4it}$	(16)

3. Theoretical Framework & Methodology

Export-led Growth in Trivariate Model	
❖ Overall Effect	$LnY_{it} = \beta_0 + \beta_1 LnEXP_{it} + \beta_2 LnINVEST_{it} + \varepsilon_{1it}$ (17)
❖ Partial Effect	$LnY_{it} = \beta_0 + \beta_1 LnDVAING_{it} + \beta_2 LnINVEST_{it} + \varepsilon_{2it}$ (18)
	$LnY_{it} = \beta_0 + \beta_1 LnFVAING_{it} + \beta_2 LnINVEST_{it} + \varepsilon_{3it}$ (19)
	$LnY_{it} = \beta_0 + \beta_1 LnPDCING_{it} + \beta_2 LnINVEST_{it} + \varepsilon_{4it}$ (20)

3. Theoretical Framework & Methodology

Export-led Growth in Multivariate Model	
■ Overall Effect	$LnY_{it} = \beta_0 + \beta_1 LnEXP_{it} + \beta_2 LnINVEST_{it} + \beta_3 VSindex_{it} + \varepsilon_{1it}$ (21)
■ Partial Effect	$LnY_{it} = \beta_0 + \beta_1 LnDVAING_{it} + \beta_2 LnINVEST_{it} + \beta_3 VSindex_{it} + \varepsilon_{2it}$ (22) $LnY_{it} = \beta_0 + \beta_1 LnFVAING_{it} + \beta_2 LnINVEST_{it} + \beta_3 VSindex_{it} + \varepsilon_{3it}$ (23) $LnY_{it} = \beta_0 + \beta_1 LnPDCING_{it} + \beta_2 LnINVEST_{it} + \beta_3 VSindex_{it} + \varepsilon_{4it}$ (24)

3. Theoretical Framework & Methodology

The Assumption of Classical Linear Regression Model (CLRM)

(1) Test for Multicollinearity by using Variance Inflation Factor (VIF)

(2) Test and solve for Heteroskedasticity by using White's Robust

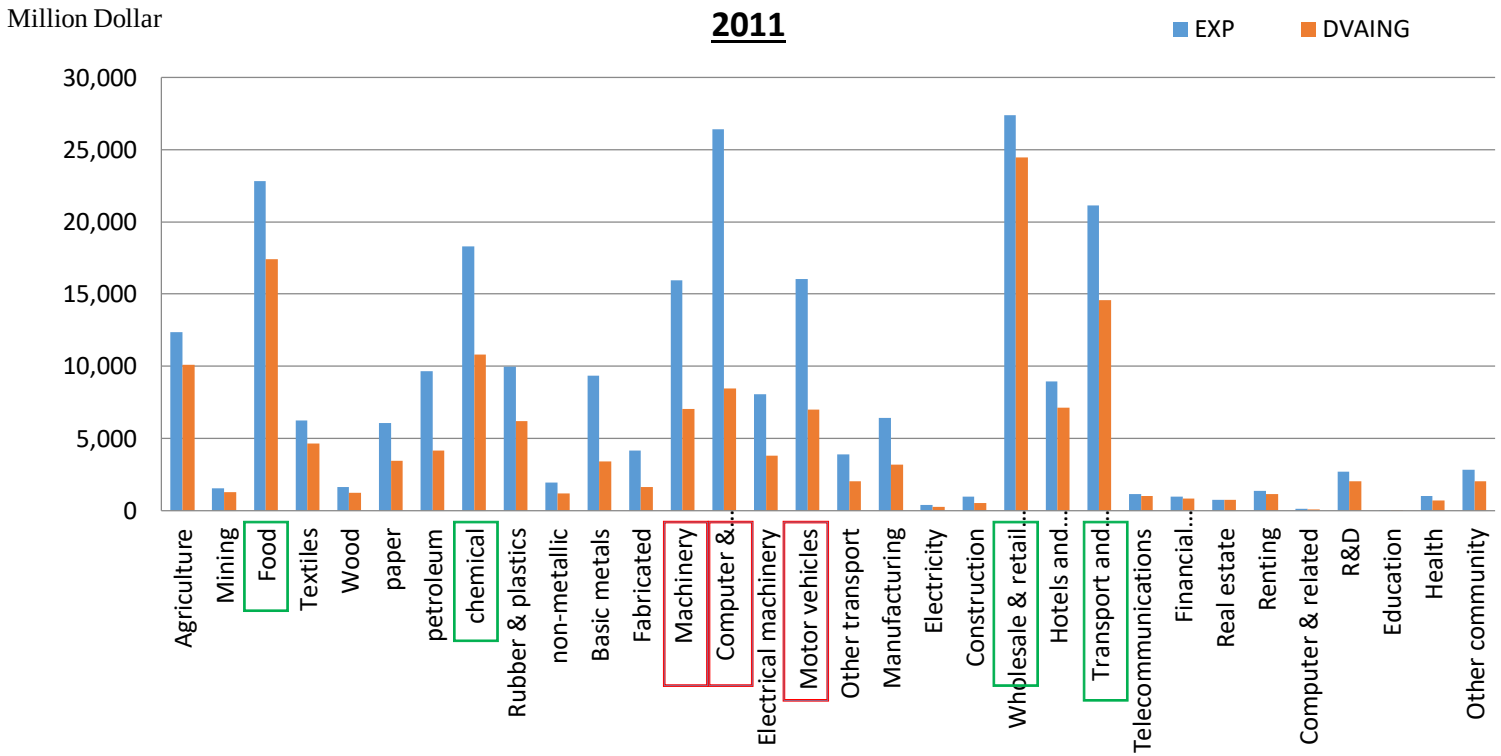
(3) Test for Endogeneity problem by using Huasman Specification Test

(4) Test for Random-Effect/Fixed-Effect by using Huasman Test

4. Results and Discussion

4.1 Decomposition of Gross Export for Thai Industries

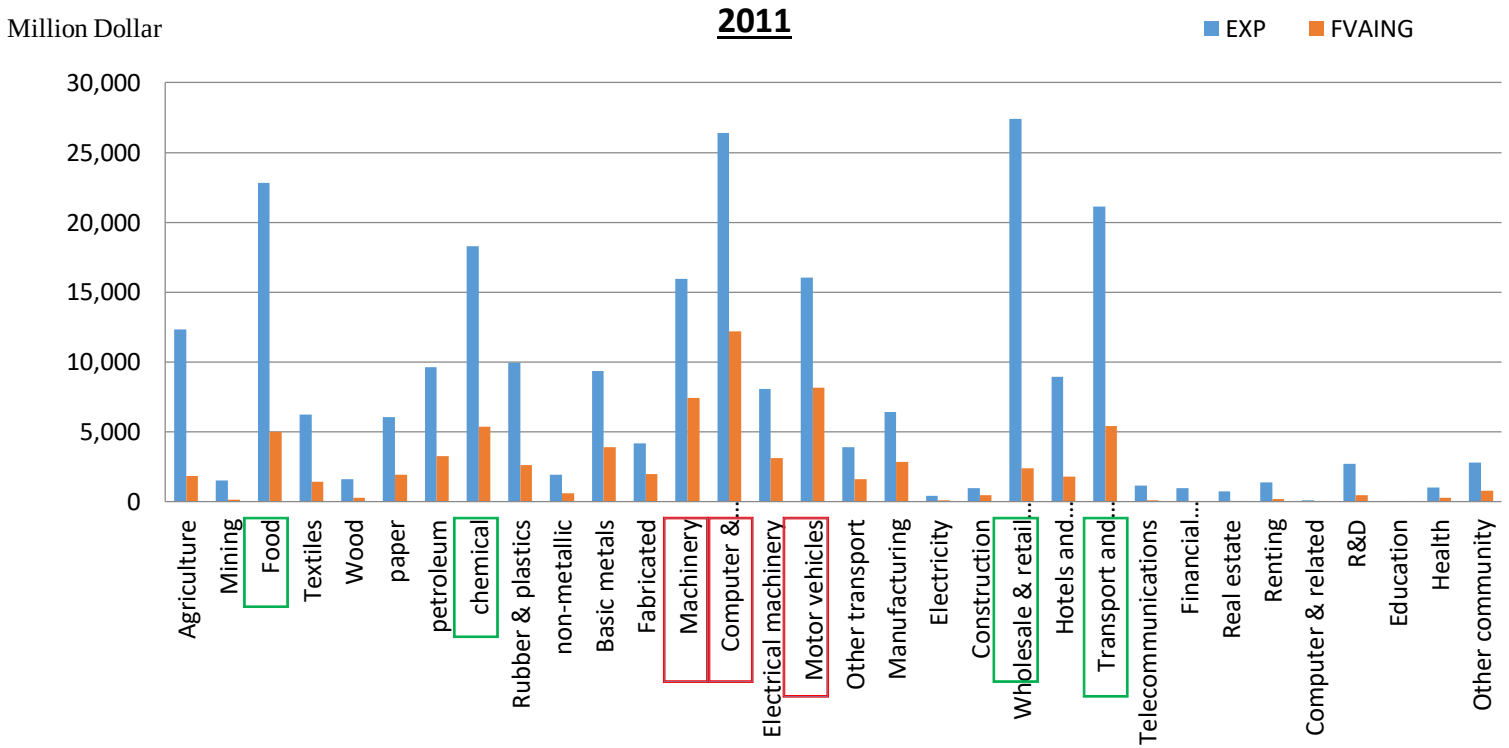
Gross Export and Domestic Value-Added in Gross Export of Thai Industries



Source: Author's calculation based on Koopman et al. (2014)

4. Results and Discussion

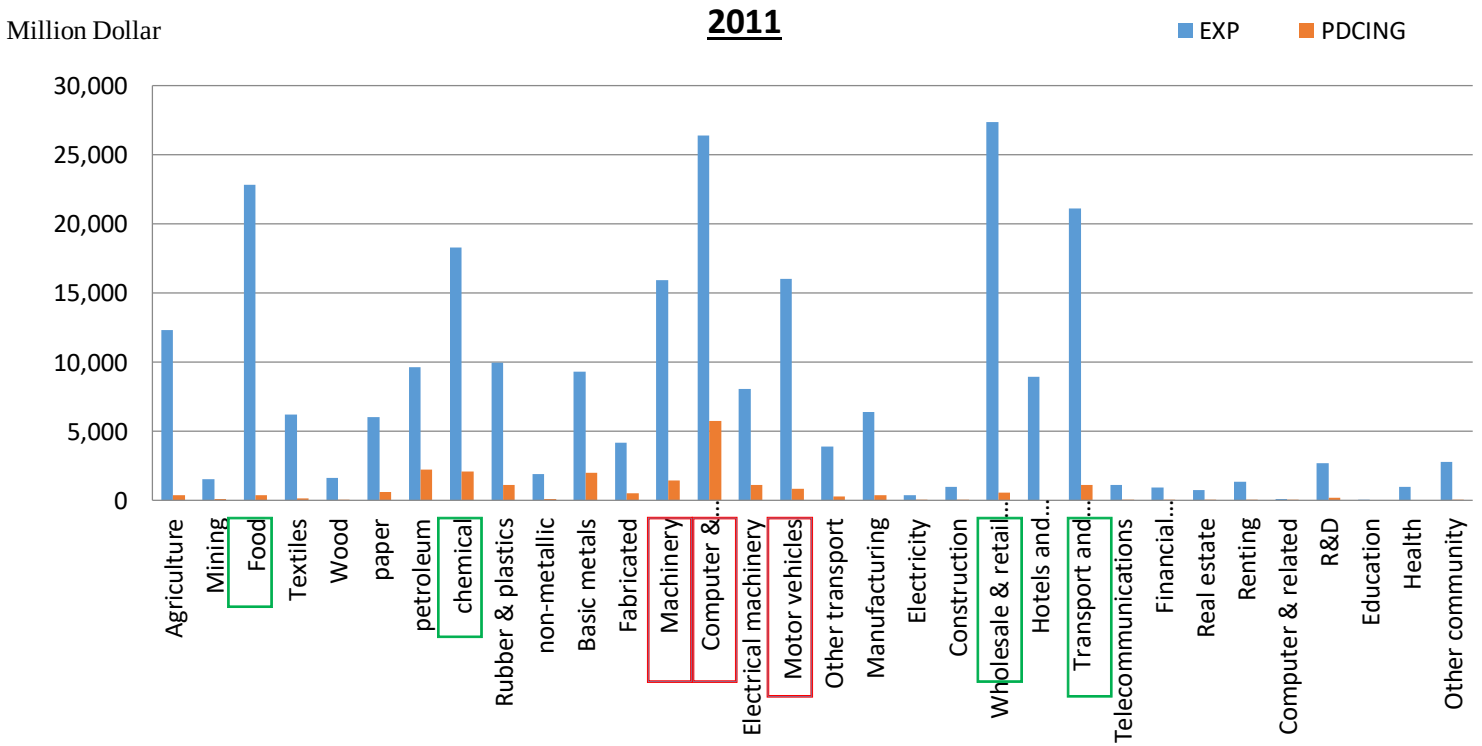
Gross Export and Foreign Value-Added in Gross Export of Thai Industries



Source: Author's calculation based on Koopman et al. (2014)

4. Results and Discussion

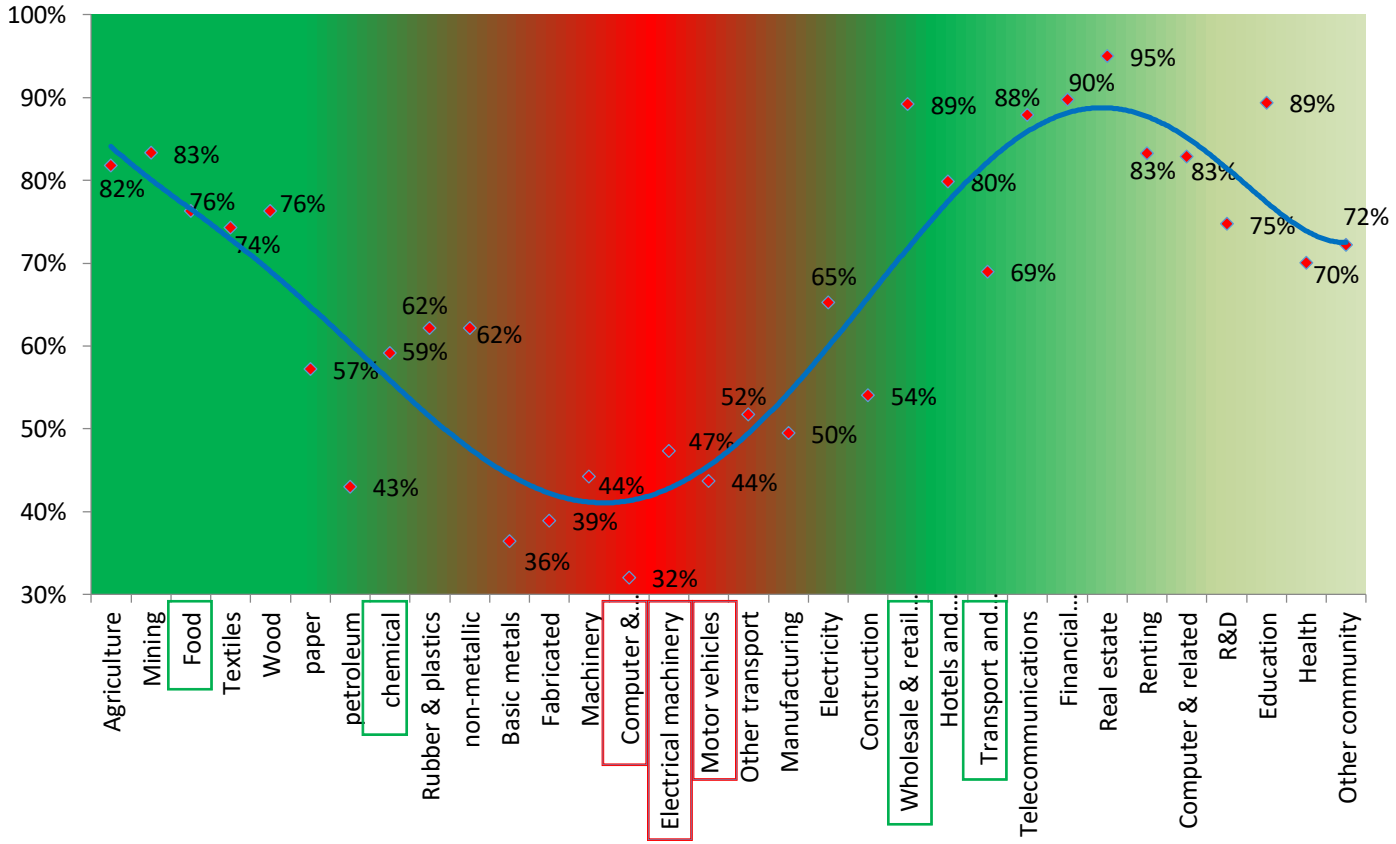
Gross Export and Pure Double Counted in Gross Export of Thai Industries



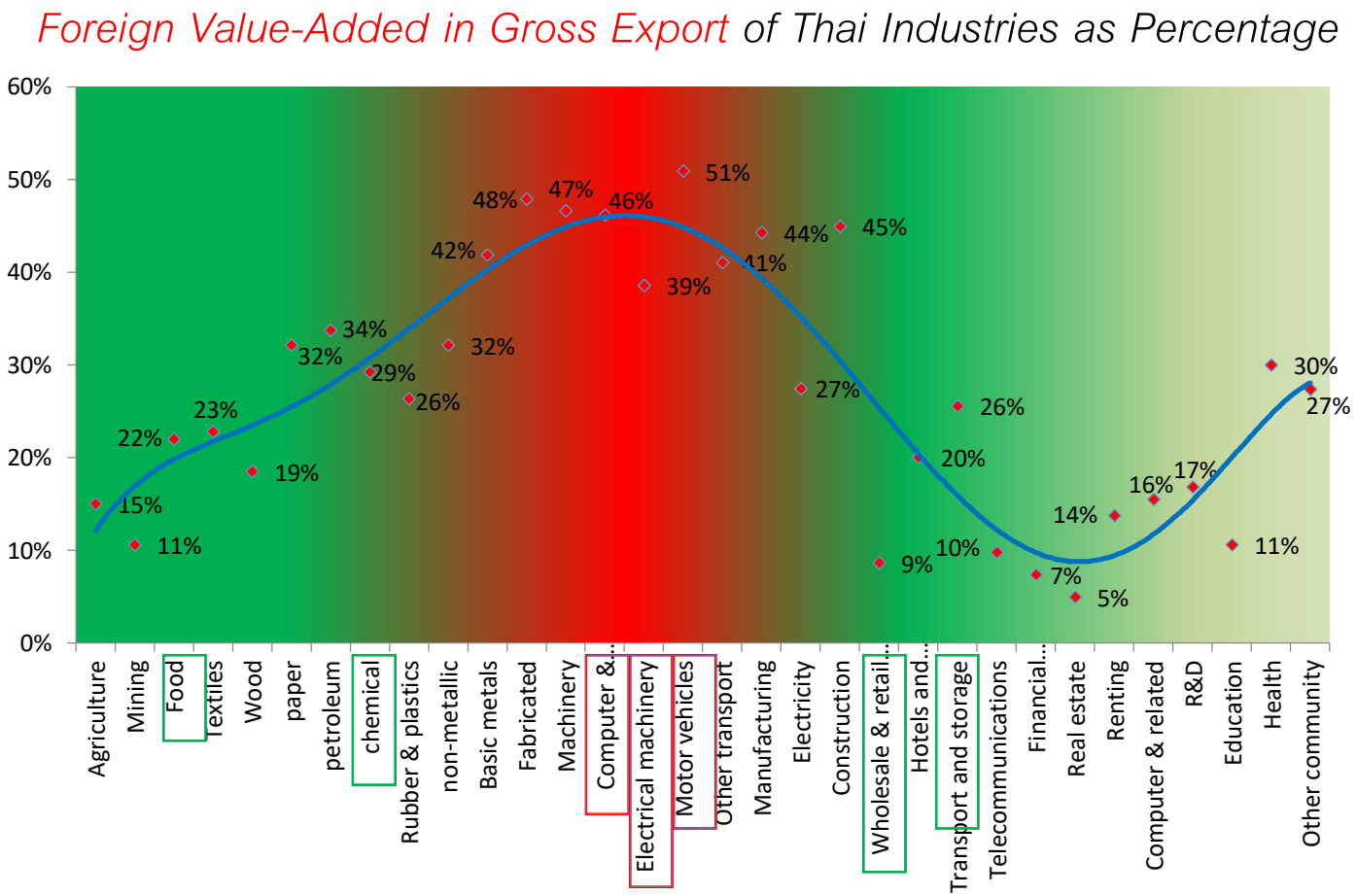
Source: Author's calculation based on Koopman et al. (2014)

4. Results and Discussion

Domestic Value-Added in Gross Export of Thai Industries as Percentage

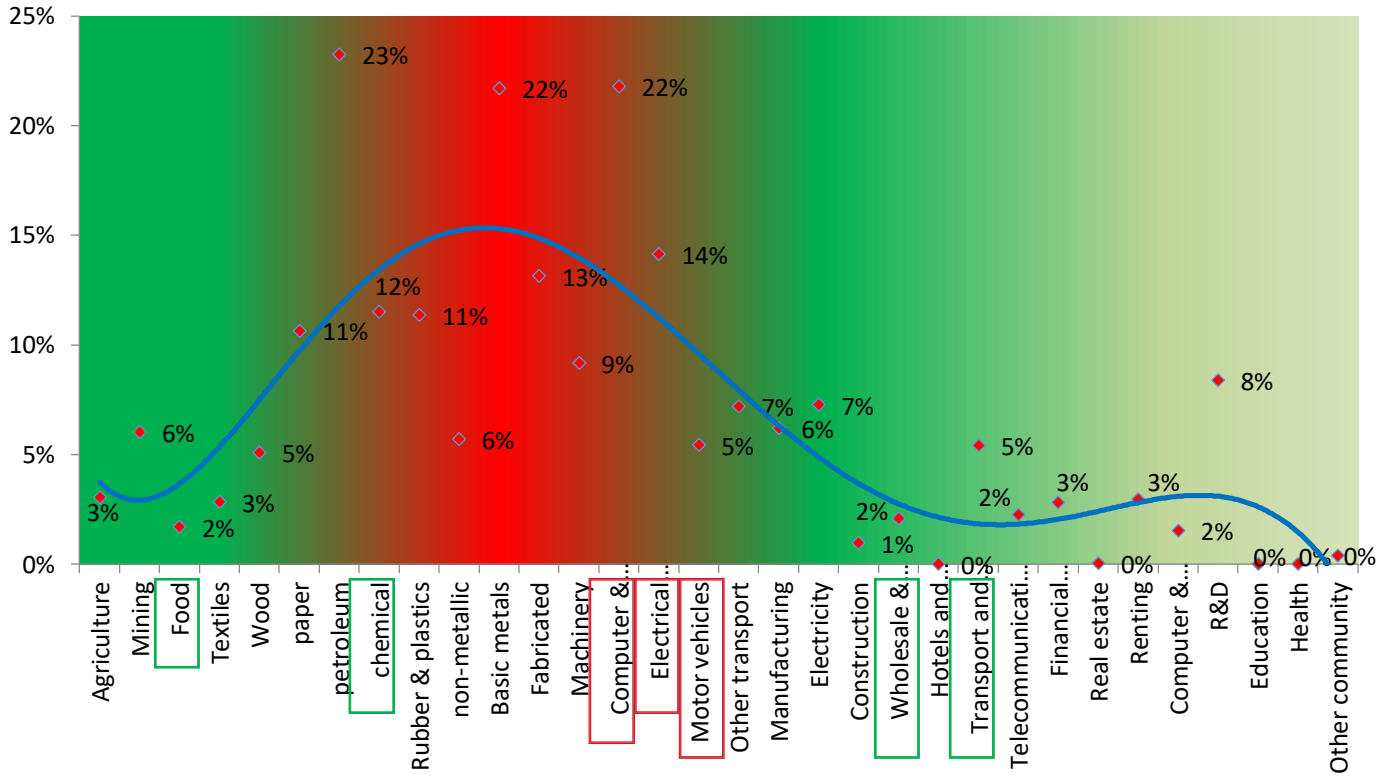


4. Results and Discussion



4. Results and Discussion

Pure Double Counted in Gross Export of Thai Industries as Percentage



4. Results and Discussion

4.2 Comparison between Conventional RCA and NRCA

Conventional RCA and New RCA of Thai Industries in 2011

Industries	RCA	NRCA	Status
Agriculture, hunting, forestry and fishing	2.3724	2.8233	Increase
Mining and quarrying	0.064	0.071	Increase
Food products, beverages and tobacco	2.4281	2.9399	Increase
Textiles, textile products, leather and footwear	0.8496	1.0386	Increase
Wood, products of wood and cork	1.4403	1.772	Increase
Pulp, paper, paper products, printing and publishing	1.6084	1.4634	Decrease
Coke, refined petroleum products and nuclear fuel	0.9248	0.867	Decrease
Chemicals and chemical products	1.0184	1.0875	Increase
Rubber and plastics products	2.2423	2.5373	Increase
Other non-metallic mineral products	1.049	1.0829	Increase
Basic metals	0.7248	0.5007	Decrease
Fabricated metal products	0.8996	0.6314	Decrease
Machinery and equipment	1.1187	0.8713	Decrease
Computer, electronic and optical equipment	1.2971	0.8791	Decrease
Electrical machinery and apparatus	1.2835	1.1391	Decrease
Motor vehicles, trailers and semi-trailers	1.1755	1.0254	Decrease

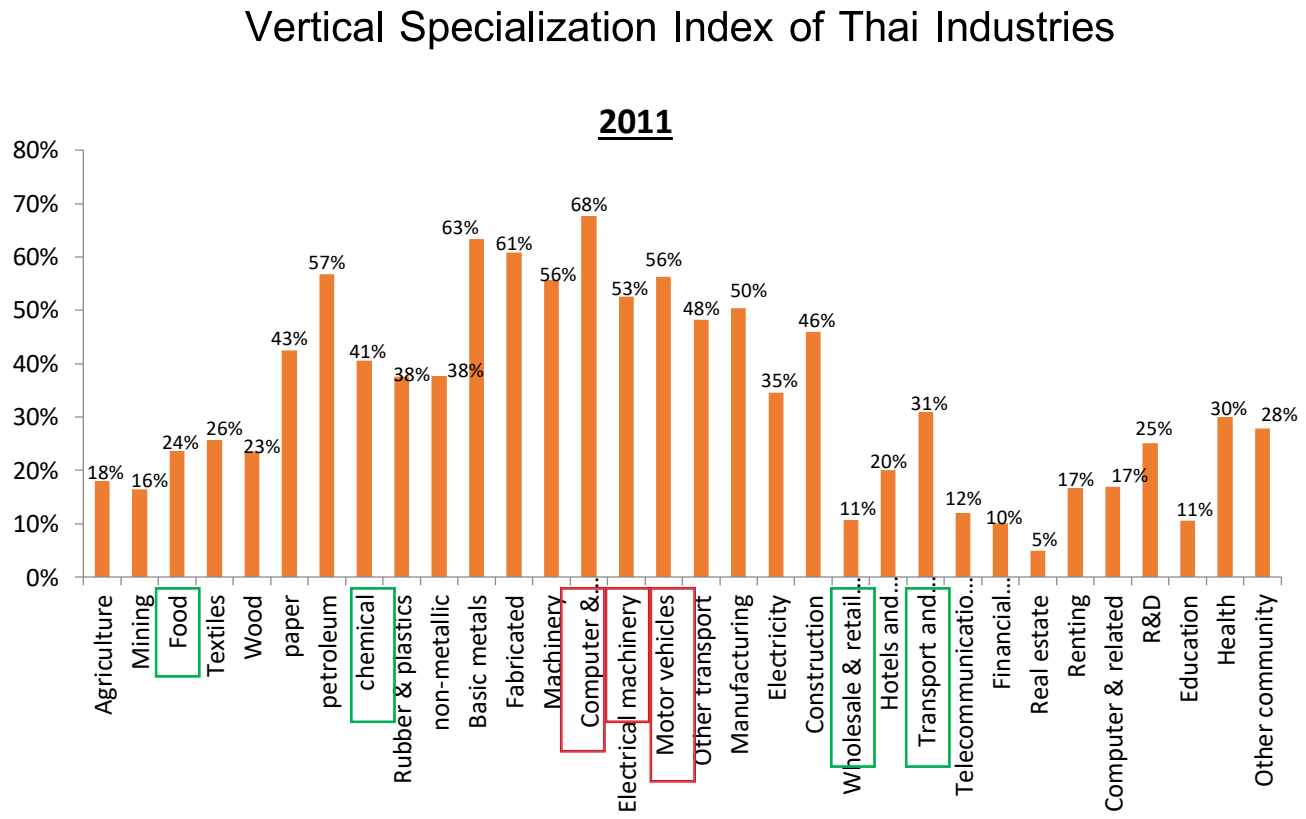
4. Results and Discussion

Industries	RCA	NRCA	Status
Other transport equipment	0.592	0.567	Decrease
Manufacturing and recycling	1.3334	1.1084	Decrease
Electricity, gas and water supply	0.3194	0.3509	Increase
Construction	0.7128	0.63	Decrease
Wholesale & retail trade and repairs	1.0086	1.2547	Increase
Hotels and restaurants	2.1892	2.5386	Increase
Transport and storage	1.1015	1.2033	Increase
Post and telecommunications	0.5986	0.7687	Increase
Financial intermediation	0.1268	0.1683	Increase
Real estate activities	0.9788	1.2276	Increase
Renting of machinery and equipment	0.8071	0.9675	Increase
Computer and related activities	0.0398	0.0512	Increase
R&D and other business activities	0.2826	0.3032	Increase
Education	0.0119	0.014	Increase
Health and social work	4.0024	3.9557	Decrease
Other community, social and personal services	0.8754	0.91	Increase

Source: Author's calculation based on Koopman et al. (2014) and OECD

4. Results and Discussion

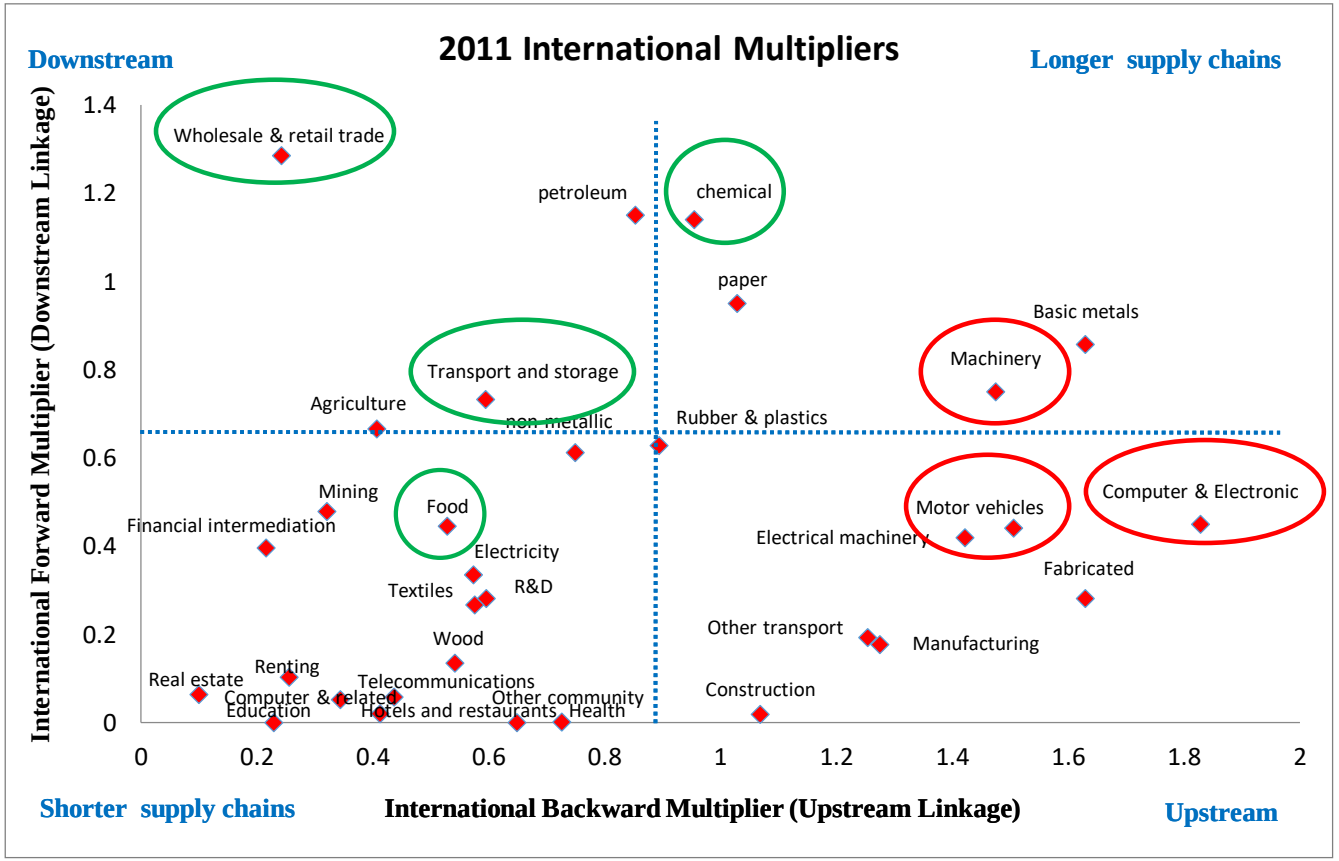
4.3 Linkage of Thai Industries in Global Value Chain



Source: Author's calculation based on Koopman et al. (2014)

4. Results and Discussion

International Forward and Backward Multipliers of Thai Industries



Source: Author's calculation based OECD

4. Results and Discussion

4.4 Regression Analysis Based on Export-led Growth Strategy

Test for CLRM Assumption

(1) Bivariate Model				
	Model1	Model2	Model3	Model4
Multicollinearlity (Mean VIF)	-	-	-	-
Heteroskedasticity	Robust	Robust	Robust	Robust
Endogeneity	NO	NO	NO	NO
Random-Effect/Fixed Effect	FE	FE	FE	FE

4. Results and Discussion

(2) Trivariate Model				
	Model1	Model2	Model3	Model4
Multicollinearlity (Mean VIF)	1.33	1.25	1.45	1.18
Heteroskedasticity	Robust	Robust	Robust	Robust
Endogeneity	NO	NO	NO	NO
Random-Effect/Fixed Effect	FE	FE	FE	FE
(3) Multivariate Model				
	Model1	Model2	Model3	Model4
Multicollinearlity (Mean VIF)	1.51	1.42	1.84	1.75
Heteroskedasticity	Robust	Robust	Robust	Robust
Endogeneity	NO	NO	NO	NO
Random-Effect/Fixed Effect	FE	FE	FE	FE

4. Results and Discussion

Panel Fixed-Effect Regression

(1) Bivariate Model				
	Model1	Model2	Model3	Model4
LOG_EXP	0.6475			
	(0.0560)***			
LOG_DVAING		0.6653		
		(0.0625)***		
LOG_FVAING			0.5835	
			(0.0422)***	
LOG_PDCING				0.5309
				(0.0371)***
CONST	3.5347	3.6611	4.9456	5.9988
	(0.4239)***	(0.4484)***	(0.2520)***	(0.1674)***
R-squared	0.0796	0.111	0.252	0.0214
F(1,31)	133.38	116.98	191.18	204.76
Prob > F	0.0000	0.0000	0.0000	0.0000
Obs	160	160	160	145

4. Results and Discussion

(2) Trivariate Model				
	Model1	Model2	Model3	Model4
LOG_EXP	0.6060			
	(0.0568)***			
LOG_DVAING		0.6205		
		(0.0626)***		
LOG_FVAING			0.5492	
			(0.0430)***	
LOG_PDCING				0.4957
				(0.0388)***
LOG_INVEST	0.1104	0.1203	0.095	0.1021
	(0.0452)**	(0.0455)**	(0.0423)**	(0.0427)**
CONST	3.3068	3.391	4.6836	5.6071
	(0.3777)***	(0.3987)***	(0.2503)***	(0.2400)***
R-squared	0.0795	0.1074	0.0309	0.0339
F(2,31)	93.78	82.08	119.16	105.31
Prob > F	0.0000	0.0000	0.0000	0.0000
Obs	160	160	160	145

4. Results and Discussion

(3) Multivariate Model				
	Model1	Model2	Model3	Model4
LOG_EXP	0.5880			
	(0.0634)***			
LOG_DVAING		0.5869		
		(0.0629)***		
LOG_FVAING			0.5625	
			(0.0568)***	
LOG_PDCING				0.5140
				(0.0578)***
LOG_INVEST	0.1031	0.1008	0.0989	0.1061
	(0.0472)**	(0.0469)**	(0.0441)**	(0.0437)**
VS_INDEX	0.8306	1.9112	-0.5606	-0.7536
	-0.7814	(0.7035)**	-0.843	-0.9766
CONST	3.228	3.391	4.7539	5.7394
	(0.3240)***	(0.3987)***	(0.1977)***	(0.1804)***
R-squared	0.0578	0.0531	0.0401	0.0479
F(3,31)	130.18	132.61	133.02	134.42
Prob > F	0.0000	0.0000	0.0000	0.0000
Obs	160	160	160	145

Note: ***, ** and * are significant at 1%, 5% and 10% respectively; number in parenthesis is Robust Standard Error and dependent variable is LOG_GDP.

4. Results and Discussion

Panel 2SLS Fixed-Effect Regression

(1) Bivariate Model				
	Model1	Model2	Model3	Model4
LOG_EXP	0.7493			
	(0.0733)***			
LOG_DVAING		0.8425		
		(0.0818)***		
LOG_FVAING			0.6141	
			(0.0462)***	
LOG_PDCING				0.559
				(0.0378)***
CONST	2.7654	2.3904	4.763	5.8716
	(0.5581)***	(0.6103)***	(0.4431)***	(0.3876)***
R-squared	0.0796	0.111	0.027	0.0214
Wald chi2(1)	104.28	106.07	176.46	218.45
Prob > F	0.0000	0.0000	0.0000	0.0000
Obs	160	160	160	145

4. Results and Discussion

(2) Trivariate Model				
	Model1	Model2	Model3	Model4
LOG_EXP	0.6917			
	(0.0725)***			
LOG_DVAING		0.7791		
		(0.0978)***		
LOG_FVAING			0.5663	
			(0.0545)***	
LOG_PDCING				0.5115
				(0.0405)***
LOG_INVEST	0.0881	0.0825	0.0896	0.097
	(0.0478)*	(0.0454)*	(0.0534)*	(0.0487)**
CONST	2.7685	2.4398	4.6079	5.5637
	(0.5269)***	(0.7015)***	(0.4148)***	(0.4471)***
R-squared	0.0802	0.1103	0.0306	0.0329
Wald chi2(2)	148.42	89.32	213.18	271.61
Prob > F	0.0000	0.0000	0.0000	0.0000
Obs	160	160	160	145

4. Results and Discussion

(3) Multivariate Model				
	Model1	Model2	Model3	Model4
LOG_EXP	0.7184315			
	(0.1576)***			
LOG_DVAING		0.7179		
		(0.1192)***		
LOG_FVAING			0.6883	
			(0.1344)***	
LOG_PDCING				0.6426
				(0.1559)***
LOG_INVEST	0.0837	0.0808	0.0784	0.0838
	(0.0487)*	(0.0480)*	(0.0378)**	(0.0371)**
VS_INDEX	-0.1788	1.1354	-1.8906	-2.2363
	-1.4935	-1.0152	-1.605	-2.0893
CONST	2.6419	2.545	4.5037	5.7447
	(0.8513)***	(0.6310)***	(0.4556)***	(0.3857)***
R-squared	0.0848	0.0786	0.061	0.0677
Wald chi2(3)	207.36	335.56	338.09	135.21
Prob > F	0.0000	0.0000	0.0000	0.0000
Obs	160	160	160	145

Note: ***, ** and * are significant at 1%, 5% and 10% respectively; number in parenthesis is Robust Standard Error and dependent variable is LOG_GDP.

5. Conclusion and Recommendation

5.1 Conclusion and Policy Implication

1. Amount of Thai gross export can be mainly decomposed into 3 categories: DVAING, FVAING and PDCING.
2. NRCA can provide more accuracy in measuring export ability of Thai industries compared to conventional RCA.
3. Computer, electronic and optical equipment can provide the highest degree of linkage to global value chain as well as the highest degree of upstream linkage; whereas the highest degree of downstream linkage can be generated by wholesale & retail trade and repairs industries.
4. Policymaker should stimulate Domestic Value-Added in Gross Export (DVAING) rather than gross export in order to create higher economic growth.

5. Conclusion and Recommendation