GLOBAL SOURCING AND DOMESTIC VALUE-ADDED IN EXPORTS

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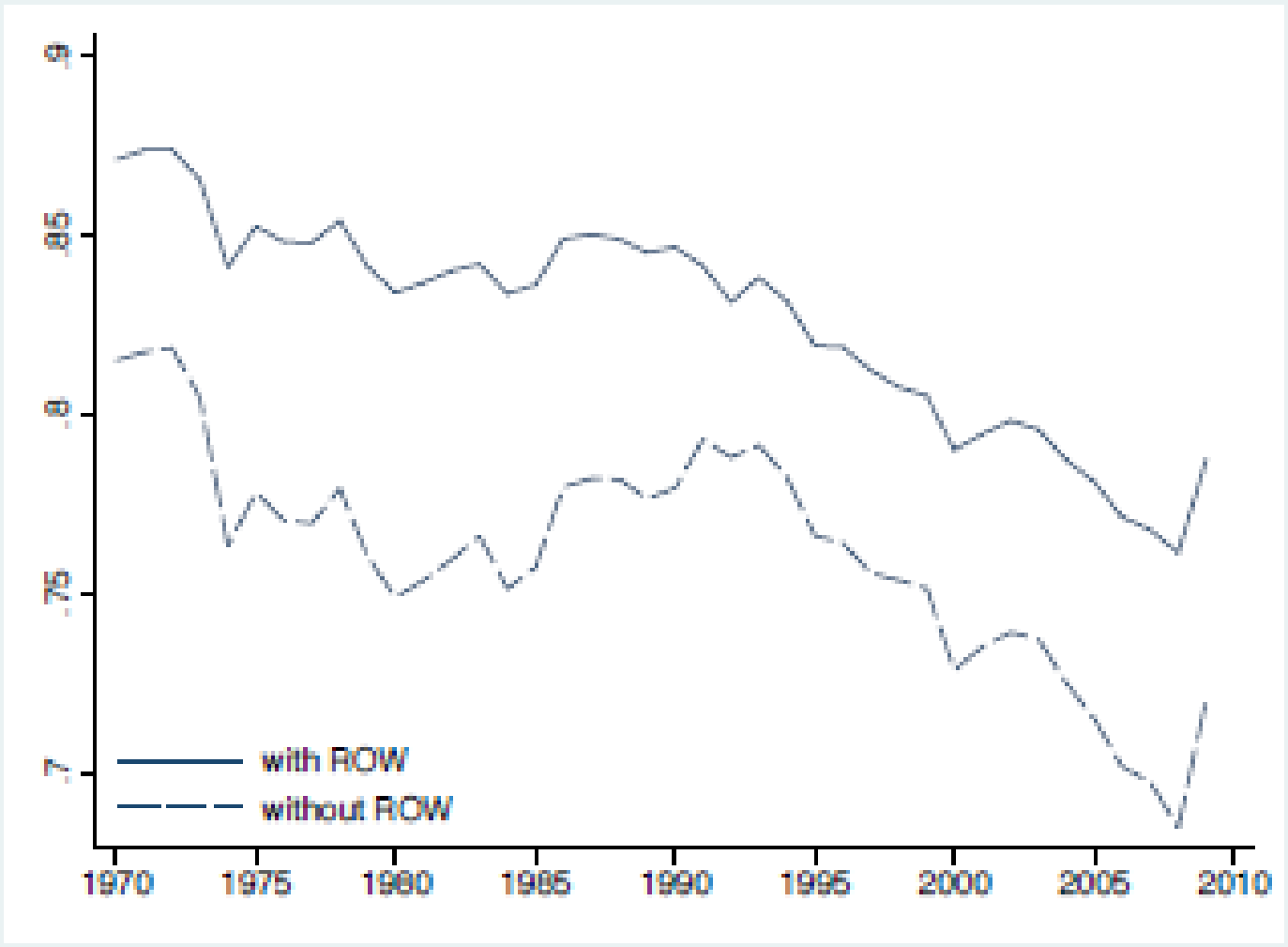
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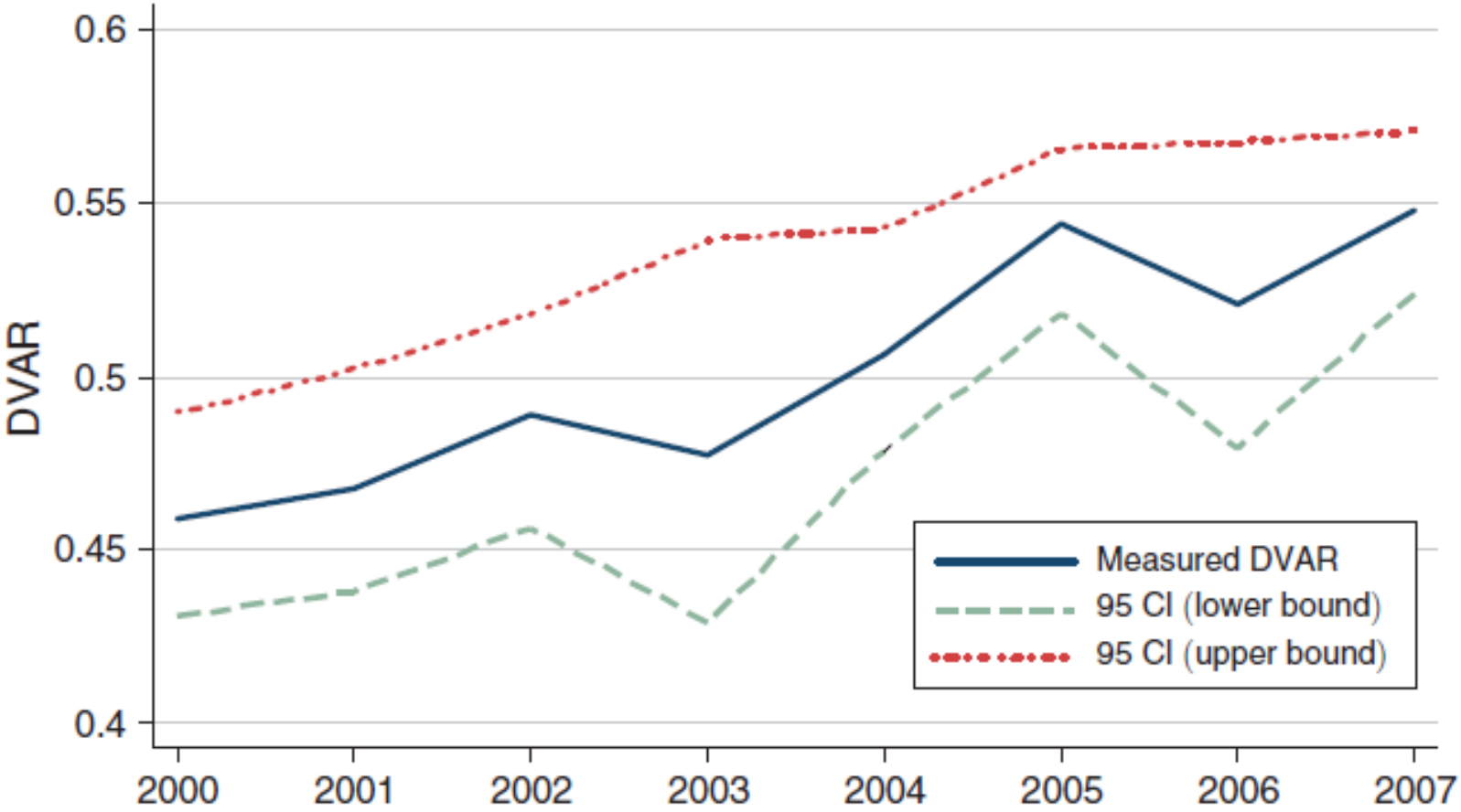
Preliminary Only.

Downward Trend in Domestic Value Added in Exports across the World



Source: Johnson and Noguera (2014)

China has recently defied the global trend



Kee and Tang (2016); also documented by Koopman, Wang and Wei (2012) for 2002 and 2007.

Misguided Policies?

- “The main drive is for countries to move up the value chain and become more specialised in knowledge-intensive, high value-added activities." (OECD, 2007)
- “Moving toward a more upstream position in production and raising economic complexity are associated with a growing share of GVC value added captured by countries." (IMF 2015)

What we do

- What contributes to a country's domestic content in exports, or its domestic value added ratio in exports (DVAR)?
- Build a multiple-sector Eaton-Kortum model with domestic and global input-output linkages (a la Caliendo-Parro) to quantify the determinants of individual countries' DVAR.
- Use the calibrated version of our model and the World Input-Output Database (WIOD) over 1995-2008 to fully decompose the changes in a country's and global DVAR due to (exogenous) changes in
  - Technology (T);
  - Trade costs (τ);
  - Other exogenous factors (factor endowments, trade imbalance)
  - (Endogenous) primary factor costs (w and r).

Related Literature

- Models of fragmentation
  - Baldwin (2006), Baldwin and Venables (2013); EK (2002); Alvarez and Lucas (2007); Yi (2003; 2010); Antras and Chor (2017)
- The measurement of global value chains.
  - Koopman, Wang and Wei (JDE 2008; AER 2014), Johnson and Noguera (2012), Johnson (2014); Timmer et al. (2014).
  - KWW (2012), Ma, Wang and Zhu (2015), Kee and Tang (2016)
- Bridging the two literatures
  - Antras and Chor (2017); Antras and de Gortari (2017); Johnson and Noguera (2017); Fally and Hillberry (2018); de Gortari (2018)

Model

- N countries; each country has potentially time-varying labor and capital endowments.
- J sectors. Output used as both final goods and intermediate inputs (with input-output linkages) anywhere.
- All countries have the capability to produce all intermediates and final goods.
- International trade is costly, and is country-pair-sector-pair specific
- Markets are perfectly competitive.
- Basically Caliendo-Parro (2015) with more flexible trade frictions.

Aggregates of Varieties

- In each country, the representative household aims to maximize the following utility function

$$U = \prod_{i=1}^{J} \left\{ \left[\int_0^1 \left(q^i(\omega) \right)^{\frac{\sigma^i - 1}{\sigma^i}} d\omega \right]^{\frac{\sigma^i}{\sigma^i - 1}} \right\}^{\alpha^i}, \text{ with } \sum_{i=1}^{J} \alpha^i = 1.$$

  - $q^i(\omega)$ stands for consumption of final good i of variety ω.

- The production function of a variety is given by

$$y^i(\omega) = z^i(\omega) \left(M^i(\omega) \right)^{1-\beta^i} \left(l(\omega) \right)^{\beta^i \mu^i} \left(k(\omega) \right)^{\beta^i \left(1-\mu^i\right)}$$

- Intermediate Composite M^i (sector i):

$$M^i = \prod_{k=1}^{J} \left\{ \left[\int_0^1 \left(q^k(\omega) \right)^{\frac{\sigma^k - 1}{\sigma^k}} d\omega \right]^{\frac{\sigma^k}{\sigma^k - 1}} \right\}^{\gamma^{ik}}, with \sum_{k=1}^{J} \gamma^{ik} = 1.$$

  - $q^k(\omega)$ is the quantity of sector-k intermediate input variety ω

Prices of Varieties

- Iceberg trade costs: $\tau_{mn}^{ji} > 1$; $j = F$ stands for final good trade costs; $\tau_{nn}^{ji} = 1$ for all i, j.

- Competitive price of a variety:

$$p_{nl}^{ji}(\omega) = \frac{\tau_{nl}^{ji} c_l^i}{z_l^i(\omega)} \qquad \text{for all } \omega \in [0,1],$$

where

$$c_l^i = \left(\frac{P_l^i}{1-\beta_l^i}\right)^{1-\beta_l^i} \left(\frac{w_l}{\beta_l^i \mu_l^i}\right)^{\beta_l^i \mu_l^i} \left(\frac{r_l}{\beta_l^i (1-\mu_l^i)}\right)^{\beta_l^i (1-\mu_l^i)}$$

- P_l^i = the price index of M_l^i. w_l and r_l are the wage and rental cost of capital.

- A firm in sector-i and country l draws efficiency z_l^i, distributed Fréchet:

$$F\left(z_l^i < z\right) = e^{-T_l^i z^{-\theta}},$$

where T_l^i stands for country l's technology stock for sector i.

Aggregate Prices and Trade Shares

- Perfect competition: firms in country n will purchase the intermediates from the firm that offers the lowest cost across all possible source countries.

- Thanks to Fréchet distribution of z, the price index of intermediates in country n and sector j

$$P_n^j = \Upsilon_n^j \prod\nolimits_{i=1}^{J} \left(p_n^{ji}\right)^{\gamma_n^{ji}} = \Upsilon_n^j \prod\nolimits_{i=1}^{J} \left(\Phi_n^{ji}\right)^{-\frac{\gamma_n^{ji}}{\theta}},$$

  where $\Upsilon_n^j = \prod_{i=1}^{J} \left(\gamma_n^{ii}\right)^{-\gamma_n^{ii}}$ is a constant and

$$\Phi_n^{ji} = \sum\nolimits_l T_l^i \left(c_l^i \tau_{nl}^{ji}\right)^{-\theta}.$$

- For sector-j in country n, the cost share of intermediates i from country l in total costs spent on intermediates i:

$$\pi_{nl}^{ji} = \frac{T_l^i \left(c_l^i \tau_{nl}^{ji}\right)^{-\theta}}{\Phi_n^{ji}}$$

Expressions of DVAR

- Domestic value added (DVA) in sales (domestic or exports) includes

1. DVA from foreign countries embodied in imported intermediates;
2. DVA embodied in domestically-produced intermediates;
3. Primary factors directly employed (direct DVA) — capital and labor.

- Let r^i_{mn} = VAR (value-added ratio) of country n embodied in country m's production of sector-i goods:

$$r^i_{nn} = \beta^i_n + (1-\beta^i_n)\sum_{h=1}^{N}\sum_{k=1}^{J}\pi^{ik}_{nh}\gamma^{ik}_n r^k_{hn}$$

$$\text{and } r^i_{mn} = (1-\beta^i_m)\sum_{h=1}^{N}\sum_{k=1}^{J}\pi^{ik}_{mh}\gamma^{ik}_m r^k_{hn} \text{ for } m \neq n$$

Expressions of DVAR in Matrix Form

- In matrix form:

$$\mathbf{r} = \left[r^i_{mn}\right] = \beta + (\mathbf{I} - \mathbf{B})\,\mathbf{G}\mathbf{r}$$
$$\Rightarrow \mathbf{r} = \left[\mathbf{I} - (\mathbf{I} - \mathbf{B})\,\mathbf{G}\right]^{-1}\beta$$

  where $\mathbf{r}$ is a $NJ \times N$ matrix of VAR of country n

- $\mathbf{B}$ is the $NJ \times NJ$ value-added share matrix with the diagonal element being β^i_n $(n = 1, ..., N;\ i = 1, ..., J)$, and other elements being zero.

- $\mathbf{G} = \left[\pi^{ik}_{nm}\gamma^{ik}_n\right]$ is the $NJ \times NJ$ global intermediate goods cost share matrix.

- $\beta = \left[\beta^i_n I_{mn}\right]$ is a $NJ \times N$ matrix (stacking up J number $N \times N$ matrixes each with element β^i_n when $m = n$ and 0 otherwise. (I_{mn} is an indicator function equal 1 when $m = n$ and 0 otherwise).

Decomposition of DVAR

- Recall that the DVAR matrix $\mathbf{r}$ satisfies

$$\mathbf{r} = \beta + (\mathbf{I} - \mathbf{B})\,\mathbf{G}\mathbf{r}$$

- Taking total derivative yields a decomposition of the yearly changes in the DVAR:

$$\begin{aligned} d\mathbf{r} &= d\beta - (d\mathbf{B})\,\mathbf{G}\mathbf{r} + (\mathbf{I} - \mathbf{B})\,(d\mathbf{G})\,\mathbf{r} + (\mathbf{I} - \mathbf{B})\,\mathbf{G}\,(\mathbf{dr}) \\ \Rightarrow d\mathbf{r} &= [\mathbf{I} - (\mathbf{I} - \mathbf{B})\,\mathbf{G}]^{-1}\,[d\beta - (d\mathbf{B})\,\mathbf{G}\mathbf{r}] \\ &\quad + [\mathbf{I} - (\mathbf{I} - \mathbf{B})\,\mathbf{G}]^{-1}\,(\mathbf{I} - \mathbf{B})\,(d\mathbf{G})\,\mathbf{r} \end{aligned}$$

- The first term of the RHS captures the pure effect of changing β_n^i
- The second term captures the effect of the changes in intermediate goods shares π_{nm}^{ik} and input-output coefficients γ_n^{ik}.

A 2 x 1 x 1 Toy Model

- 2 countries, with technology level T_i and wage w_i for country i, and $t = T_1/T_2$; $c = c_1/c_2$. Define $\tau_1 \equiv \tau_{12}$ and $\tau_2 \equiv \tau_{21}$.
- 1 primary factor of production (labor), one sector, and IO linkages.
- Trade Shares

$$\begin{aligned}
\pi_{11} &= \frac{tc^{-\theta}}{tc^{-\theta} + \tau_1^{-\theta}}, \pi_{12} = \frac{\tau_1^{-\theta}}{tc^{-\theta} + \tau_1^{-\theta}}, \\
\pi_{22} &= \frac{1}{1 + tc^{-\theta}\tau_2^{-\theta}}, \pi_{21} = \frac{tc^{-\theta}\tau_2^{-\theta}}{1 + tc^{-\theta}\tau_2^{-\theta}}.
\end{aligned}$$

- DVAR follows

$$\begin{aligned}
r_{11} &= \beta + (1-\beta)\left(\pi_{11}r_{11} + \pi_{12}r_{21}\right) \\
r_{21} &= (1-\beta)\left(\pi_{21}r_{11} + \pi_{22}r_{21}\right)
\end{aligned}$$

Partial Effect on DVAR

- Totally differentiating gives

$$\begin{aligned} dr_{11} &= (1-\beta)(\pi_{11}dr_{11} + \pi_{12}dr_{21}) + (1-\beta)(r_{11} - r_{21})\, d\pi_{11} \\ dr_{21} &= (1-\beta)(\pi_{21}dr_{11} + \pi_{22}dr_{21}) - (1-\beta)(r_{11} - r_{21})\, d\pi_{22} \end{aligned}$$

  which leads to

$$dr_{11} = Ad\pi_{11} - Bd\pi_{22}$$

  where $A > B > 0$.

- Taylor series expansion of $d\pi_{11}$ and $d\pi_{22}$ to the second order derivative gives the decomposition of effects on DVAR due to different forces

Pure and Interactive Effects

Rearranging the terms and ignoring the second order effects on c, the effect can be decomposed into

- Pure effect of technology

$$(C+D)\frac{dt}{t} - [C\pi_{11} + D\pi_{21}]\left(\frac{dt}{t}\right)^2$$

  where C, $D > 0$.

- Pure effect of trade frictions

$$-C\left[\frac{d\tau_1^{-\theta}}{\tau_1^{-\theta}} - \pi_{12}\left(\frac{d\tau_1^{-\theta}}{\tau_1^{-\theta}}\right)^2\right] + D\left[\frac{d\tau_2^{-\theta}}{\tau_2^{-\theta}} - \pi_{21}\left(\frac{d\tau_2^{-\theta}}{\tau_2^{-\theta}}\right)^2\right]$$

- Interactive effect of technology and trade frictions

$$C\left(\pi_{11} - \pi_{12}\right)\left(\frac{dt}{t}\right)\left(\frac{d\tau_1^{-\theta}}{\tau_1^{-\theta}}\right) + D\left(\pi_{22} - \pi_{21}\right)\left(\frac{dt}{t}\right)\left(\frac{d\tau_2^{-\theta}}{\tau_2^{-\theta}}\right)$$

  where $C = A\pi_{11}\left(1 - \pi_{11}\right)$ and $D = B\pi_{22}\left(1 - \pi_{22}\right)$

Major Source of Data

Use 2013 edition of the World Input-Output (WIOD) Database

- $J = 40$ countries + ROW
- $S = 35$ industries/sectors
- $T = 14$ years: 1995-2008
- A model to map the yearly changes in the $NJ \times NJ$ (2,059,225) global intermediate goods cost share matrix $\mathbf{G}$ due to changes in intermediate goods shares π_{nm}^{ik}

Taking the Model to Data

- We estimate the change in competitiveness (relative to the US) using the following gravity equation, which is derived from the model:

$$\ln\left(\frac{\pi_{nlt}^{ji}}{\pi_{nnt}^{ji}}\right) = \ln\left(T_{lt}^{i}\left(c_{lt}^{i}\right)^{-\theta}\right) - \theta ex_{lt}^{i} - \ln\left(T_{nt}^{i}\left(c_{nt}^{i}\right)^{-\theta}\right) - \theta v_{nlt}^{ji}$$

- The estimated asymmetric bilateral trade costs $\{\tau_{nl}^{ji}\}$ is obtained from the gravity estimation based on

$$\ln \tau_{nlt}^{ji} = ex_{lt}^{i} + v_{nlt}^{ji}$$

- The data are directly obtained from the WIOD table or PWT9.0 (Penn World Table).

Solving for the Equilibrium

- Following Dekle, Eaton, and Kortum (2008), we use hat algebra to characterize the equilibrium changes. $\widehat{x} = x'/x$
- For each year, use the estimated $\{\widehat{T}_l^i \left(\widehat{c}_l^i\right)^{-\theta}\}$ and $\{\widehat{\tau}_{nl}^{ji}\}$ as initial values. Start with a guess of $\{\widehat{w}_l\}$ and $\{\widehat{r}_l\}$, solve for:

$$\widehat{c}_l^i = \left(\widehat{P}_l^i\right)^{1-\beta_l^i} \left(\widehat{w}_l\right)^{\beta_l^i \mu_l^i} \left(\widehat{r}_l\right)^{\beta_l^i \left(1-\mu_l^i\right)}$$

$$\widehat{P}_n^j = \prod_{i=1}^{J} \left(\widehat{p}_n^{ji}\right)^{\gamma_n^{ji}}$$

$$\widehat{p}_n^{ji} = \left[\sum_{l=1}^{N} \pi_{nl}^{ji} \widehat{T}_l^i \left(\widehat{c}_l^i \widehat{\tau}_{nl}^{ji}\right)^{-\theta}\right]^{-\frac{1}{\theta}}$$

- We can thus get the changes in trade shares $\{\widehat{\pi}_{nl}^{ji}\}$, and thus the new trade shares $\pi_{nl}^{ji\prime} = \pi_{nl}^{ji} * \widehat{\pi}_{nl}^{ji}$

$$\widehat{\pi}_{nl}^{ji} = \widehat{T}_l^i \left(\frac{\widehat{c}_l^i \widehat{\tau}_{nl}^{ji}}{\widehat{p}_n^{ji}} \right)^{-\theta}$$

Constraints

- The total expenditure on final goods satisfies

$$E'_n = w'_n L'_n + r'_n K'_n + D'_n$$

- Total production of each sector in each country $\{X_n^{i\prime}\}$ through

$$X_n^{i\prime} = \sum\nolimits_{k=1}^{J} \sum\nolimits_{m=1}^{N} \left(1 - \beta_m^k\right) \gamma_m^{ki} \pi_{mn}^{ki\prime} X_m^{k\prime} + \sum\nolimits_{m=1}^{N} \pi_{mn}^{Fi\prime} \alpha_m^i E'_m$$

- Capital and labor market clearing conditions

$$\begin{aligned} r'_n K'_n &= \sum\nolimits_{i=1}^{J} \beta_n^i \left(1 - \mu_n^i\right) X_n^{i\prime} \\ w'_n L'_n &= \sum\nolimits_{i=1}^{J} \beta_n^i \mu_n^i X_n^{i\prime} \end{aligned}$$

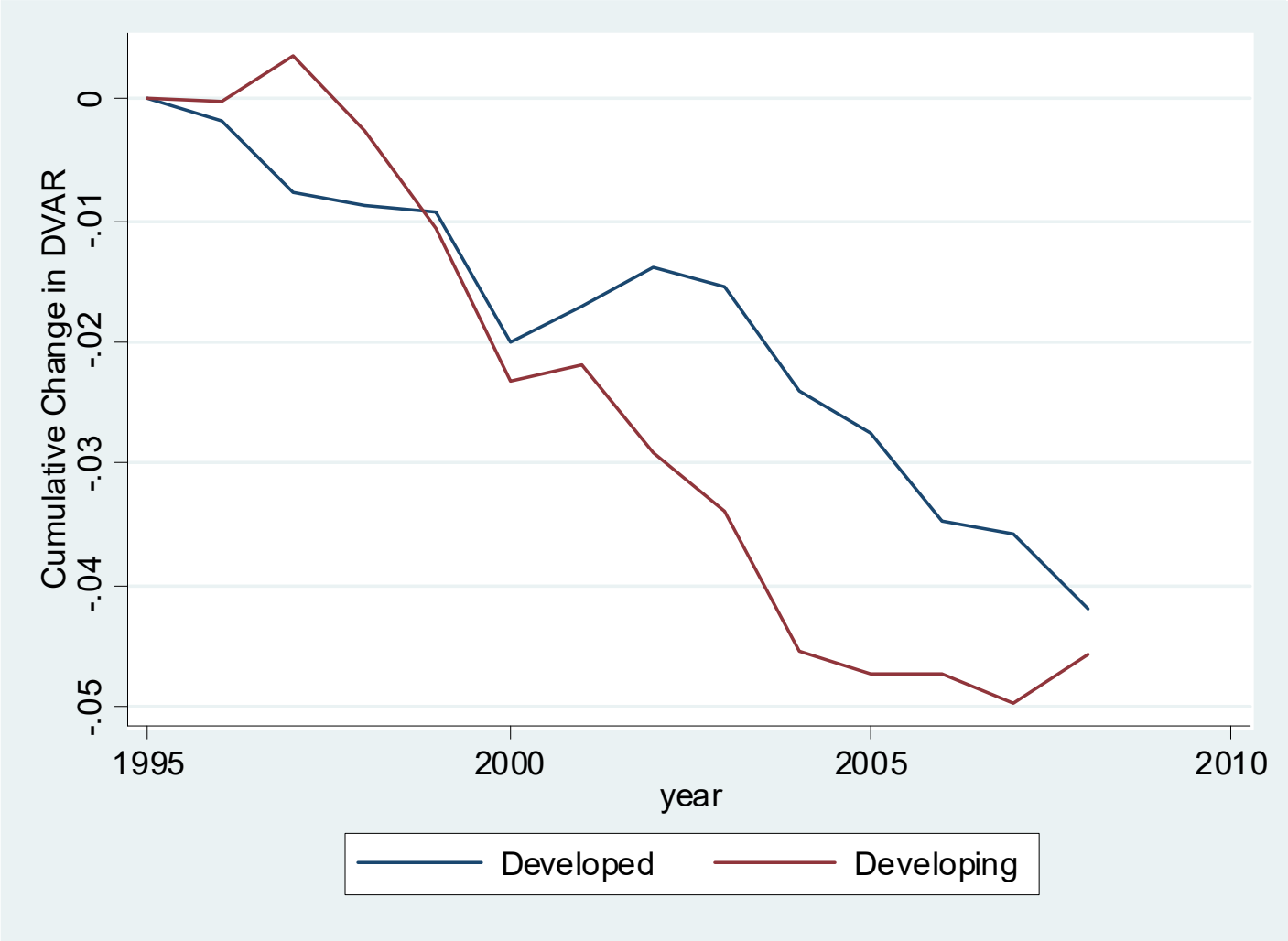


Figure 1: Developed and Developing Countries' DVAR

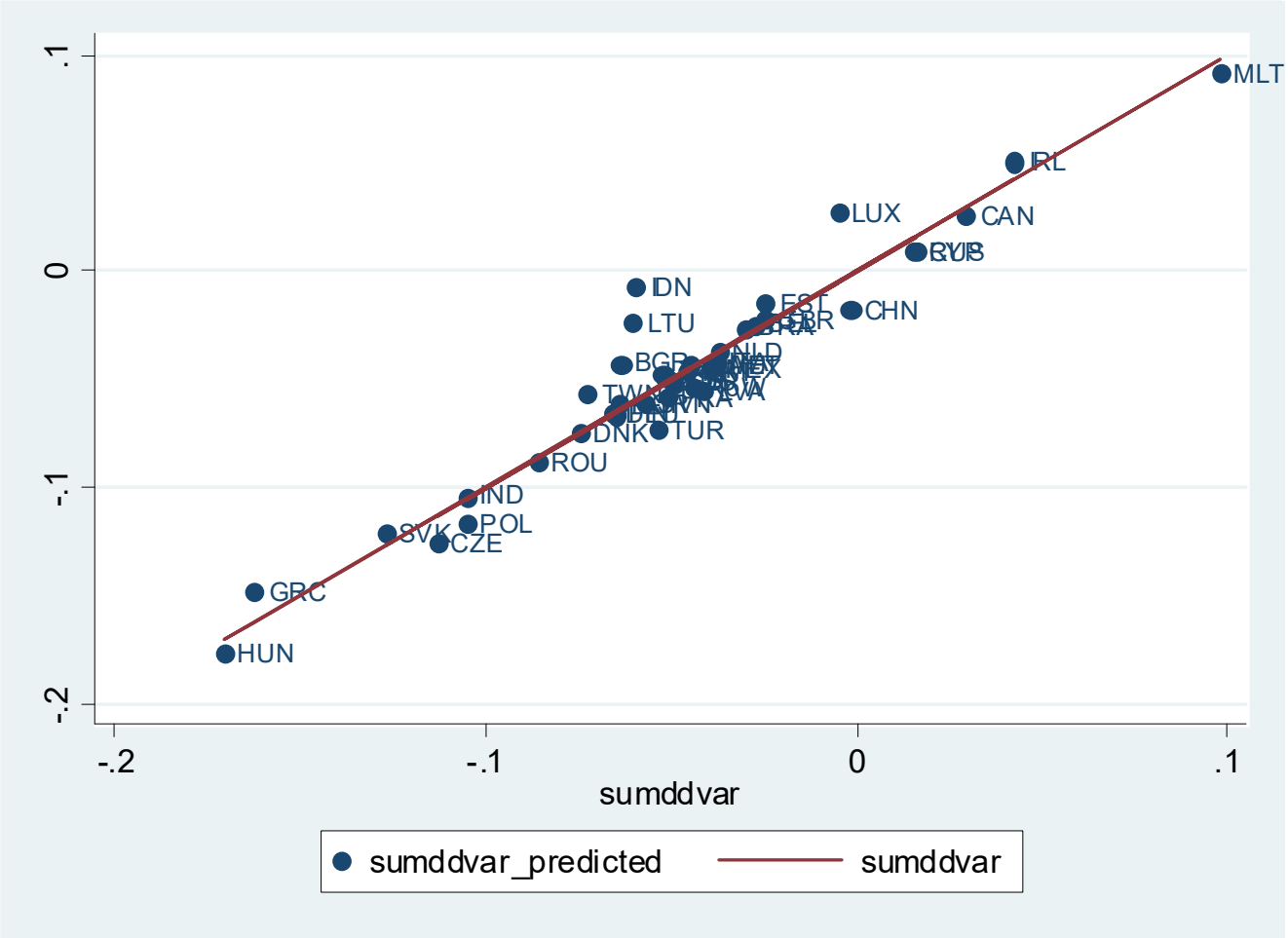


Figure 2: Fit of the Calibration.

The vertical axis is our prediction and the horizontal axis is the data. The fit is very good.

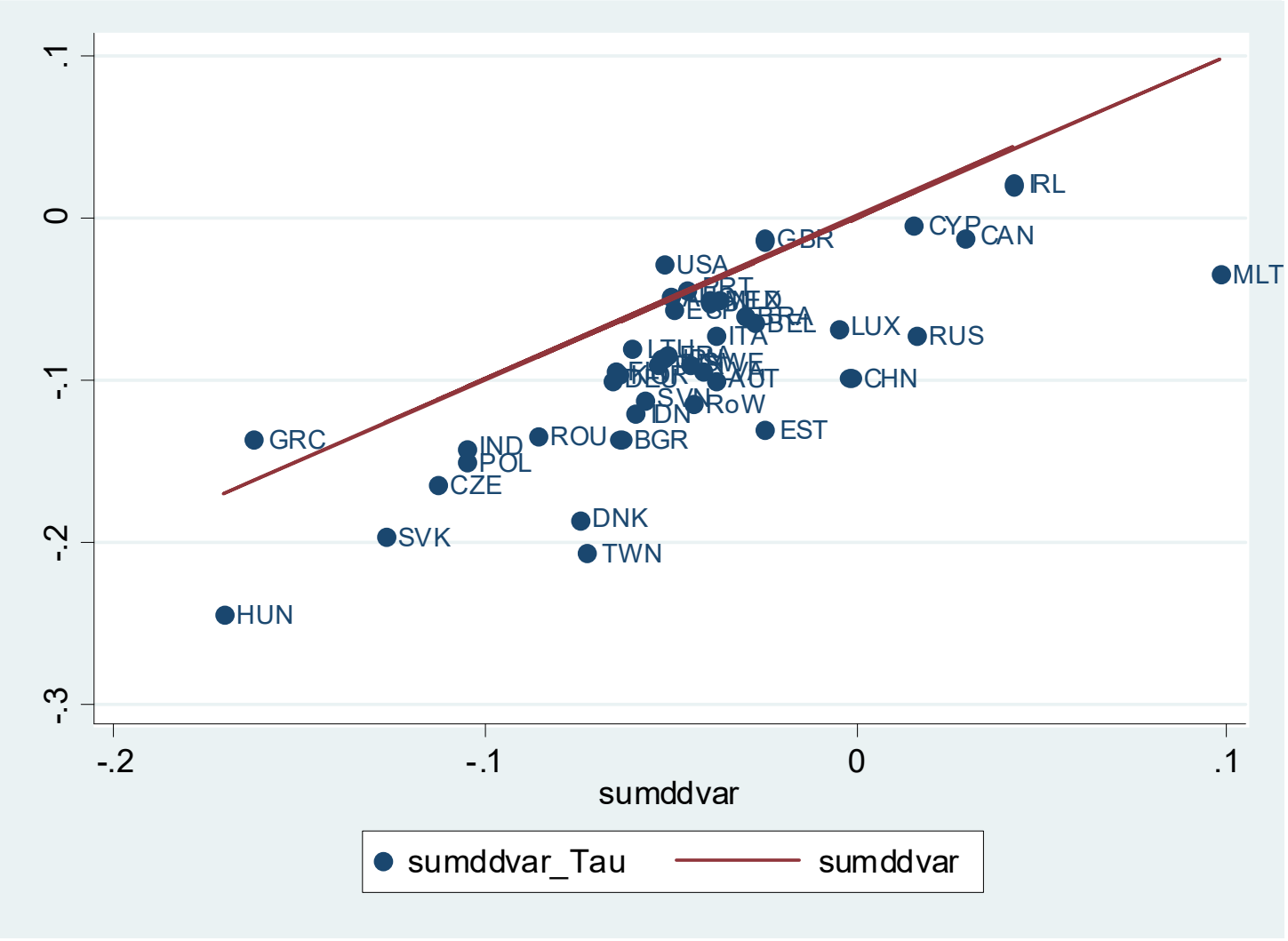


Figure 3: The Pure (Stand-alone) Effect of Changes in τ.

The pure (stand-alone) effect of changes in trade costs does not fit the data very well.

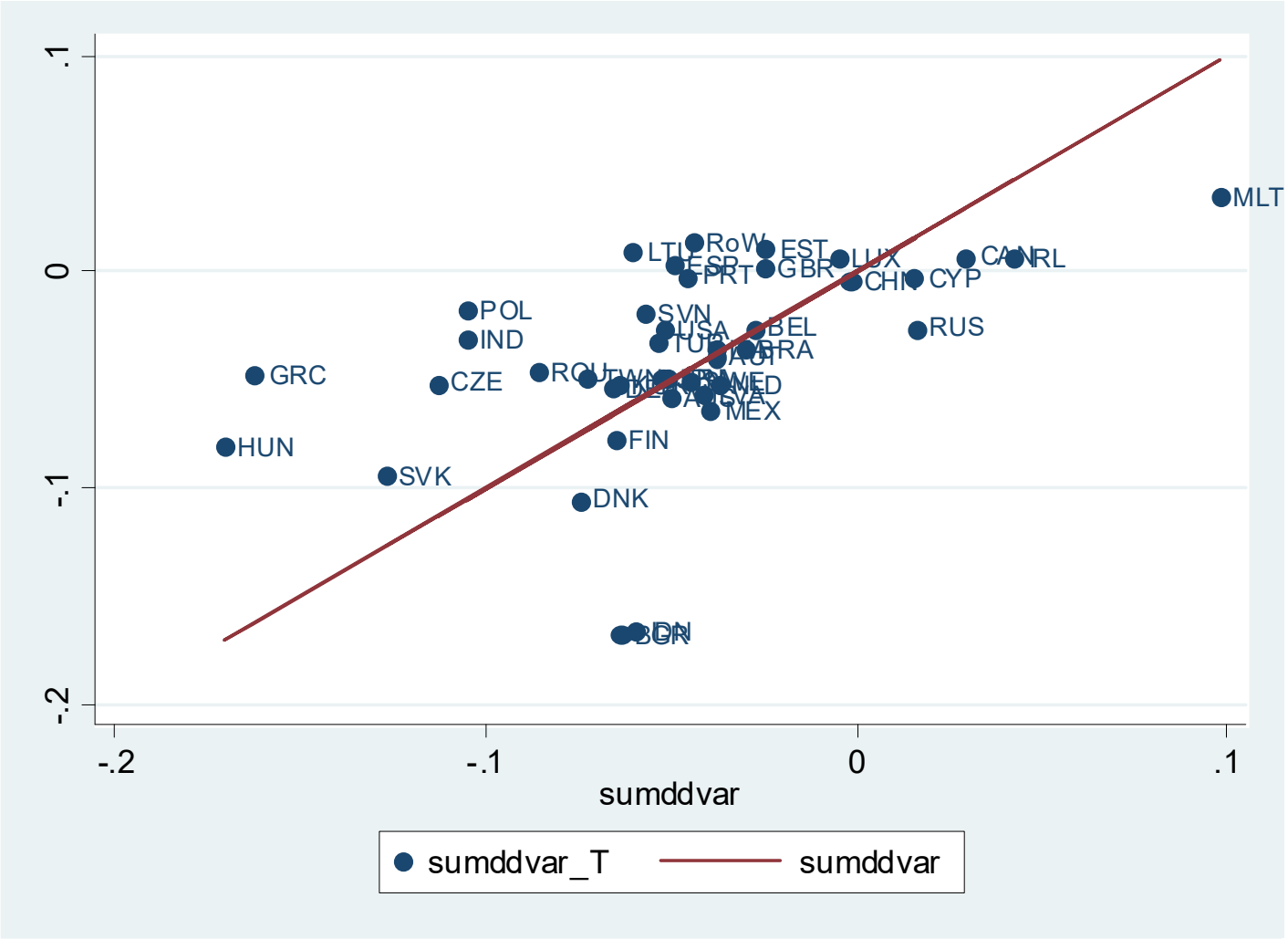


Figure 4: Pure Effect of Changes in T.

The pure effect of changes in technology stocks also does not fit the data well.

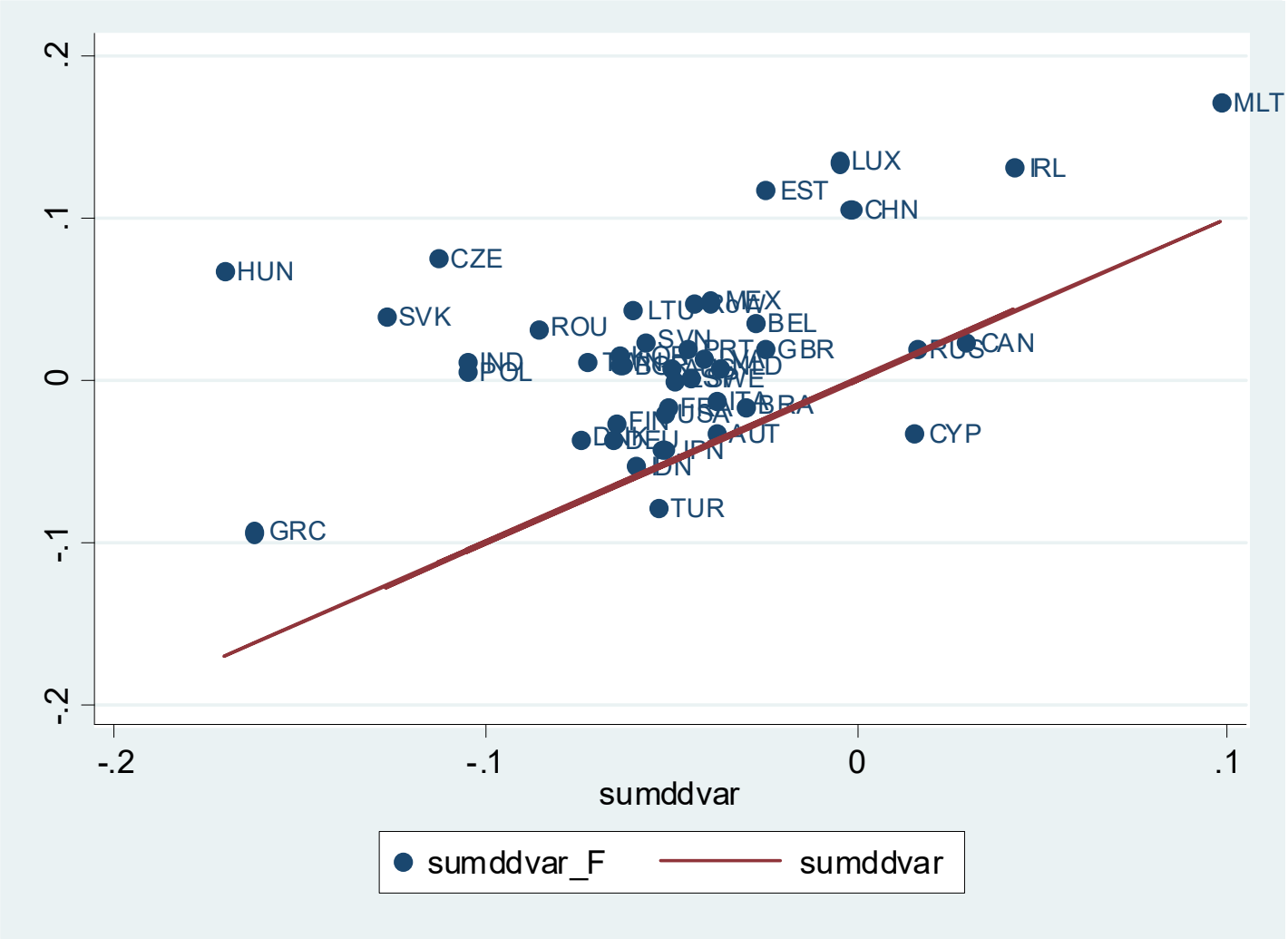


Figure 5: Pure Effects of Changes in Other Factors (i.e. K, L and trade balance). The pure effect of "other factors" provides the poorest fit among the three sets of factors.

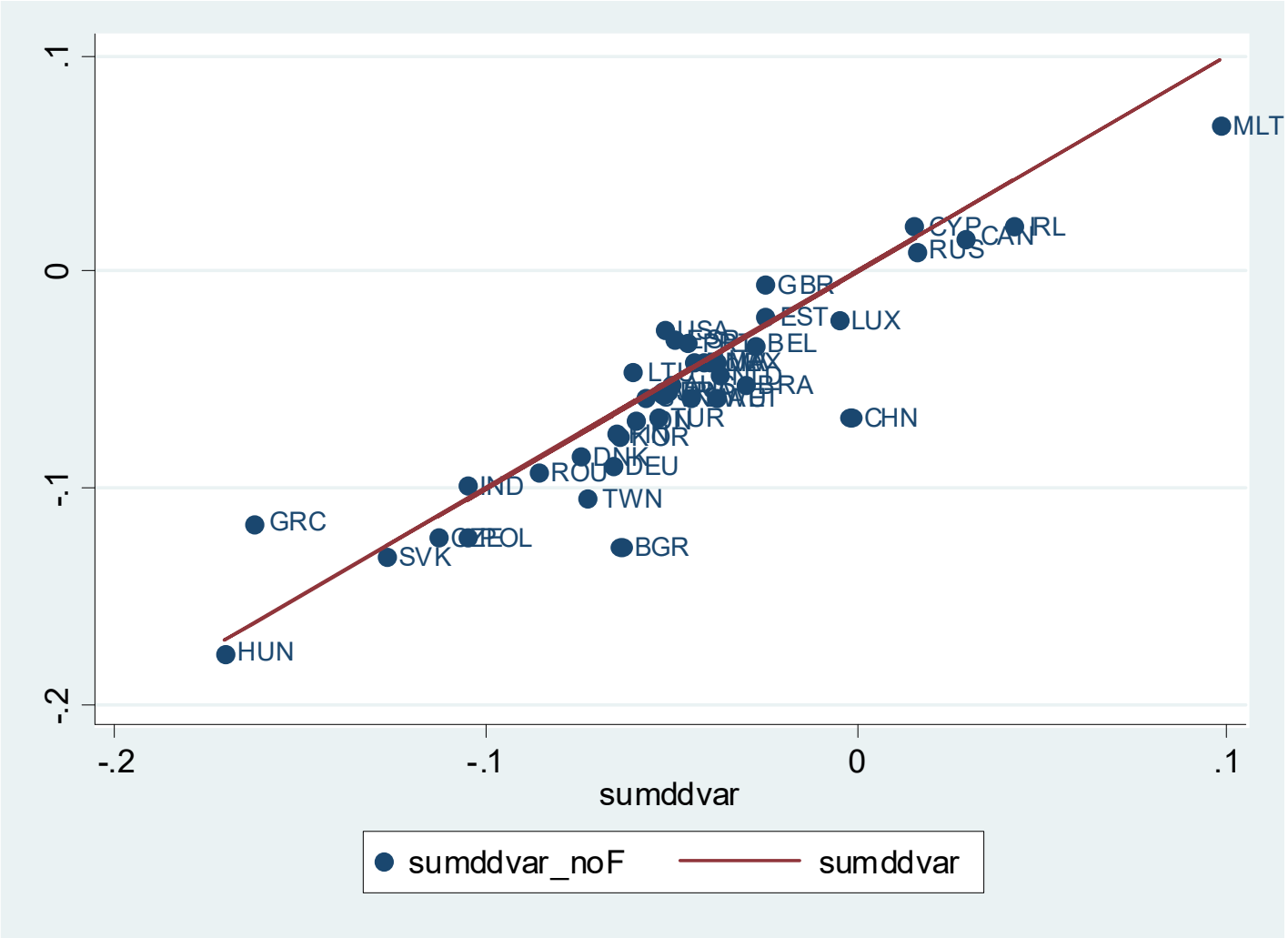


Figure 6: Counterfactuals of Shutting Down Other Factors

Decomposition Results

- Percentage-point Changes in DVAR (1995-2008)

	Global	Developed	Developing
Total	-4.36	-4.20	-4.58
due to changes in			
Technology (stand-alone)	-2.78	-3.25	-2.28
Trade Costs (stand-alone)	-8.03	-5.84	-10.62
Other Factors (stand-alone)	0.94	-0.69	2.75
Tech * Trade Costs	5.79	4.82	6.99
Tech * Other Factors	-0.72	0.42	-1.98
Trade Costs * Other Factors	-0.86	0.41	-2.27
All Three Forces	1.05	-0.14	2.38
Residual	0.25	0.07	0.45

Total Effects

- Percentage-point Changes in DVAR (1995-2008)

	Global	Developed	Developing
Total	-4.36	-4.20	-4.58
total effect of			
Technology	3.34	1.84	5.11
Trade Costs	-2.05	-0.74	-3.52
Other Factors	0.40	0.01	0.88

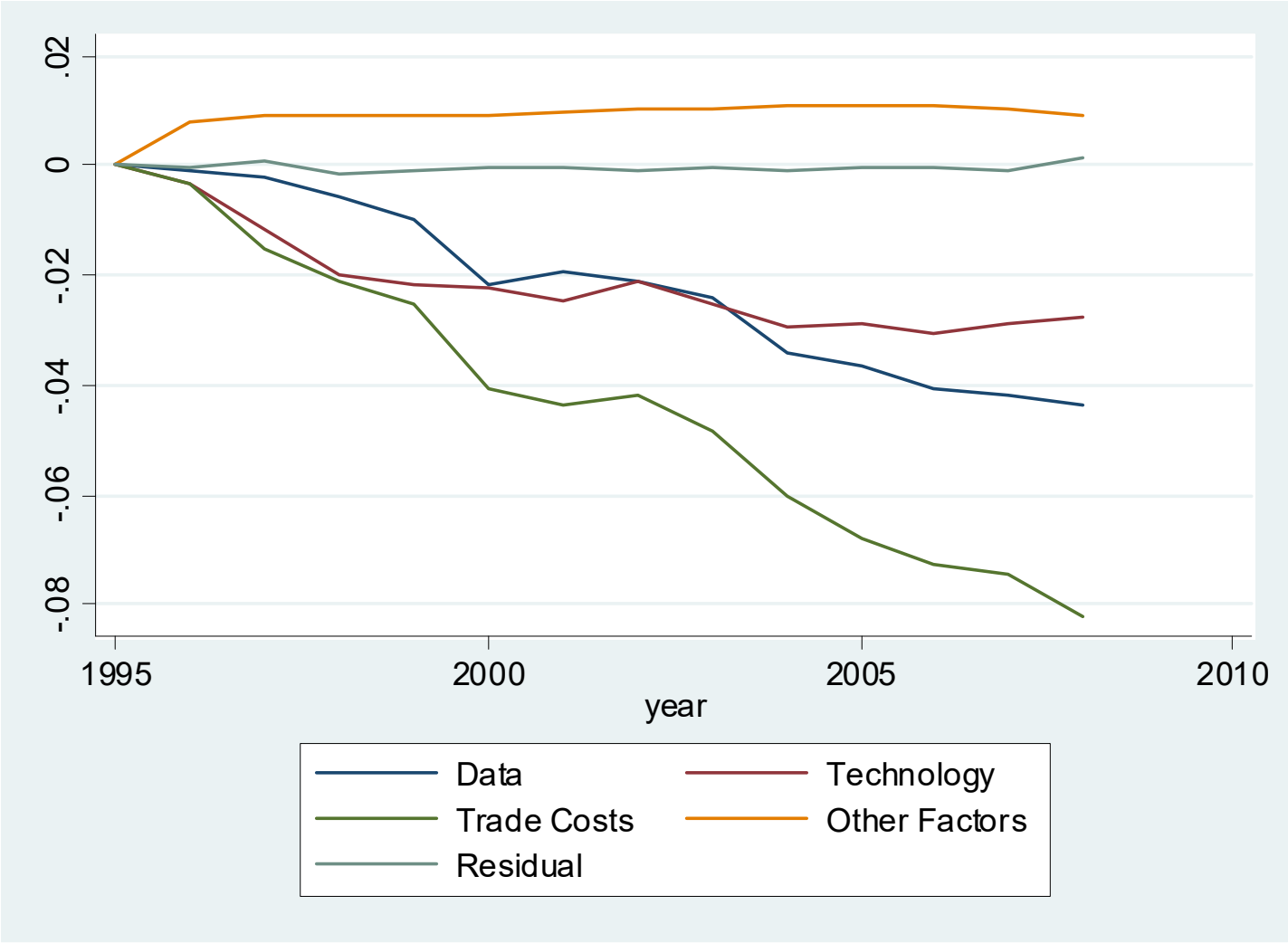


Figure 7: Different Pure Effects on Global DVAR

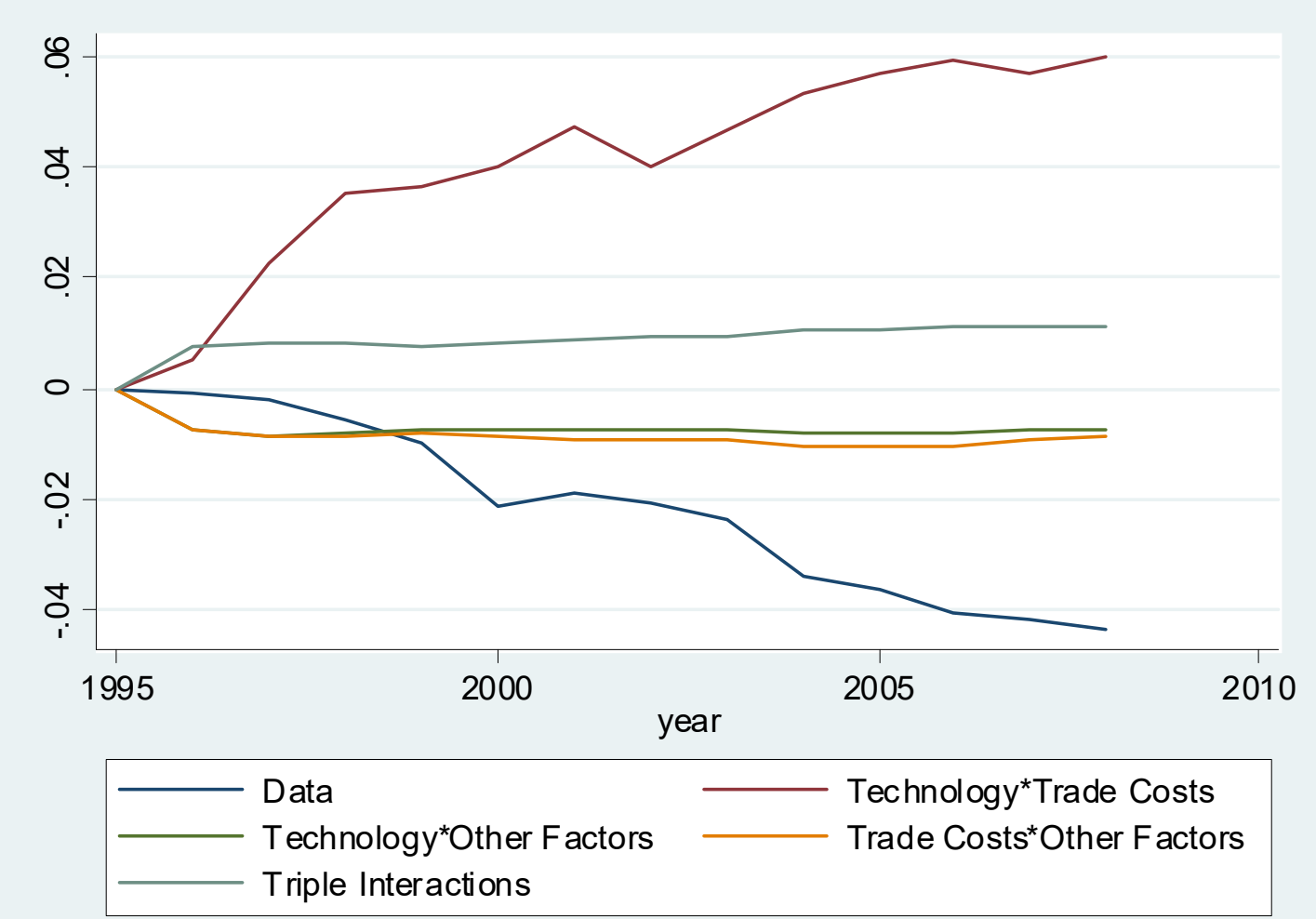


Figure 8: Effects of Interaction Terms on Global DVAR

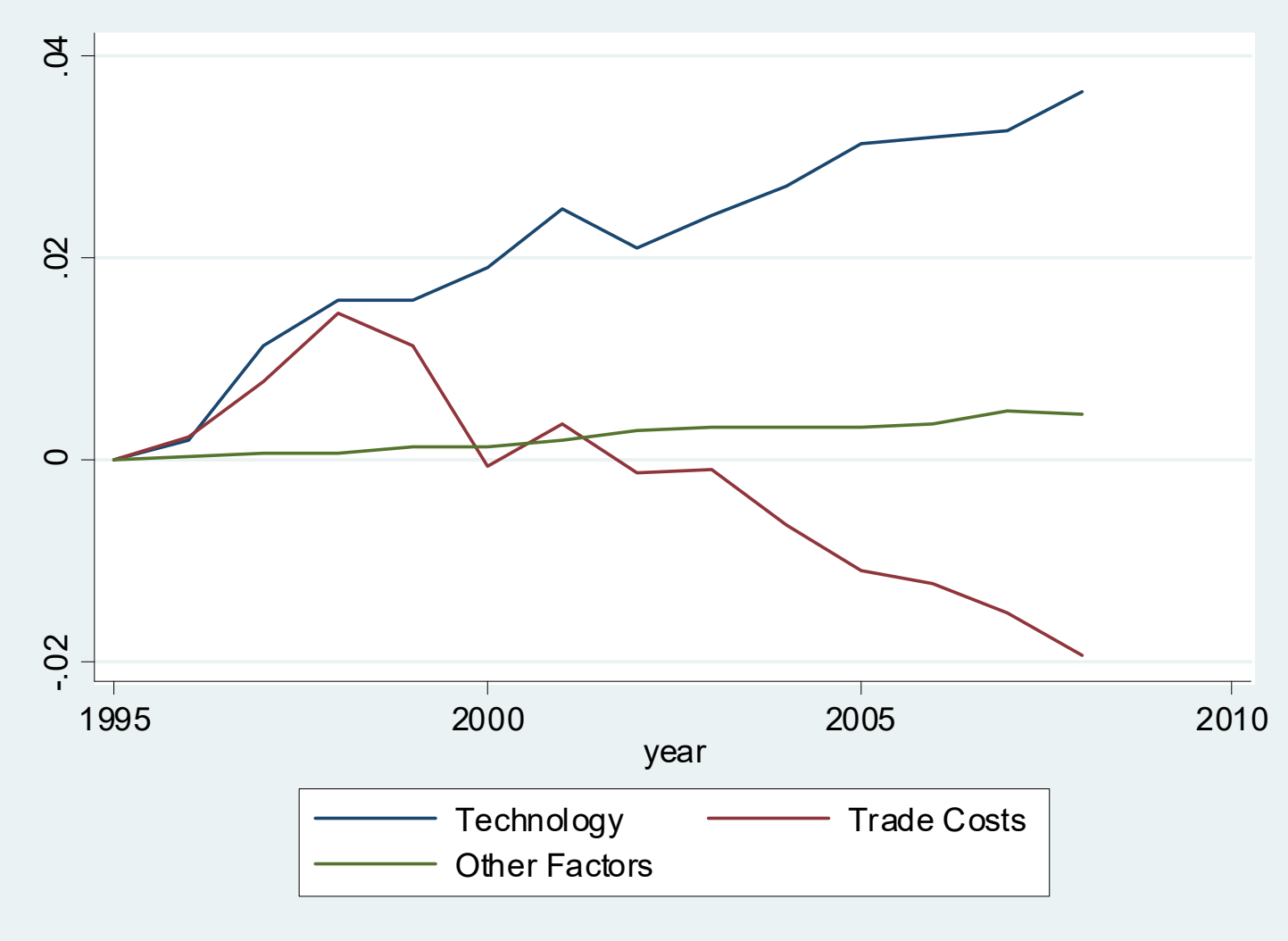


Figure 9: Total Effects of T, τ, and Other Factors on Global DVAR

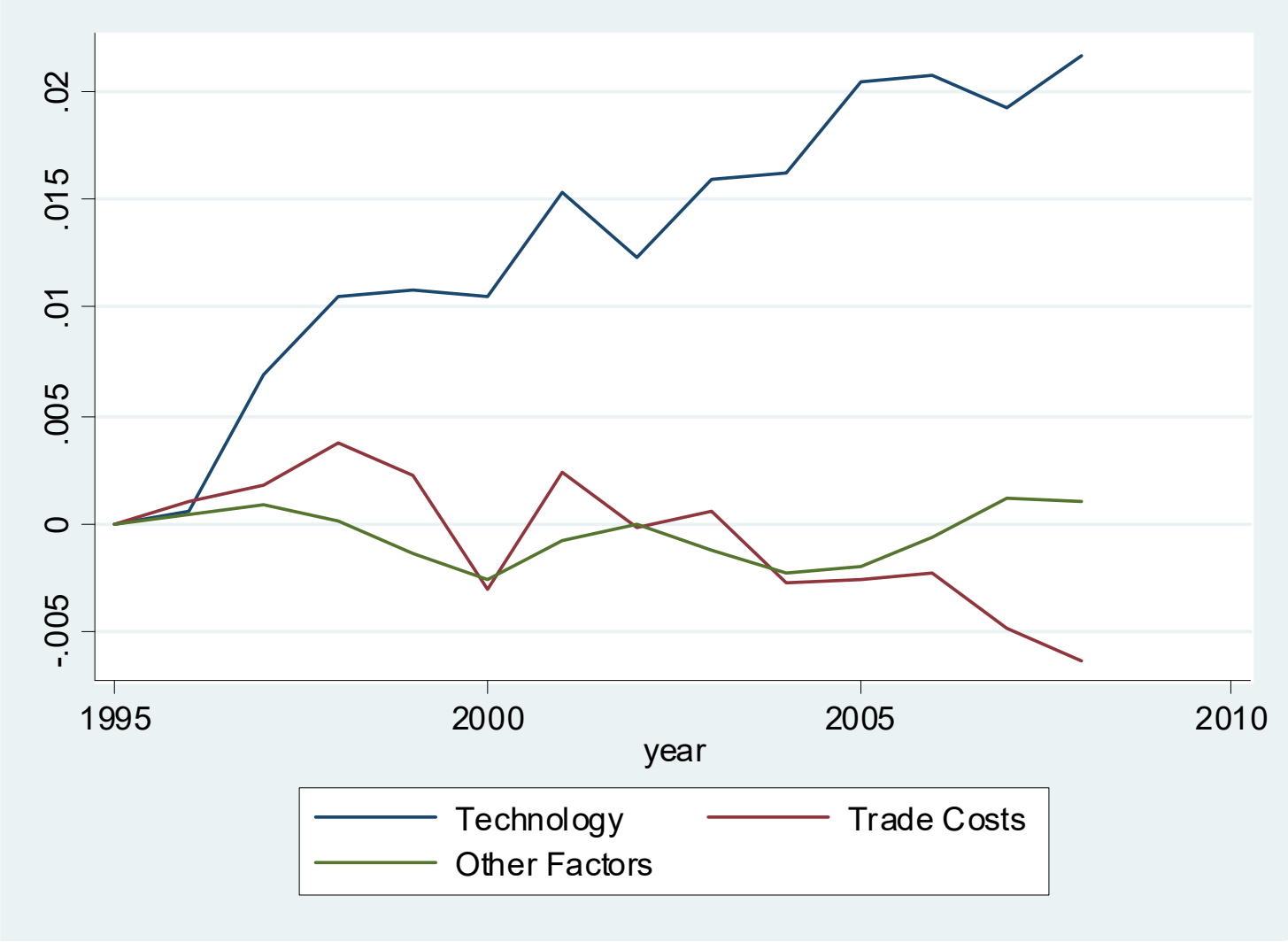


Figure 10: Total effects of T, τ and other factors for Developed Countries

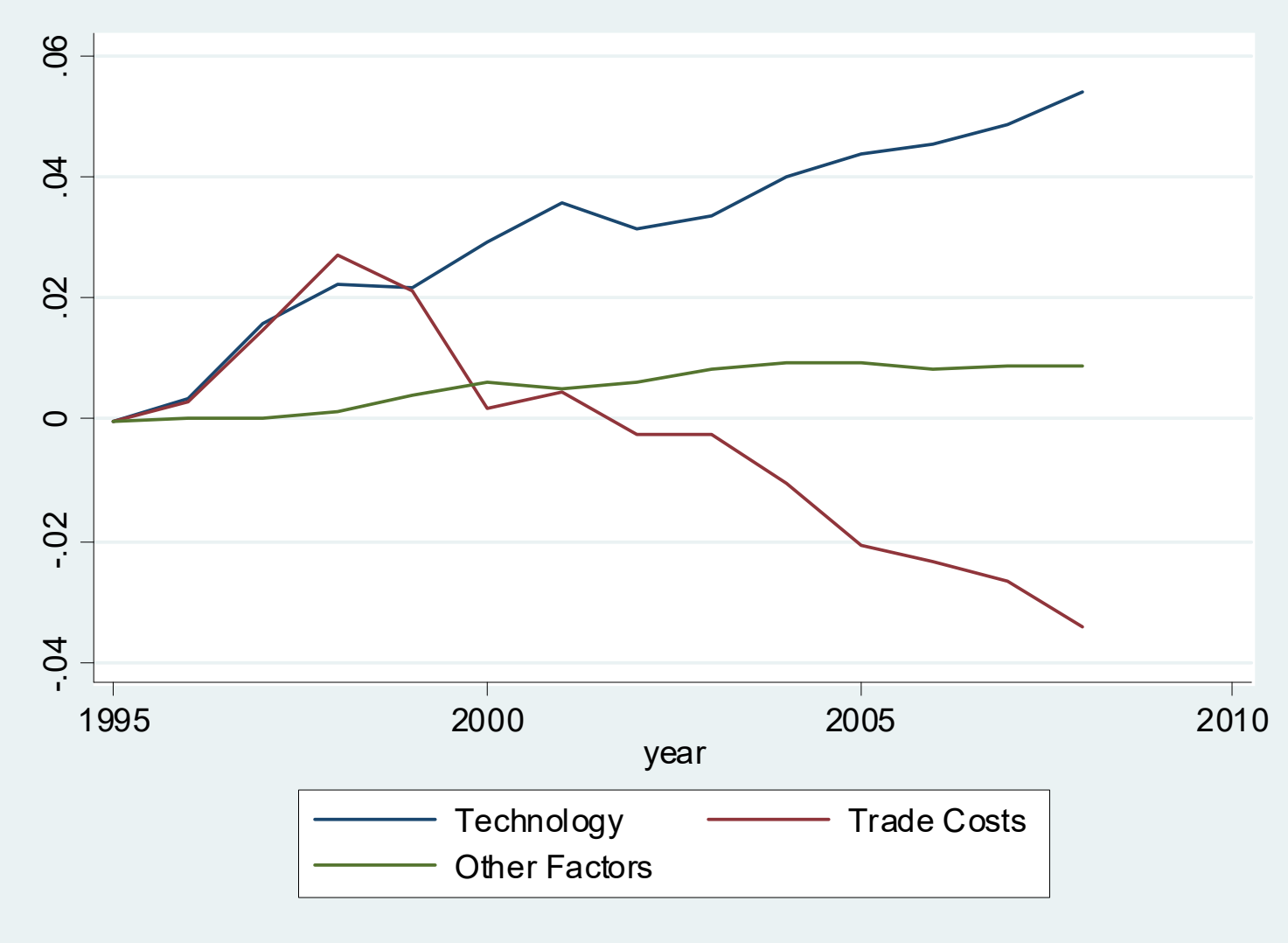


Figure 11: Total effects of T, τ and other factors on Developing Countries

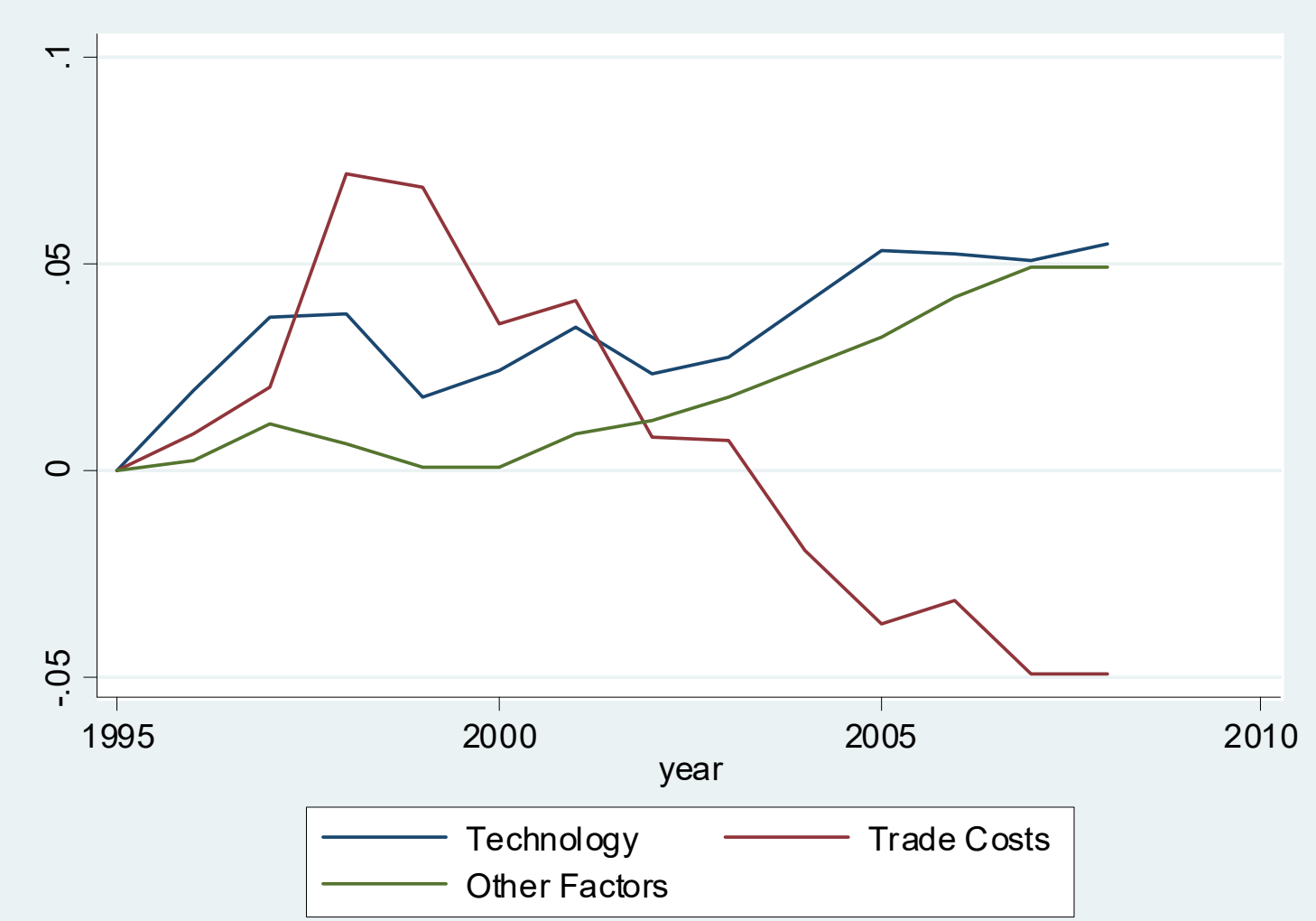


Figure 12: Total effects of T, τ and other factors on China

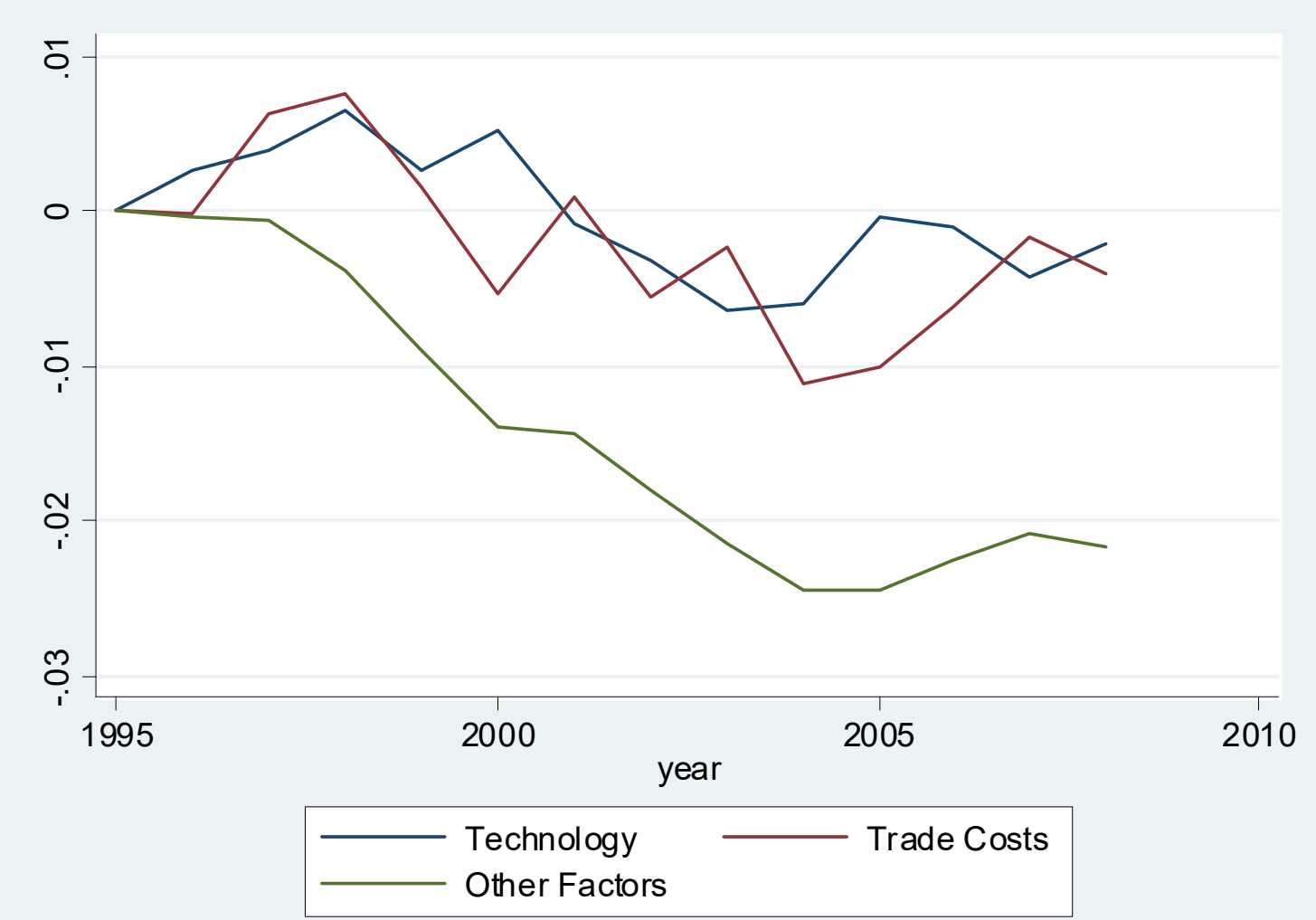


Figure 13: Total effects of T, τ and other factors on the US

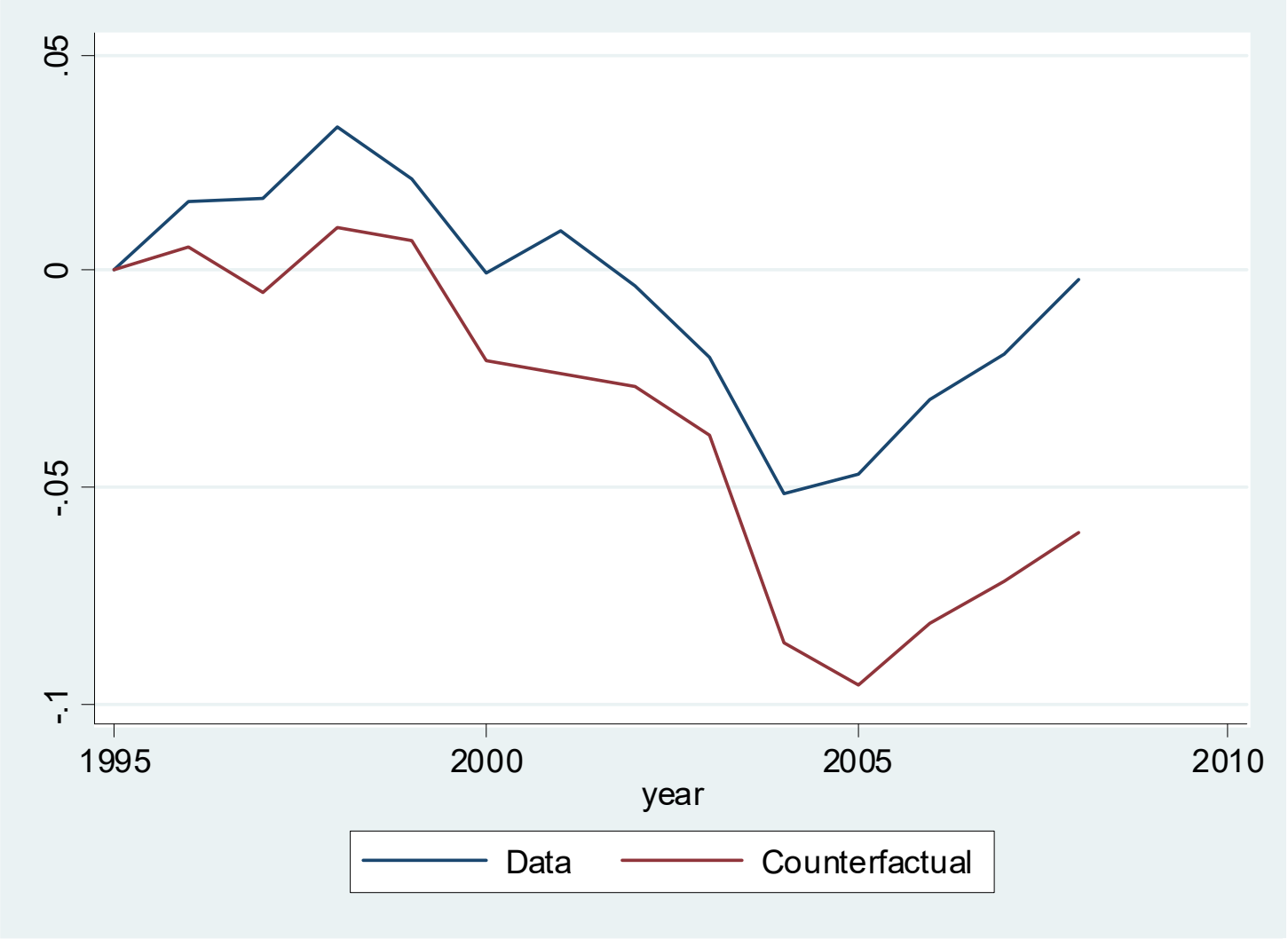


Figure 14: Effects of Shutting Down Changes in China's T on China's DVAR

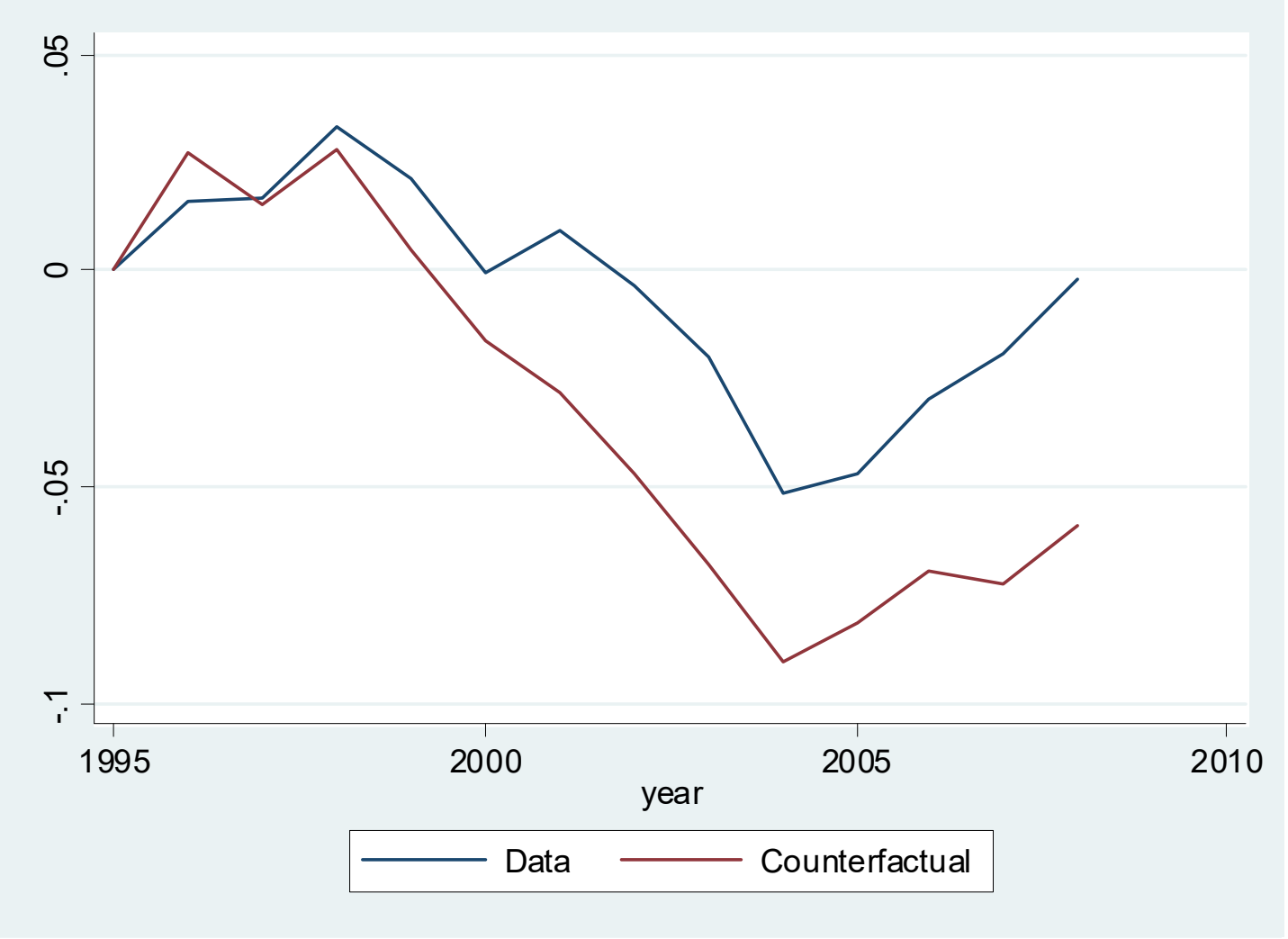


Figure 15: Effects of Shutting Down Changes in China's τ on China's DVAR

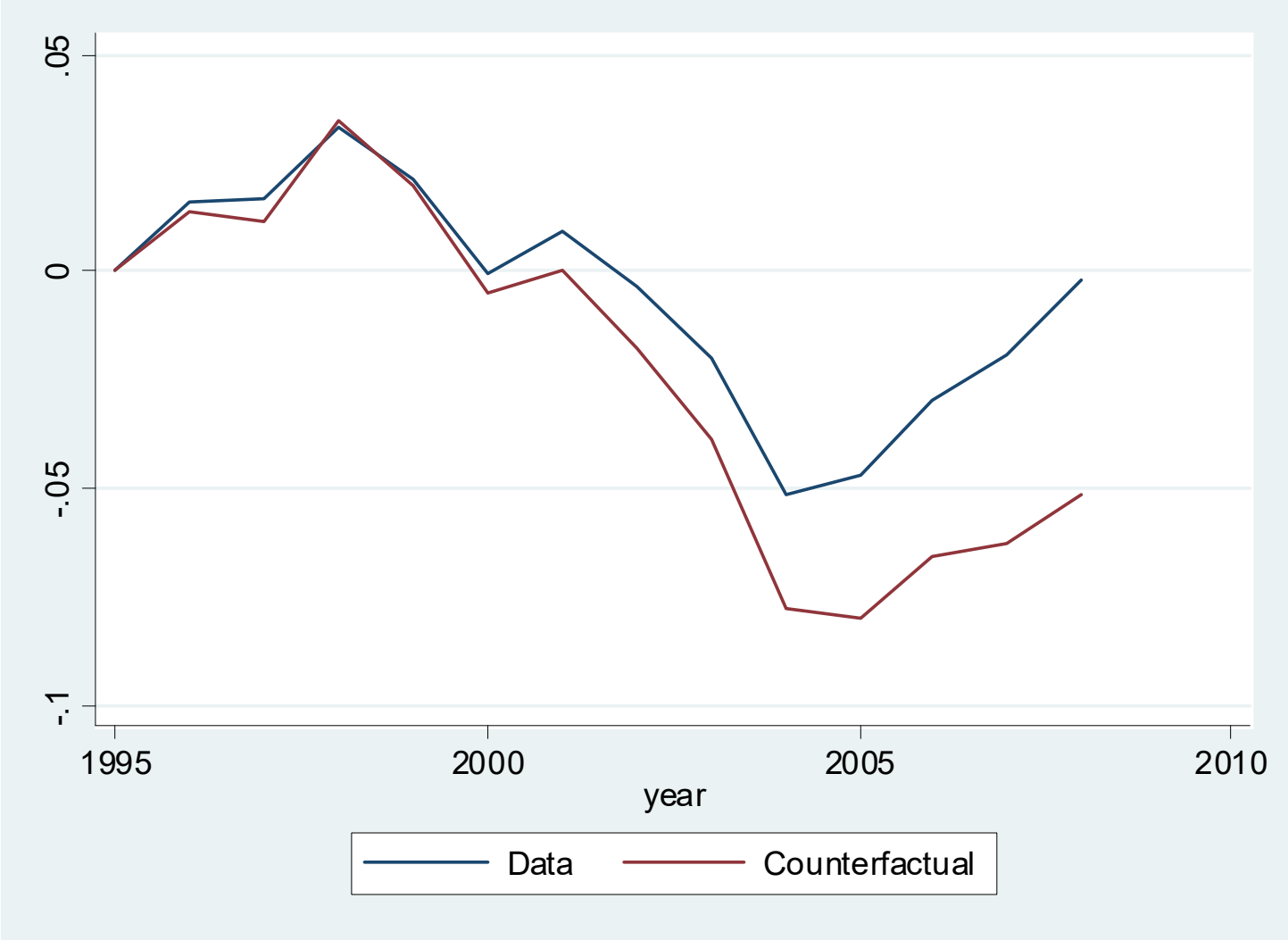


Figure 16: Effects of Shutting Down Changes in China's Capital on China's DVAR

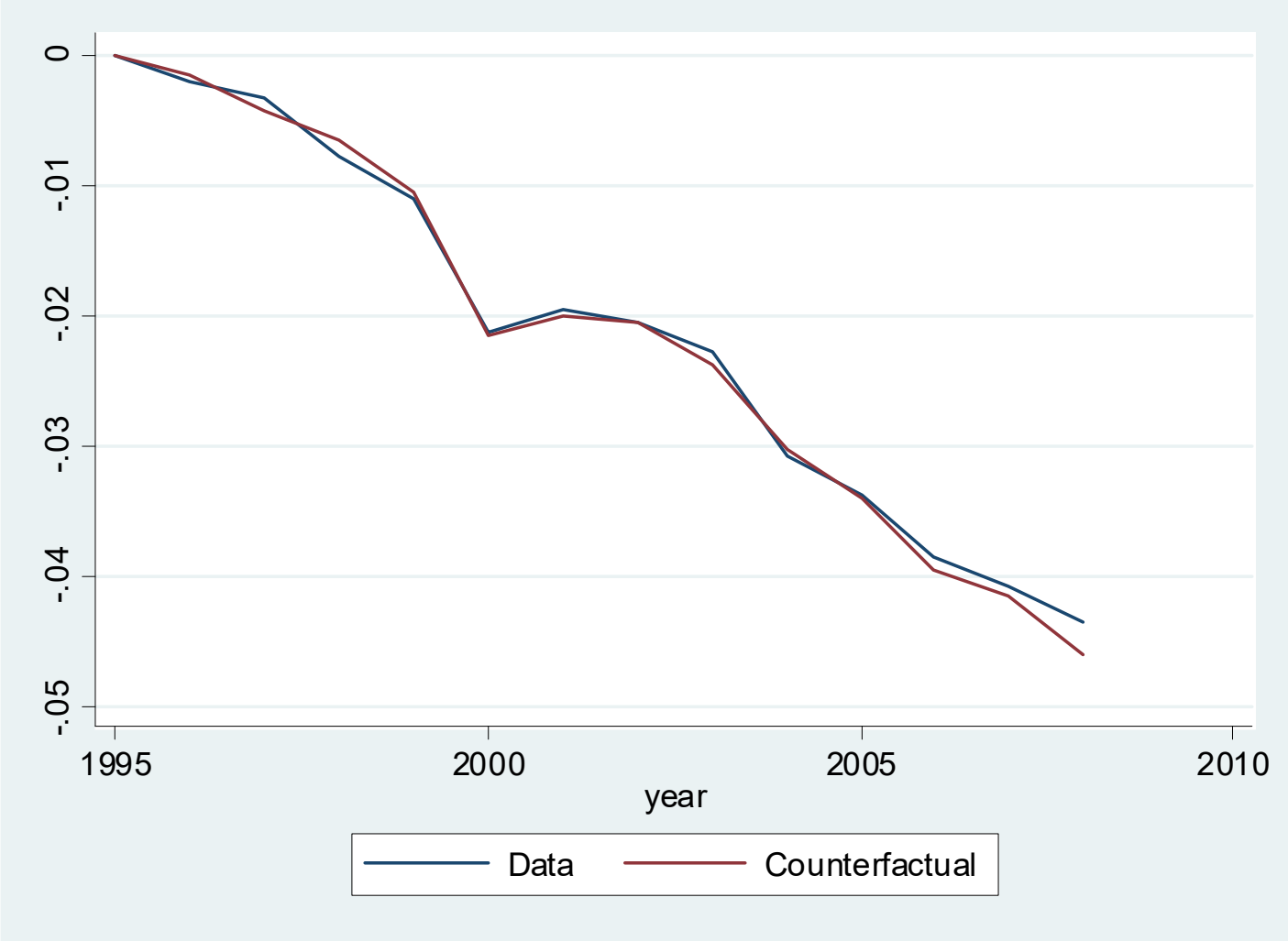


Figure 17: Effects of Shutting Down Changes in China's Technology on ROW's DVAR

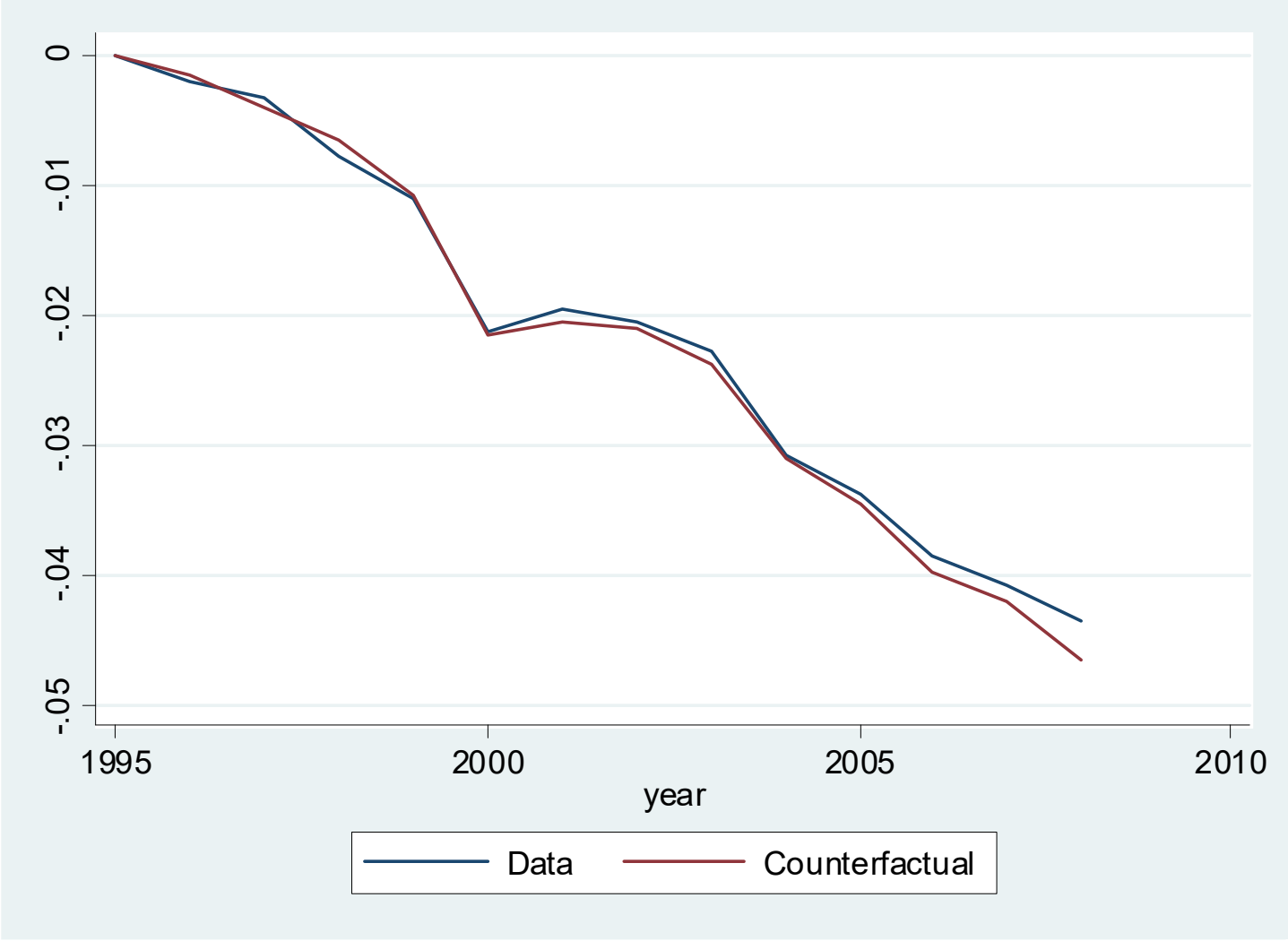


Figure 18: Effects of Shutting Down Changes in China's τ on ROW's DVAR

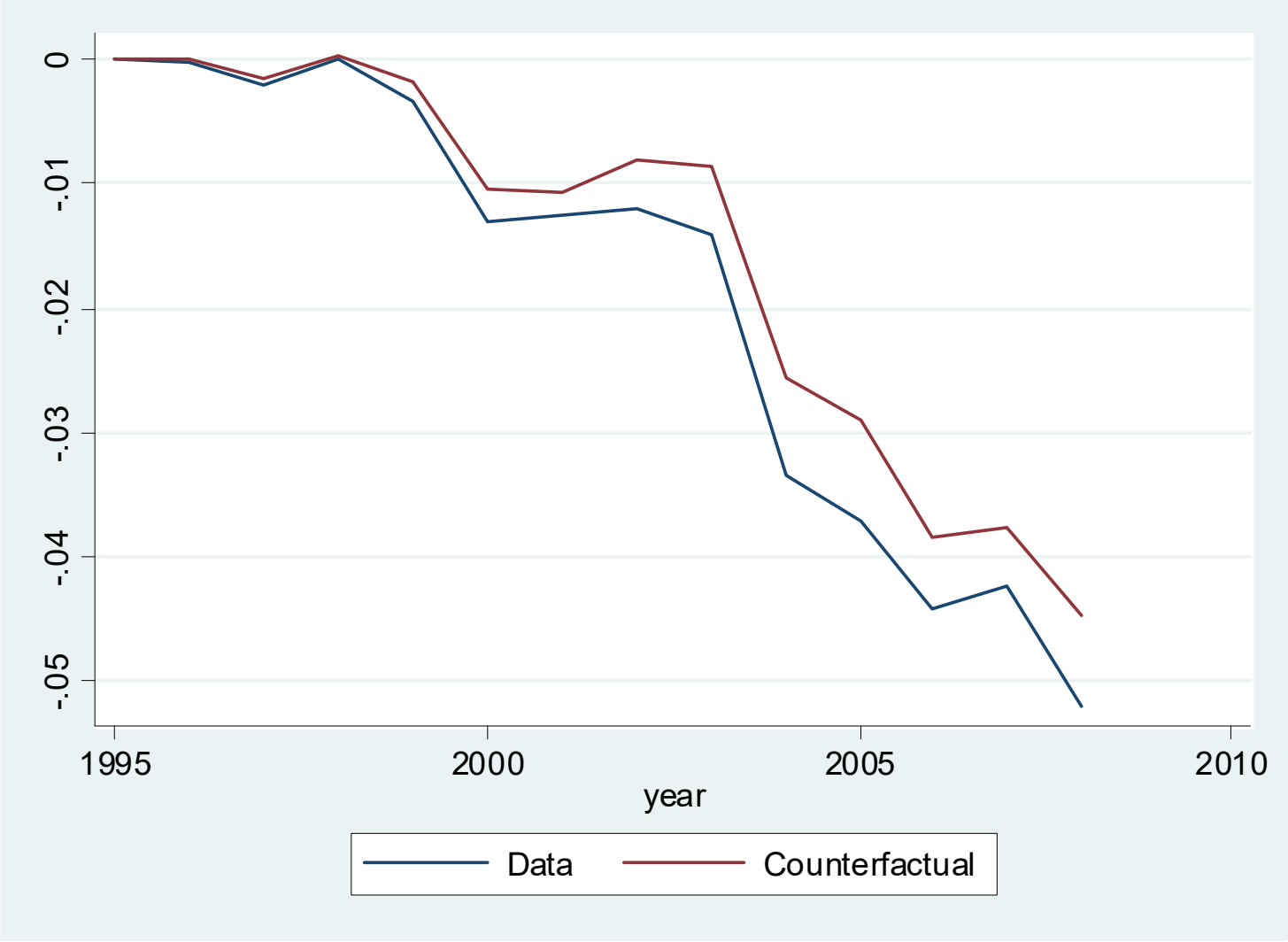


Figure 19: Effects of Shutting Down Changes in China's T on US's DVAR

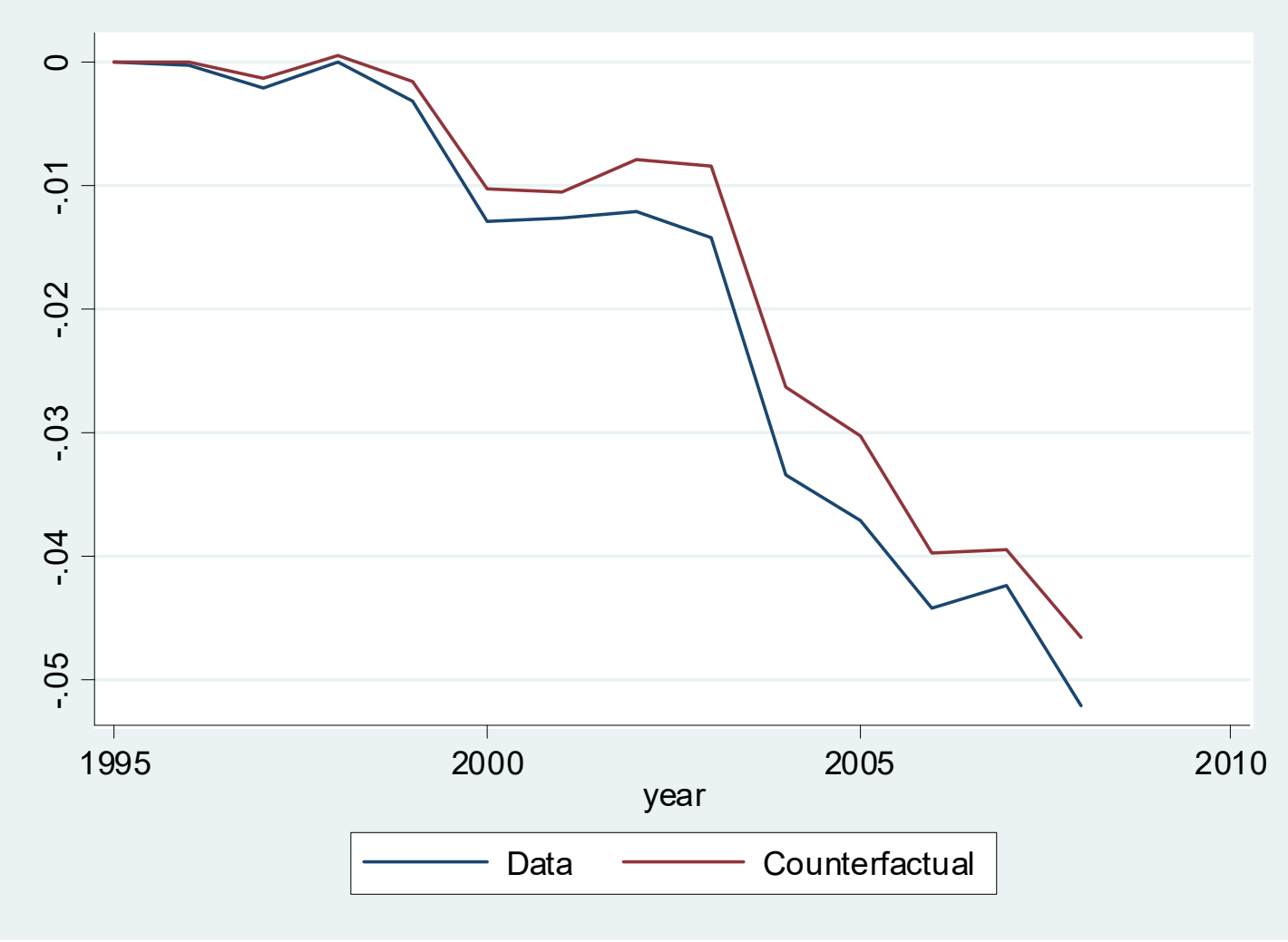
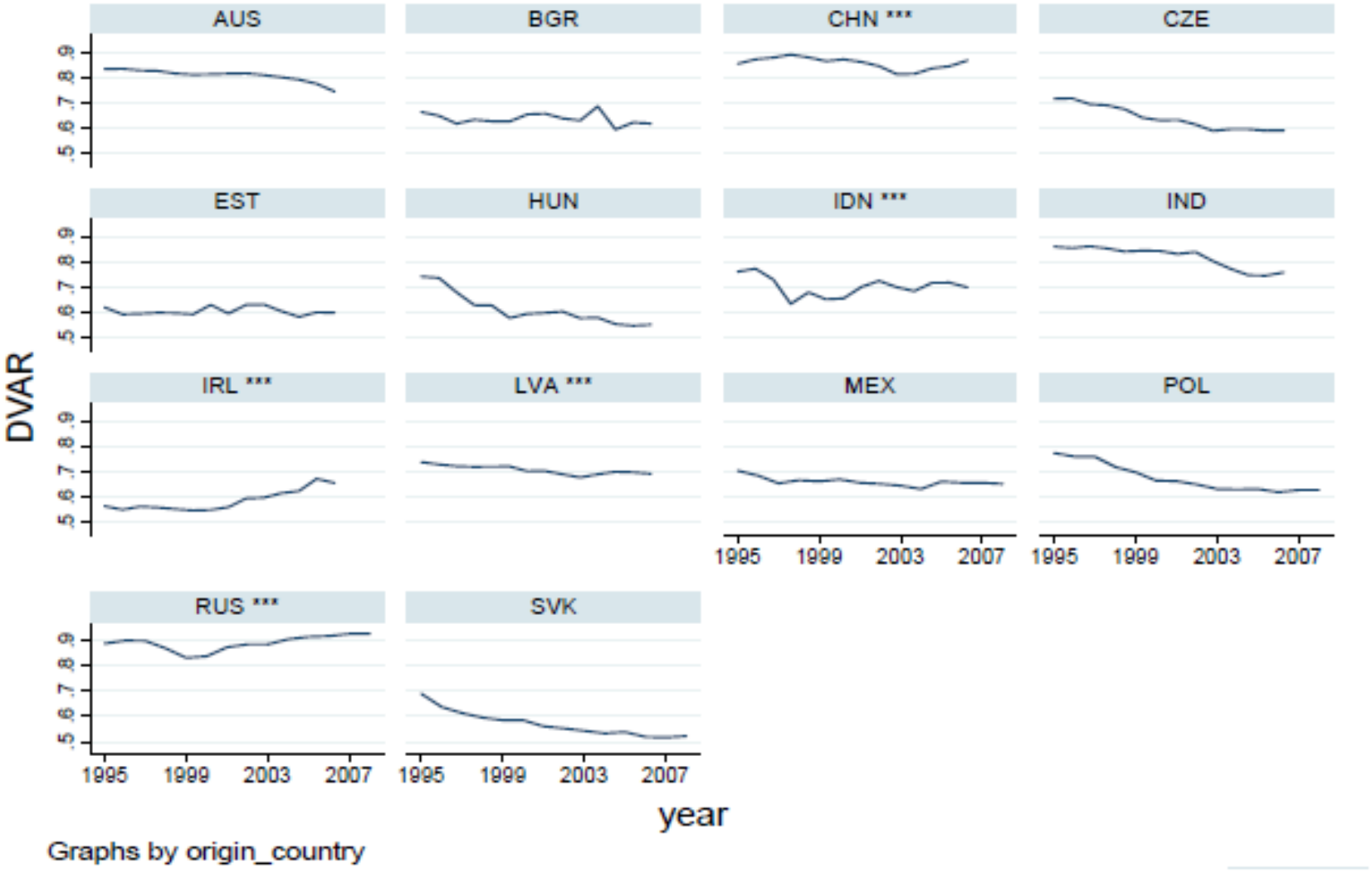


Figure 20: Effects of Shutting Down Changes in China's τ on US's DVAR

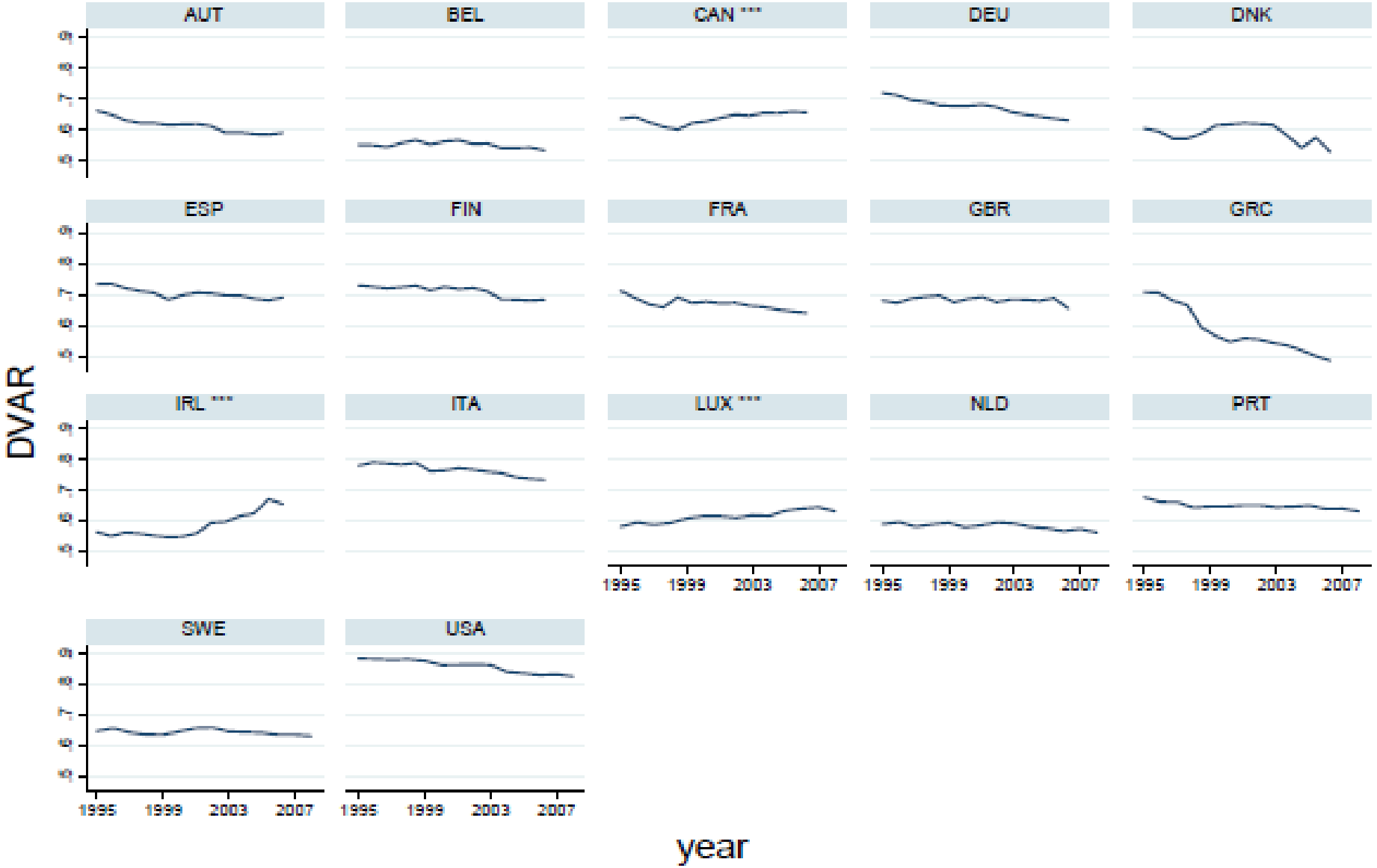
Conclusion

- Based on a multi-sector EK model with domestic and global input-output linkages, we quantify the contributions of different factors to the changes in individual countries' and global DVAR (1995-2008)
- In addition to trade frictions, emphasize the importance of the positive effect of technology on countries' and global DVAR.
- The contribution of other exogenous factors (factor endowment, trade imbalance) are small.
- Fast-growing countries, like China, which experienced a substantial improvement in technology, despite falling trade frictions, could have DVAR increasing over time.

Fast Growing Countries' DVAR



Developed Countries' (OECD) DVAR


AUT
BEL
CAN ***
DEU
DNK
ESP
FIN
FRA
GBR
GRC
IRL ***
ITA
LUX ***
NLD
PRT
SWE
USA
DVAR
.5
.6
.7
.8
.9
1995
1999
2003
2007
year
Graphs by origin_country
stata™