Terms of Trade and Total Factor Productivity: Empirical evidence from Latin American emerging markets

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Introduction

- In the last decade high terms of trade have boosted economic activity in many emerging market economies
- In the region Mexico, Chile, Peru are among the economies that have benefited from this favorable external environment
- Typically, this economies have experimented a boost in investment in the tradable sector, which have increased potential output, and also TFP.
- How much of the increase in TPF can be linked to high terms of trade?
- In this paper we present a two step procedure to answer this question:
  - First we use a DSGE model $\rightarrow$ to estimated TFP: Signal extraction stage
  - $\{ToT_t, TFP_t\}_{t=0}^{\infty} \rightarrow$ TFP decomposition between domestic and external factors: SVAR stage.
- We use quarterly data for Chile, Mexico and Peru.

Features of the Model

- Our framework follows a standard RBC model for a small open economy similar to Chang and Fernández (2013) and García-Cicco et.al. The model main features are: (2010).
- Imperfect access to international capital markets, which generates an endogenous risk premium, linked to the foreign net debt position .
- Variable capacity utilization. Firms can expand output not only by hiring more workers but also by using capital more intensively, at the cost of accelerating depreciation.
- Permanent productivity shock. Variables in the model are not stationary.

Main equations

- Production function

$$Y_t = a_t \left(U_t K_t\right)^{\alpha} \left(A_t N_t\right)^{1-\alpha} ,$$

- Capital Accumulation

$$K_{t+1} = I_t + (1 - \delta U_t^{\varphi}) K_t - \frac{\psi_K}{2} \left(\frac{K_{t+1}}{K_t} - X \right)^2 K_t ,$$

- Interest rate, country-specific spread, and the risk premium

$$\begin{aligned} R_t &= R_t^* S_t + \psi_D \left(e^{\widetilde{D}_{t+1} - D} - 1 \right) , \\ ln(S_t/S) &= \eta \mathbb{E}_t (ln X_{t+1} + a_{t+1}) , \\ ln(R_t^*/R^*) &= \rho_{r^*} ln(R_{t-1}^*/R^*) + \varepsilon_t^{r^*} , \varepsilon_t^{r^*} \sim N(0, \sigma^{r^*}) , \end{aligned}$$

- Trade Balance

$$Y_t - C_t - I_t = D_t - \frac{D_{t+1}}{R_t} ,$$

Main equations

- Euler equation and labor market equilibrium condition

$$
\begin{aligned}
1 &= \beta E_t\left(R_t \frac{U_{c,t+1}}{U_{c,t}}\right), \\
\tau \upsilon A_{t-1} N_t^{\upsilon-1} &= (1-\alpha)\frac{Y_t}{N_t},
\end{aligned}
$$

where $U_{c,t} = [C_t/A_{t-1} - \tau N_t^{\upsilon}]^{-\sigma}$,

- Investment decision

$$
1+\psi_k \mathbb{E}_t\left(\frac{K_{t+1}}{K_t} - X\right) = \beta \mathbb{E}_t\left\{\frac{U_{c,t+1}}{U_{c,t}}\left[\alpha\frac{Y_{t+1}}{K_t} + 1 - \delta U_{t+1}^{\varphi} + \frac{\psi_k}{2}\left(\left(\frac{K_{t+2}}{K_{t+1}}\right)^2 - X^2\right)\right]\right\},
$$

- Capital utilization decision

$$
\alpha\frac{Y_t}{U_t} = \varphi\delta U_t^{\varphi-1} K_t.
$$

Main equations

The TFP, $a_t\left(A_t\right)^{1-\alpha}$, has to components:

- The permanent productivity shock A_t, that is assumed to follow a random walk in logs:

$$\begin{aligned} lnA_t &= lnA_{t-1} + lnX_t\,, \\ lnX_t &= (1-\rho_x)ln(X) + \rho_x lnX_{t-1} + \varepsilon_t^x\,, \varepsilon_t^x \sim N(0,\sigma^x)\,. \end{aligned}$$

- The transitory productivity shock, a_t, that follows a stationary autoregressive stochastic process in logs:

$$lna_t = \rho_a lna_{t-1} + \varepsilon_t^a\,, \varepsilon_t^a \sim N(0,\sigma^a)\,.$$

- The model is calibrated to reproduce main business cycle features of the three economies analysed.

Moments

Table: Second moments

Statistics : **Mexico**								
		Data				Model		
$\Delta ln(Y)$	$\Delta ln(C)$	$\Delta ln(I)$	$\Delta TB/Y$	$\Delta ln(ToT)$	$\Delta ln(Y)$	$\Delta ln(C)$	$\Delta ln(I)$	$\Delta TB/Y$
Standard deviation (in %)								
1.645	1.981	5.104	1.269	4.874	1.884	1.920	5.791	1.335
Relative S.D w.r.t $\Delta ln(Y)$								
1.000	1.205	3.103	0.772	2.963	1.000	1.019	3.073	0.709
Correlation with $\Delta ln(Y)$								
1.000	0.827	0.742	-0.374	0.255	1.000	0.969	0.905	-0.672
Correlation with $\Delta TB/Y$								
-0.374	-0.431	-0.568	1.000	0.134	-0.672	-0.824	-0.918	1.000
Serial correlation								
0.167	0.181	0.395	0.278	0.150	-0.046	-0.052	-0.063	-0.079

Note: \[1] For Peru, as quarterly data for terms of trade is only available since 1990.I, the second moments in data reported here for this variable covers only the period 1990.2-2013.IV.

Moments

Table: Second moments

Statistics : **Chile**								
Data					Model			
$\Delta ln(Y)$	$\Delta ln(C)$	$\Delta ln(I)$	$\Delta TB/Y$	$\Delta ln(ToT)$	$\Delta ln(Y)$	$\Delta ln(C)$	$\Delta ln(I)$	$\Delta TB/Y$
Standard deviation (in %)								
1.287	1.333	4.471	2.084	4.974	1.285	1.656	4.789	1.812
Relative S.D w.r.t $\Delta ln(Y)$								
1.000	1.036	3.474	1.619	3.865	1.000	1.289	3.727	1.410
Correlation with $\Delta ln(Y)$								
1.000	0.783	0.591	0.030	0.223	1.000	0.763	0.693	-0.301
Correlation with $\Delta TB/Y$								
0.030	-0.149	-0.410	1.000	0.487	-0.301	-0.721	-0.759	1.000
Serial correlation								
0.169	0.384	0.321	0.268	0.484	-0.114	-0.087	-0.076	-0.030

Note: \1 For Peru, as quarterly data for terms of trade is only available since 1990.I, the second moments in data reported here for this variable covers only the period 1990.2-2013.IV.

Moments

Table: Second moments

Statistics : **Peru**								
Data					Model			
$\Delta ln(Y)$	$\Delta ln(C)$	$\Delta ln(I)$	$\Delta TB/Y$	$\Delta ln(ToT)^{\backslash 1}$	$\Delta ln(Y)$	$\Delta ln(C)$	$\Delta ln(I)$	$\Delta TB/Y$
Standard deviation (in %)								
2.909	3.366	10.090	2.104	4.226	2.925	3.534	10.566	2.768
Relative S.D w.r.t $\Delta ln(Y)$								
1.000	1.157	3.469	0.723	1.746	1.000	1.208	3.612	0.946
Correlation with $\Delta ln(Y)$								
1.000	0.790	0.564	-0.276	0.139	1.000	0.888	0.871	-0.611
Correlation with $\Delta TB/Y$								
-0.276	-0.320	-0.350	1.000	0.320	-0.611	-0.878	-0.874	1.000
Serial correlation								
0.360	0.203	0.011	-0.051	0.303	-0.068	-0.090	-0.087	-0.084

Note: \1 For Peru, as quarterly data for terms of trade is only available since 1990.I, the second moments in data reported here for this variable covers only the period 1990.2-2013.IV.

Model ⇒ Data

- The model in its loglinear form can be written, in matricial form, as:

$$\Gamma_0 \mathbf{W}_t + \Gamma_1 \mathbb{E}_t \mathbf{W}_{t+1} + \Gamma_2 \mathbf{W}_{t-1} + \Gamma_\varepsilon \varepsilon_t = 0 \tag{1}$$

  where $\mathbf{W}_t$ includes the set of predetermined and non-predetermined variables, ε_t stands for the shocks of the model, and Γ contain the parameters of the model.

- Next, after solving the modelo we obtain:

$$\mathbf{W}_t = \mathbf{A}\mathbf{W}_{t-1} + \mathbf{B}\varepsilon_t \,. \tag{2}$$

- The observable variables can be writtern in terms of the state variables as follows

$$\mathbf{y}_t = \mathbf{Z}\mathbf{W}_t + \mathbf{d} + u_t \,, \tag{3}$$

  where $\mathbf{Z}$ is conformable matrix, we are ready to represent the state-space form of our system.

Model ⇒ Data

- We use quarterly data of gross domestic product (Y), consumption (C), investment (I), and the trade balance-to-GDP ratio (TBY) for Chile (1996.I to 2013.IV), Mexico (1980.I to 2013.IV) and Peru (1990.I-2013.IV). The map from observable variables to state variables in the model, given by equation in (3), is defined by:

$$\begin{aligned}
\Delta lnY_t &= y_t - y_{t-1} + x_{t-1} + lnX + \varepsilon_t^Y, \\
\Delta lnC_t &= c_t - c_{t-1} + x_{t-1} + lnX + \varepsilon_t^C, \\
\Delta lnI_t &= i_t - i_{t-1} + x_{t-1} + lnX + \varepsilon_t^I, \\
\Delta TBY_t &= tby_t - tby_{t-1} + \varepsilon_t^{TBY}.
\end{aligned}$$

- Given these state-space form of the model, the Kalman filter, jointly with a smoother, allows us to build recursively the estimates for the times series of the total factor productivity, $TFP_t = a_t A_t^{(1-\alpha)}$, based on estimates of the non observable variables a_t and X_t.

Decomposition of TFP: SVAR model

- Next, we use a VAR model for TPF and terms of trade (TOT). We use this model to identify domestic productivity shocks and terms of trade shocks, by considering that domestic shocks do not have a long-run effects on terms of trade, as follows:

$$\begin{bmatrix} \Delta TOT_t \\ \Delta TFP_t \end{bmatrix} = B(L) \begin{bmatrix} \Delta TOT_{t-1} \\ \Delta TFP_{t-1} \end{bmatrix} + C_\varepsilon \begin{bmatrix} \varepsilon_t^{TOT} \\ \varepsilon_t^{TFP} \end{bmatrix},$$

  The identification restriction implies that domestic TFP shocks do not affect terms of trade in the long-run, therefore, the long-run impact matrix $\Theta(1)$, is restricted as follows:

$$\Theta(1) = \lim_{j\to\infty} \left(E_t - E_{t-1}\right) \begin{bmatrix} TOT_{t+j} \\ TFP_{t+j} \end{bmatrix} = \begin{bmatrix} \sum_{s=0}^{s=\infty} \theta_{11}^{(s)} & 0 \\ \sum_{s=0}^{s=\infty} \theta_{21}^{(s)} & \sum_{s=0}^{s=\infty} \theta_{22}^{(s)}. \end{bmatrix}$$

- This assumption takes into account the fact that terms of trade in this economies are mostly driven by exogenous fluctuations in commodity prices.

TFP decomposition

The impact of terms of trade shocks are not negligible in the long run...

Table: VAR results: Variance decomposition of TFP (in %)

Horizon (k)	Chile		Mexico		Peru	
(quarters)	ε_t^{TOT}	ε_t^{TFP}	ε_t^{TOT}	ε_t^{TFP}	ε_t^{TOT}	ε_t^{TFP}
1	1.45	98.55	14.40	85.60	2.43	97.57
2	10.45	89.55	19.63	80.37	8.39	91.61
3	13.62	86.38	19.99	80.01	9.32	90.68
4	14.38	85.62	20.02	79.98	9.43	90.57
10	14.57	85.43	20.02	79.98	9.45	90.55
40	14.57	85.43	20.02	79.98	9.45	90.55

Note: Each figure at horizon k stands for the percentage of the $k-$quarter forecasting error explained by ε_t^{TOT} or ε_t^{TFP} shocks. For Chile the results correspond to a VAR(1), for Mexico to a VAR(2) and a VAR(1) for Peru.

Historical decomposition: Chile

... and in the short run.

Table: TFP decomposition (Average annual growth rate, in %)

Period	Terms of Trade	TFP: DSGE estimation[1] (a)	TFP: Without ε_t^{TOT} shocks[2] (b)	Difference (a) -(b)
Chile, VAR(1)				
1998-2000	5.308	1.191	1.178	0.013
2001-2007	13.086	2.848	2.408	0.440
2008-2013	3.338	1.926	2.087	-0.161
2008	*-12.894*	*1.227*	*2.011*	*-0.784*
2009	*0.953*	*-0.628*	*0.371*	*-0.999*
2010	*23.308*	*3.092*	*1.885*	*1.208*
2011	*3.922*	*3.165*	*2.974*	*0.191*
2012	*-6.341*	*2.276*	*3.000*	*-0.724*
2013	*-2.740*	*1.770*	*2.227*	*-0.457*
1998-2013	5.422	2.117	2.089	0.028
STD(in %)	4.974	1.239	0.884	

\1 Estimates based on stage #1. \2 Estimates based on stage #2.

Historical decomposition: Mexico

Table: TFP decomposition (Average annual growth rate, in %)

Period	Terms of Trade	TFP: DSGE estimation\1 **(a)**	TFP: Without ε_t^{TOT} shocks\2 **(b)**	Difference **(a) -(b)**
Mexico, VAR(2)				
1982-1990	-5.378	0.721	1.144	-0.423
1991-2000	0.319	0.831	0.663	0.168
2001-2007	2.752	1.631	1.206	0.425
2008-2013	-0.317	0.781	0.648	0.133
2008	*1.235*	*0.046*	*-0.331*	*0.377*
2009	*-11.063*	*-2.021*	*-0.848*	*-1.173*
2010	*7.588*	*1.403*	*0.383*	*1.020*
2011	*6.820*	*2.079*	*1.255*	*0.824*
2012	*-3.640*	*1.534*	*1.612*	*-0.077*
2013	*-0.070*	*0.961*	*0.857*	*0.105*
1982-2013	-1.189	0.947	0.900	0.047
STD(in %)	4.857	1.197	0.907	

Historical decomposition: Peru

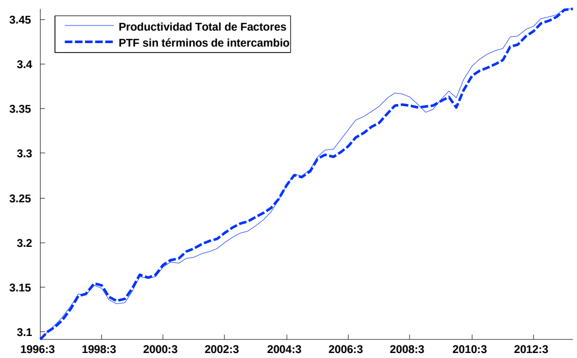
Table: TFP decomposition (Average annual growth rate, in %)

Period	Terms of Trade	TFP: DSGE estimation\1 (a)	TFP: Without ε_t^{TOT} shocks\2 (b)	Difference (a) -(b)
Peru, VAR(1)				
1981-1990	-3.887	-2.405	n.a	
1992-2000	-2.004	2.242	2.655	-0.413
2001-2007	8.060	3.625	2.449	1.176
2008-2013	1.823	2.421	2.331	0.090
2008	*-14.523*	*3.871*	*5.916*	*-2.045*
2009	*-3.095*	*-0.187*	*1.793*	*-1.980*
2010	*18.223*	*5.089*	*2.077*	*3.012*
2011	*5.526*	*3.618*	*2.504*	*1.114*
2012	*-4.957*	*2.473*	*3.377*	*-0.904*
2013	*-4.743*	*1.194*	*1.912*	*-0.719*
1992-2013	1.049	2.634	2.553	0.080
STD(in %)	4.226	2.371	1.998	

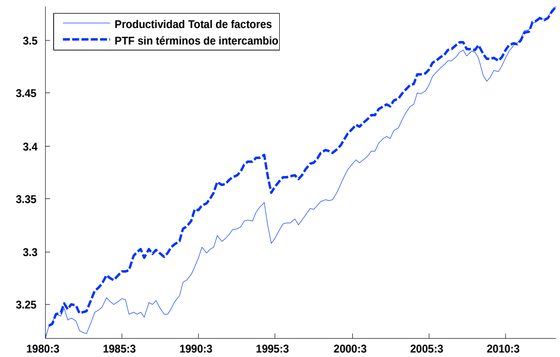
Conclusions

- Empirical results show that terms of trade shocks had indeed generated important gains in TFP for the Chilean, Mexican and Peruvian economy, in during the 2000s .
- The estimation also shows that the periods of negative terms of trade explain an slowdown in TFP growth, in particular during the recession period of 2008-2009.
- Short-run effects seem more predominant than long-run effects. In the long-run, the variance decomposition shows that the terms of trade are more important for Mexico and Chile; whereas for Peru the short-run effects seems more important.
- Extensions,
    - We can explore with the model also the impact of terms of trade shocks on investment and consumption. We require to include two unit roots in the model. We leave this for future work.

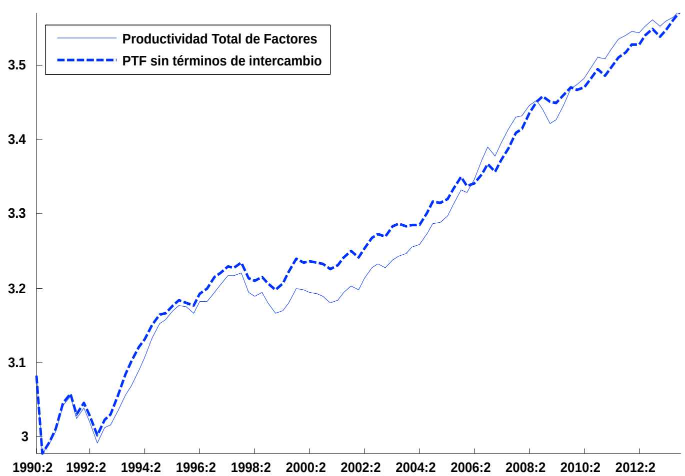
Chile: Logaritmo de la productividad total de factores (1996.II-2013.IV)



México: Logaritmo de la productividad total de factores (1980.II-2013.IV)



Perú: Logaritmo de la productividad total de factores (1990.I-2013.IV)



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