The Impact of Productivity on Welfare of Nations through Global Value Chains

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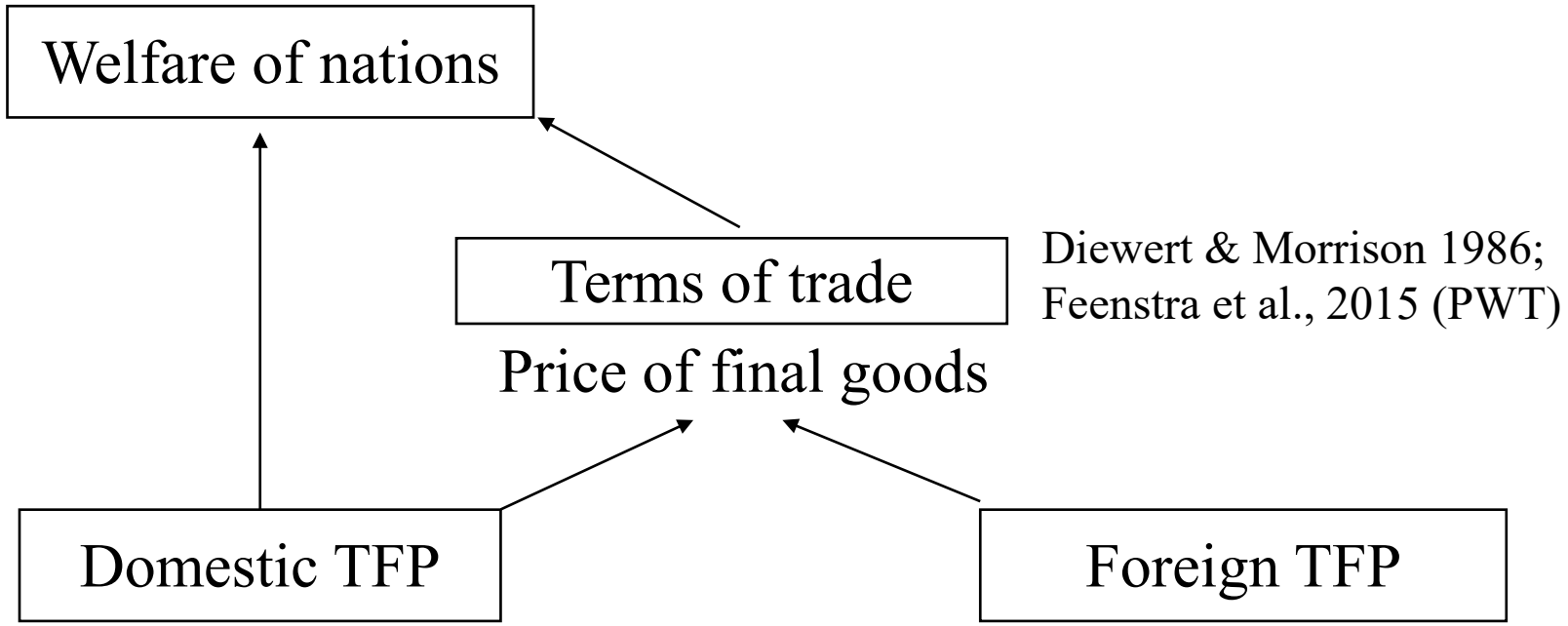
Background

GVC analysis has mainly focused on backward and forward linkages, where value added and employment are created by deepening of international division of labor, etc...

But recent GVC analysis start to focus more on productivity issue, such as how TFP growth in other countries affects German automobile production (Timmer). But analysis on how TFP changes in the factor endowment in the world affects each country's welfare is still limited. We will address this research gap.

Motivation



Diewert & Morrison 1986;
Feenstra et al., 2015 (PWT)

Made in a country

Made in the world

Research Objective

We developed a model to:

(1) measure the gap between GDP growth and welfare growth of a nation

(2) further elucidate how this disparity is influenced by global TFP growth through GVCs.

Significance:

growing geopolitical instability + restructuring of GVCs (globalization to "slowbalization“): the welfare effects from other countries' TFP growth have gained increasing significance in shaping the trade and technology policies.

Literature

(1) Nexus between TFP and welfare

(Basu et al., 2009; Petrin & Levinsohn, 2012; Basu et al., 2022).

(2) Incorporates input-output relationships into the welfare analysis.

(Caliendo & Parro, 2015; Kleinman et al., 2020)

(3) Terms of trade effect

(Diewert & Morrison 1986; Reinsdorf, 2010; Ossa, 2014; Caliendo & Parro, 2015; Feenstra et al., 2015; Lee, 2023)

Contributions

(1) We developed a concise yet potent model investigating the contribution of domestic and foreign TFP growth on welfare growth from the perspective of GVC TFP. The model is based on growth accounting, employing the least assumptions.

(2) We contribute to the literature on terms of trade (TOT) effect by decomposing it into three sub-effects, and further distinguish the domestic GVC contribution from foreign ones.

(3) We endogenized the factor prices as a function of TFP and factor quantities with Armington assumption as a starting point.

Data

We used the WIOD, which covers 56 sectors in 44 countries ranging from 2000 to 2014. It includes the world input–output tables (WIOTs) and social economic accounts (SEAs) , which provide abundant information on output, value-added, intermediate input, labor input, capital input, and price indices at the country-sector level.

Limitation of data:

We are uncertain about the extent to which the price data within the WIOD accurately captures quality change of output, and the variations in how this issue is addressed across different countries remain unclear.

PWT might be used as a supplement in our next step.

Basic Model

Growth of welfare of nations: $\frac{p\Delta c_h}{pc_h}$

Growth of wealth of nations: $\frac{p\Delta y_h}{py_h}$

We assume trade balance of each country:

$$pc_h = py_h \equiv p(\boldsymbol{I} - \boldsymbol{A})x_h \tag{I-2}$$

$$\Rightarrow \frac{p\Delta c_h}{pc_h} = \frac{p\Delta y_h}{py_h} + \frac{\Delta p(y_h - c_h)}{py_h} \tag{I-3}$$

Growth of welfare of nations= GDP effect+ Terms of trade(TOT) effect

Sectoral TFP growth $\dot{\pi}_{hi}$: measures the residual growth of sectoral gross output not accounted for by the growth of intermediate and primary inputs of the sector.

$$\dot{\pi}_{hi} = \frac{\Delta x_{hi}}{x_{hi}} - \sum_{s=1}^{H}\sum_{j=1}^{I} \frac{p_{sj}}{p_{hi}x_{hi}} \Delta\left(a_{sj,hi}x_{hi}\right) - \frac{w_{hi}}{p_{hi}x_{hi}} \Delta(\ell_{hi}x_{hi}) - \frac{r_{hi}}{p_{hi}x_{hi}} \Delta(\kappa_{hi}x_{hi})$$

GVC TFP growth $\dot{\pi}^{G}_{hi}$: measures the residual growth of final products not accounted for by the growth of primary inputs of various sectors within the GVC.

$$\dot{\pi}^{G}_{hi} = \frac{\Delta y_{hi}}{y_{hi}} - \sum_{s=1}^{H}\sum_{j=1}^{I} \frac{r_{sj}}{p_{hi}y_{hi}} \Delta\left(\gamma_{sj,hi}y_{hi}\right) - \sum_{s=1}^{H}\sum_{j=1}^{I} \frac{w_{sj}}{p_{hi}y_{hi}} \Delta\left(\lambda_{sj,hi}y_{hi}\right) \quad \text{(I-5)}$$

Basic Model

Based on the dual measure of GVC TFP, we have

$$\dot{\pi}^G = -(r\Delta\boldsymbol{\gamma} + w\Delta\boldsymbol{\lambda})\hat{p}^{-1} \quad \text{(I-6)}$$

Therefore, (I-5) can be rewritten as

$$\Rightarrow \Delta p = -\dot{\pi}^G\hat{p} + \Delta r\boldsymbol{\gamma} + \Delta w\boldsymbol{\lambda} \quad \text{(I-7)}$$

GVC TFP growth rate can be expressed as a function of world-wide TFP growth sectoral TFP growth rates.

$$\dot{\pi}^G = \dot{\pi}\hat{p}\boldsymbol{B}\hat{p}^{-1}$$

National welfare growth:

$$\frac{p\Delta c_h}{pc_h} = \left[\sum_{i=1}^{I}\left(\frac{p_{hi}x_{hi}}{py_h}\dot{\pi}_{hi}\right) + \sum_{i=1}^{I}\left(\frac{w_{hi}}{py_h}\Delta l_{hi}\right) + \sum_{i=1}^{I}\left(\frac{r_{hi}}{py_h}\Delta k_{hi}\right)\right] + \left[\frac{-\dot{\pi}\hat{p}\boldsymbol{B}(y_h - c_h)}{py_h} + \frac{\Delta r\hat{\kappa}\boldsymbol{B}(y_h - c_h)}{py_h} + \frac{\Delta w\hat{\ell}\boldsymbol{B}(y_h - c_h)}{py_h}\right] \quad \text{(I-12)}$$

World welfare growth:

$$\frac{p\Delta c}{pc} = \sum_{h=1}^{H}\frac{py_h}{py}\left[\sum_{i=1}^{I}\left(\frac{p_{hi}x_{hi}}{py_h}\dot{\pi}_{hi}\right) + \sum_{i=1}^{I}\left(\frac{w_{hi}}{py_h}\Delta l_{hi}\right) + \sum_{i=1}^{I}\left(\frac{r_{hi}}{py_h}\Delta k_{hi}\right)\right] \quad \text{(I-13)}$$

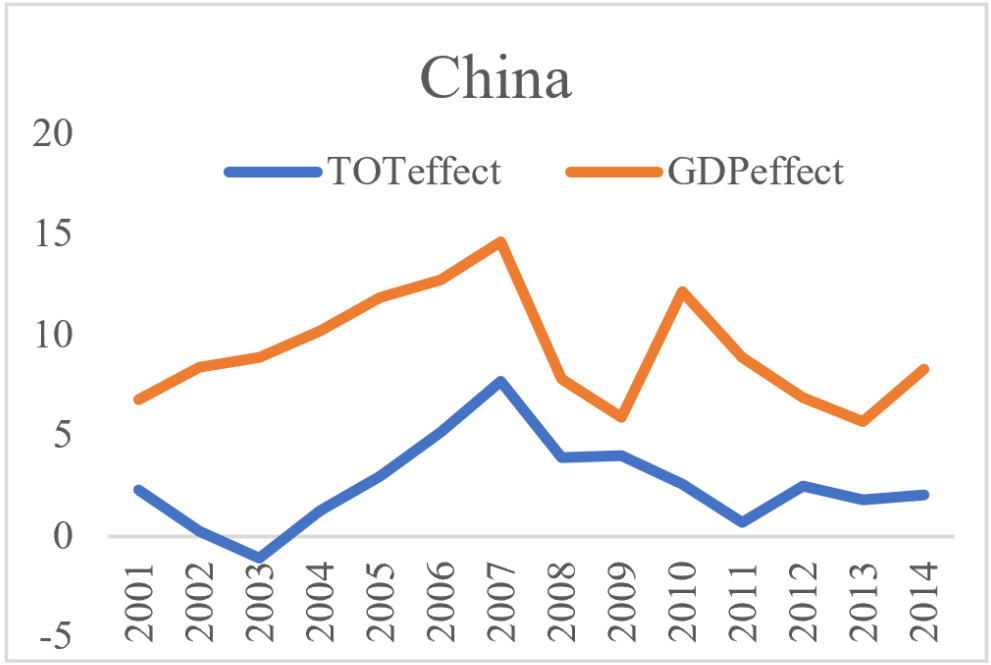
Empirical Evidence

Table 1: Growth of welfare of nations (%)

	CHN			USA		
year	RHS	LHS	Ratio	RHS	LHS	Ratio
2001	9.06	7.79	1.16	2.11	10.02	0.21
2002	8.63	7.70	1.12	1.62	6.90	0.24
2003	7.78	8.48	0.92	1.32	4.66	0.28
2004	11.45	9.08	1.26	1.78	3.06	0.58
2005	14.84	8.64	1.72	1.80	2.16	0.83
2006	17.88	10.83	1.65	1.23	5.50	0.22
2007	22.30	12.70	1.76	-0.21	4.59	-0.05
2008	11.68	9.81	1.19	-2.91	0.15	-19.42
2009	9.87	10.38	0.95	-0.35	-4.11	0.08
2010	14.73	11.71	1.26	0.76	-0.17	-4.36
2011	9.52	10.53	0.90	0.15	-2.39	-0.06
2012	9.39	7.53	1.25	2.93	3.04	0.96
2013	7.48	7.31	1.02	1.12	1.37	0.82
2014	10.32	7.10	1.45	2.39	4.57	0.52

Empirical Evidence

(1) Notably, China witnessed substantial welfare growth from 2001 to 2014, and reaped significant benefits from both the TOT effect and the GDP effect.
(2) However, these benefits began to wane in the aftermath of the 2008 financial crisis. Conversely, the TOT effect in the United States exhibited improvements following the global financial crisis of 2008.
(3) The GDP effect closely mirrors the country's GDP growth. The evolution of the TOT effect may be attributed to growing protectionism and trade tensions.



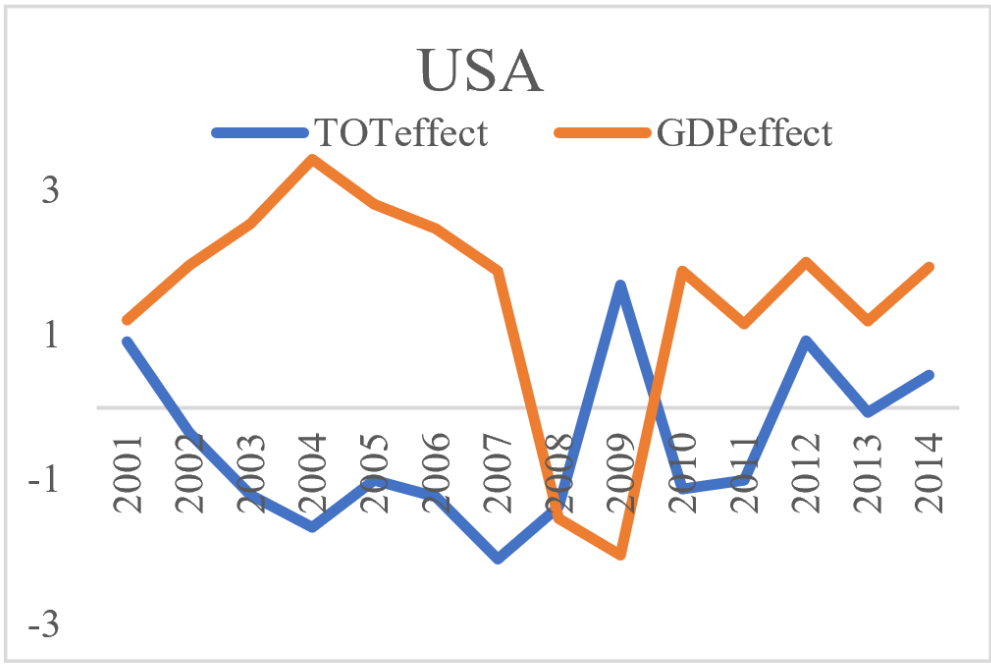


Figure 1: Two components of welfare growth in China and the United States

Empirical Evidence

(1) Notably, China consistently gains substantial benefits from global TFP growth each year, while the United States does not enjoy as significant an advantage in this regard.
(2) Upon conducting a more in-depth investigation into the country origins, it becomes evident that the positive TOT effect in China resulting from global wage change primarily stems from China's wage growth during the sample period.

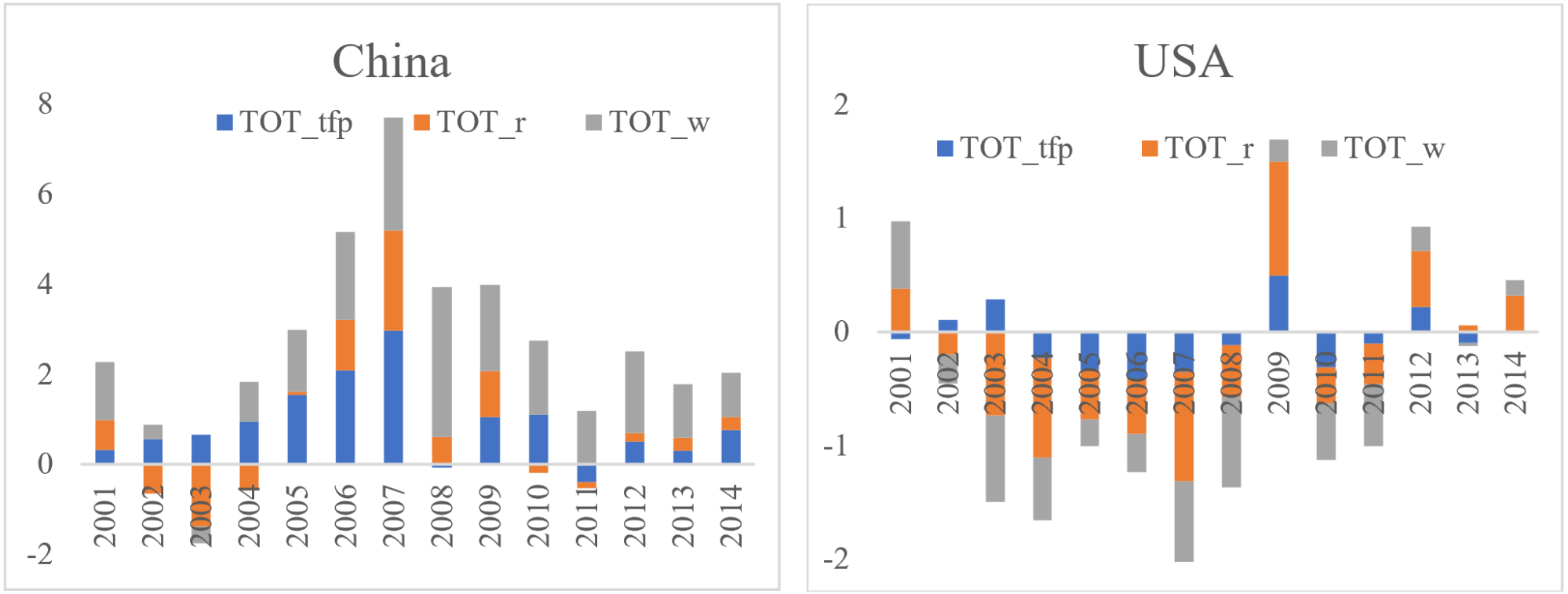


Figure 2: Three components of TOT effect in China and the United States (2001-2014)

Empirical Evidence

Table 2: Country origins of TOT effect (%)

	CHN			USA		
year	USA	JPN	CHN	USA	JPN	CHN
2001	-0.03	0.44	1.67	0.59	0.22	-0.04
2002	-0.05	0.16	1.68	0.69	0.07	-0.04
2003	-0.11	-0.20	2.67	1.07	-0.08	-0.07
2004	-0.06	-0.32	5.02	0.53	-0.10	-0.15
2005	-0.05	-0.03	5.29	0.46	-0.01	-0.18
2006	-0.04	0.12	7.18	0.29	0.04	-0.27
2007	-0.08	-0.07	10.96	0.47	-0.03	-0.47
2008	-0.02	-0.27	5.64	0.10	-0.10	-0.28
2009	-0.01	0.16	1.51	0.05	0.06	-0.09
2010	-0.10	-0.24	4.76	0.53	-0.09	-0.31
2011	-0.05	-0.11	2.52	0.37	-0.04	-0.18
2012	-0.03	-0.02	1.46	0.29	-0.01	-0.12
2013	0.00	0.19	1.64	-0.01	0.11	-0.14
2014	-0.03	0.05	1.56	0.24	0.03	-0.15

Empirical Evidence

Table 3: Country origins of each component of TOT effect (%)

	CHN from USA			USA from CHN		
Year	TOT_tfp	TOT_r	TOT_w	TOT_tfp	TOT_r	TOT_w
2001	0.00	0.00	-0.03	**-0.01**	0.00	-0.03
2002	-0.02	-0.02	-0.02	**-0.02**	0.00	-0.03
2003	-0.03	-0.04	-0.04	**-0.02**	-0.01	-0.04
2004	0.00	-0.01	-0.05	**-0.04**	-0.04	-0.07
2005	0.01	-0.02	-0.04	**-0.07**	-0.04	-0.08
2006	0.01	-0.01	-0.03	**-0.10**	-0.07	-0.11
2007	-0.02	-0.02	-0.04	**-0.15**	-0.16	-0.16
2008	0.01	-0.01	-0.02	**0.00**	-0.06	-0.22
2009	-0.01	0.00	-0.01	**-0.02**	0.02	-0.09
2010	-0.03	-0.04	-0.02	**-0.11**	-0.04	-0.15
2011	-0.01	-0.02	-0.02	**0.01**	-0.04	-0.15
2012	0.00	-0.01	-0.01	**-0.02**	0.02	-0.12
2013	0.01	0.00	-0.01	**-0.02**	-0.02	-0.10
2014	0.00	-0.01	-0.02	**-0.07**	0.00	-0.08

Extended Model (1)

Now we relax our assumption on zero international trade surplus of each country. When international trade is not balanced, ordinary way to measure standard of living is to add real trade surplus to the real final expenditure as a measure of wellbeing.

$$\sum_{h=1}^{H} \frac{py_h}{\sum_{h=1}^{H} py_h} G\dot{D}P_h^e$$

$$= \sum_{h=1}^{H} \frac{p\Delta y_h}{\sum_{h=1}^{H} py_h} + \sum_{h=1}^{H} \frac{\Delta py_h - \Delta pc_h}{\sum_{h=1}^{H} py_h} - \sum_{h=1}^{H} \left(\frac{py_h - pc_h}{pc_h} \right) \frac{\Delta pc_h}{\sum_{h=1}^{H} py_h}$$

$$= \sum_{h=1}^{H} \frac{p\Delta y_h}{\sum_{h=1}^{H} py_h} - \sum_{h=1}^{H} \left(\frac{py_h - pc_h}{pc_h} \right) \frac{\Delta pc_h}{\sum_{h=1}^{H} py_h}$$

(I-17)

Extended Model (2)

As equation (I-12) shows, other things being equal, sectoral TFP growth and factor prices around the globe will affect a nation's welfare. But factor prices, w and r, are endogenously determined by sectoral TFP growth. In order to evaluate total impact of TFP growth, we need to analyze how sectoral TFP growth affects factor prices. We quantitatively analyze this issue by introducing general equilibrium model with an Armington-type assumptions.

$$\Delta x_{sj} = -\sigma_j \dot{p}_{sj} x_{sj} + (\sigma_j - 1) \sum_{h=1}^{H} \sum_{i=1}^{I} \left(x_{sj,hi} \sum_{s=1}^{H} \frac{p_{sj} x_{sj,hi}}{\sum_{s=1}^{H} p_{sj} x_{sj,hi}} \dot{p}_{sj} \right)$$

$$+ \sum_{h=1}^{H} \sum_{i=1}^{I} x_{sj,hi} (\dot{p}_{hi} + \dot{x}_{hi}) + (\sigma_j - 1) \sum_{h=1}^{H} \left(c_{sj,h} \sum_{s=1}^{H} \frac{p_{sj} c_{sj,h}}{\sum_{j=1}^{N} p_{sj} c_{sj,h}} \dot{p}_{sj} \right) + \sum_{h=1}^{H} c_{sj,h} (\dot{pc}_h) \quad \text{(I-31)}$$

From equations, (I-20) and (I-21) and our assumptions on $\Delta w_h / w_h$ and $\Delta r_h / r_h$, we have the following market clearing conditions of labor and capital service market in country h.

$$\sum_{i=1}^{I} w_{hi} \, l_{hi} \dot{l}_{hi} = \sum_{i=1}^{H} w_{hi} \, l_{hi} \dot{p}_{hi} + \sum_{i=1}^{I} w_{hi} \, l_{hi} \dot{x}_{hi} - \sum_{i=1}^{H} w_{hi} \, l_{hi} \dot{w}_h \quad \text{(I-32)}$$

$$\sum_{i=1}^{I} r_{hi} \, k_{hi} \dot{k}_{hi} = \sum_{i=1}^{I} r_{hi} \, k_{hi} \dot{p}_{hi} + \sum_{i=1}^{I} r_{hi} \, k_{hi} \dot{x}_{hi} - \sum_{i=1}^{H} r_{hi} \, k_{hi} \dot{r}_h \quad \text{(I-33)}$$

Findings

(1)China may have gained more from the ascent of global value chains in comparison to the U.S..

(2)Following the global financial crisis of 2008, the significant TOT effect in China began to diminish, whereas the TOT effect in the U.S. exhibited improvements.

(3)Both China and the U.S.' contribution to each other's TOT effect is primarily negative. However, the change in capital prices in China results in a positive TOT effect in the U.S. in many years. This suggests that substantial investments made in China may have generated positive externalities for the U.S. through GVCs.

Future Research

(1) Considering the quality of factors and products, such as working hours and education levels;

(2) Investigating the impact of imports from countries with lower labor costs on national welfare growth, such as the U.S.' increased imports from China;

(3) Accounting for the significant role of FDI by utilizing Input-Output tables that differentiate between domestic and foreign-owned firms.

Thank you for your kind attention!