An Exercise on Growth Accounting for Turkey: 1990 - 2009

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Basic formulation I

Let $Y = AF(K, L)$ be the production function where A denotes the total factor productivity (TFP), K capital and L labor.

- Let g_X be growth rate for $X = Y, A, K, L$. Taking logarithms of both sides and deriving with respect to time yields

$$g_Y = g_A + \frac{F'_K K}{Y} g_K + \frac{F'_L L}{Y} g_L$$

F'_K and F'_L are social marginal products of capital and labor. One can compute them using capital and labor prices once the nature of competition is specified. Empirical works assume usually perfect competition. However g_A is unobserved directly. It can be obtained as a *residual*, only if we know all others. This is the original idea of Solow, hence its name: *Solow residual*.

Basic formulation II

- Under perfect competition the production factors are paid their social marginal products: $F'_K = r$ and $F'_L = w$. Defining capital and labor shares by s_K and s_L we have

$$s_K = \frac{rK}{Y} = \frac{F'_K K}{Y}, \quad s_L = \frac{wL}{Y} = \frac{F'_L L}{Y}$$

Then, *Solow residual* (or equivalently *TFPG*) is obtained as

$$g_A = g_Y - \frac{F'_K K}{Y} g_K - \frac{F'_L L}{Y} g_L$$

$$g_A = g_Y - s_K g_K - s_L g_L$$

Remark: s_K and s_L are variable. The only hypothesis is the one of perfect competition. If the production function is Cobb-Douglas, then s_K and s_L would be constant and equal to the exponents of K, L.

Multiple inputs I

- $Y = AF(K_1, K_2, L_1, L_2)$ where 1 may be modern sector and 2 may be traditional sector. TFP may be measured correctly if we have access to the growth rate and their income shares. So the true TFPG is

$$g_A = \frac{\dot{Y}}{Y} - \frac{r_1 K_1}{Y}\frac{\dot{K}_1}{K_1} - \frac{r_2 K_2}{Y}\frac{\dot{K}_2}{K_2} - \frac{w_1 L_1}{Y}\frac{\dot{L}_1}{L_1} - \frac{w_2 L_2}{Y}\frac{\dot{L}_2}{L_2}$$

- What if one uses aggregate shares of K and L? The biased TFPG is given by

$$\tilde{g}_A = \frac{\dot{Y}}{Y} - \frac{r_1 K_1 + r_2 K_2}{Y}\frac{\dot{K}}{K} - \frac{w_1 L_1 + w_2 L_2}{Y}\frac{\dot{L}}{L}$$

Multiple inputs II

and the bias:

$$\tilde{g}_A - g_A = \frac{K_1 K_2}{KY}(r_1 - r_2)\left(\frac{\dot{K}_1}{K_1} - \frac{\dot{K}_2}{K_2}\right) + \frac{L_1 L_2}{LY}(w_1 - w_2)\left(\frac{\dot{L}_1}{L_1} - \frac{\dot{L}_2}{L_2}\right)$$

which is positive if $r_1 > r_2$ and $\dot{K}_1/K_1 > \dot{K}_2/K_2$ (and similarly for labor).

- This will introduce an upward bias if inputs are reallocated from low quality sectors to high quality ones. In Turkey we know that there is a considerable migration from rural areas to urban areas/cities. If urban wage rate, w_1, exceeds rural wage rate, w_2, then using aggregate shares instead of sectoral shares would yield a higher TFPG.

Estimating TFPG

If we assume perfect competition and constant returns to scale:

- If we know K, L, Y and s_K (or s_L)
- Solow residual is given by (in discrete-time formulation)

$$g^A_{t+1} = \log\left(\frac{A_{t+1}}{A_t}\right) \approx \log\left(\frac{Y_{t+1}}{Y_t}\right) - (1-\bar{s}_{Lt}) \log\left(\frac{K_{t+1}}{K_t}\right) - \bar{s}_{Lt} \log\left(\frac{L_{t+1}}{L_t}\right)$$

  with $\bar{s}_{Lt} = [s_{Lt+1} + s_{Lt}]/2$.
- **Required data:** K, s_L, Y, L series

Dual growth accounting I

If factor prices (wages, interest rates) are observed in equilibrium, this alternative may be simpler to use. But, we need some strong assumptions in order to construct the data on quantities of labor, output and capital when we use primal approach.

- Derivation

$$
\begin{aligned}
Y &= rK + wL \\
\Rightarrow \frac{\dot{Y}}{Y} &= \frac{\dot{r}K + r\dot{K}}{Y} + \frac{\dot{w}L + w\dot{L}}{Y} \\
&= s_K \frac{\dot{r}}{r} + s_K \frac{\dot{K}}{K} + s_L \frac{\dot{w}}{w} + s_L \frac{\dot{L}}{L}
\end{aligned}
$$

$$
\Rightarrow \underbrace{\frac{\dot{Y}}{Y} - s_K \frac{\dot{K}}{K} - s_L \frac{\dot{L}}{L}}_{g_P} = \underbrace{s_K \frac{\dot{r}}{r} + s_L \frac{\dot{w}}{w}}_{g_D} \quad (A)
$$

Dual growth accounting II

- **intuition**: rising factor prices (for factors of given quality) can be sustained only if output is increasing for given inputs. So a weighted average of the growth of the factor prices gives TFP growth.
- **Required data:** s_L, r, w series (If we assume perfect competition and constant returns to scale)

Measuring inputs: Capital stock I

- The main difficulty lies in estimating the initial level of capital stock for a given date. Empirical works usually rely on *perpetual inventory method*.
- Given the accumulation function for capital stock

$$K_{t+1} = K_t(1 - \delta) + I_t$$

We need to know I, δ and K_0. National accounts report only I, one needs to guess δ and K_0. Impossible without further hypothesis...

- The idea is to assume that the economy is approximately on its balanced growth path at the beginning of the period under consideration. Then I, Y and K all grow at a constant rate g.

Measuring inputs: Capital stock II

- Using the difference equation for capital accumulation

$$g_{t+1} = \frac{K_{t+1} - K_t}{K_t} = -\delta + \frac{I_t}{K_t} \Rightarrow g_{t+1} + \delta = \frac{I_t}{K_t}$$

Then, assuming the economy on the balanced growth path

$$g + \delta = \frac{I}{K} \Rightarrow K_0 = \frac{I_0}{g + \delta}$$

In practice g is obtained as the average growth rate of the first 5 (or 10) years.

- Example:

$$\Rightarrow K_{1960} = \frac{I_{1960}}{g + \delta}$$

where g is the average growth rate of investment (or GDP) from 1961 to 1970.

Measuring inputs: Capital stock III

- Another parameter to be estimated is δ. The value of δ can be chosen so that the average ratio of *depreciation to GDP* observed in the data (national accounts) is the same as in the generated data, Conesa-Kehoe-Ruhl (2007).

$$\frac{1}{T}\sum_{i=1}^{T}\frac{\delta K_t}{Y_t} = \text{Average depreciation/GDP in national accounts}$$

Measuring inputs: Labor

- Ideally we would like to use "hours worked", but usually we use number of workers because of lack of data...
- Labor is not homogeneous; different education levels make workers heterogeneous with respect to labor productivity. Following Hall-Jones (1999) one can correct for schooling quality.
- H: human capital accumulated by schooling. 1 unit of raw labor L becomes $exp(z\,S)$ units of efficient labor after S years of schooling. So $H = L\,exp(z\,S)$ where z is Mincerian return to schooling. z is a piecewise linear specification (Psacharopoulos, 1994).

Measuring inputs: Factor shares I

- A first way for getting factor shares is regressing g_Y on g_K and g_L. The intercept in this regression would be an estimate of g_A and the coefficients on g_K and g_L give factor shares of capital and labor.
- A second approach widely used in empirical works is computing factor shares directly from national accounts or input-output tables. An adjustment is necessary for self-employment because standard labor share measure ignores the labor income of proprietors and unpaid family workers. Self-employed workers typically earn a mix of capital and labor income which is difficult to decompose.

Measuring inputs: Factor shares II

- According to the income approach to measuring GDP, we have the following

$$Y = W + \Pi + T + \delta K$$

  W: Compensation of employees; Π: Net Operating Surplus (agriculture and others); T: Net indirect taxes (*taxes* − *subsidies*) on production and imports; δK: Consumption of fixed capital.

- Net operating surplus can be seen as “profit” of both incorporated and unincorporated enterprises. But the owners, or other members of their households, work without receiving any wage or salary in the case of unincorporated enterprises. We need to correct for this. This is the idea behind the "Adjusted Labour Share" (ALS): we assume that the share of labor income in

Measuring inputs: Factor shares III

unincorporated sector is the same as its share in the rest of the economy, i.e. self-employed workers earn the same wages as people who work as employees.

- First method: we use operating surplus of private unincorporated enterprises, $OSPUE$ (mixed income in SNA 2008, SNA 1993), in national accounts, as suggested by Gollin (2002):

$$ALS = \frac{W}{Y - T - OSPUE}$$

- Second method: we use self-employment statistics, Gollin (2002):

$$ALS = \frac{W}{Y - T}\frac{N}{L}$$

where L: number of employees and N: total employment.

Measuring inputs: Factor shares IV

- Third method: not all countries report *OSPUE* (or mixed income) separately. For the majority of countries "operating surplus" covers both operating surplus (incorporated enterprises) and mixed income (unincorporated enterprises). Bernanke and Gurkaynak (2001) proposed *impited* OSPUE as a solution. They assume that the corporate share of total private-sector income (operating surplus and corporate employee compensation) is the same as the share of the labor force employed in the corporate sector.

$$impOSPUE = \frac{N - L}{N}(W + \Pi) \Rightarrow ALS = \frac{W}{Y - T - impOSPUE}$$

Results : Penn 7.0 and Barro-Lee (2010) I

- Let $Y = AK^{\alpha}X^{1-\alpha}$, where $X = L, H$
- $H = Le^{zS}$ with S being average years of schooling and z Mincerian return to schooling(Bils and Klenow, 2000).
- S: Average years of schooling (15+ population) comes from Barro-Lee (2010). Original observations has a 5-year interval. A linear approximation is used to generate annual data on human capital.
- Following Hall and Jones (1999) we use

$$z = \begin{cases} 0.135 & \text{if } S \leq 4 \\ 0.101 & \text{if } 4 < S \leq 8 \\ 0.068 & \text{if } S > 8 \end{cases}$$

Results : Penn 7.0 and Barro-Lee (2010) II

- Capital stock is derived using perpetual inventory method (PIM), i.e. $K_{t+1} = K_t(1-\delta) + I_t$ and

$$K_{1960} = \frac{I_{1960}}{g+\delta}$$

  where g is the average growth rate of GDP from 1961 to 1970.
- $\alpha = 1/3$, $\delta = 0.03$ (relatively low depreciation rate, but our results are robust if we use 0.05 instead)
- 120 countries respect data requirements between 1960-2008.
- GDP and investment are measured in PPP (at 2005 constant prices).
- Results:

Results : Penn 7.0 and Barro-Lee (2010) III

country	years	g.S	g.HJ
China	1990s	4.83	3.87
Ireland	1990s	2.97	2.85
Chile	1990s	2.21	1.87
Argentina	1990s	1.86	1.65
India	1990s	1.37	1.59
Taiwan	1990s	2.07	1.49
Italy	1990s	0.16	1.35
Peru	1990s	-0.13	0.93
Poland	1990s	1.20	0.80
Rep. of Korea	1990s	1.40	0.65
Thailand	1990s	1.01	0.49
France	1990s	-0.24	0.45
United States	1990s	0.64	0.42
Israel	1990s	0.65	0.40

Results : Penn 7.0 and Barro-Lee (2010) IV

Finland	1990s	0.28	0.21
Sweden	1990s	0.46	0.05
Portugal	1990s	0.42	0.02
Iran	1990s	1.08	-0.04
Turkey	1990s	0.27	-0.42
Indonesia	1990s	-0.36	-0.97
Hungary	1990s	-0.08	-1.08
Bulgaria	1990s	-1.78	-2.03
Mexico	1990s	-1.39	-2.23
Brazil	1990s	-1.52	-2.80
Romania	1990s	-2.75	-3.04

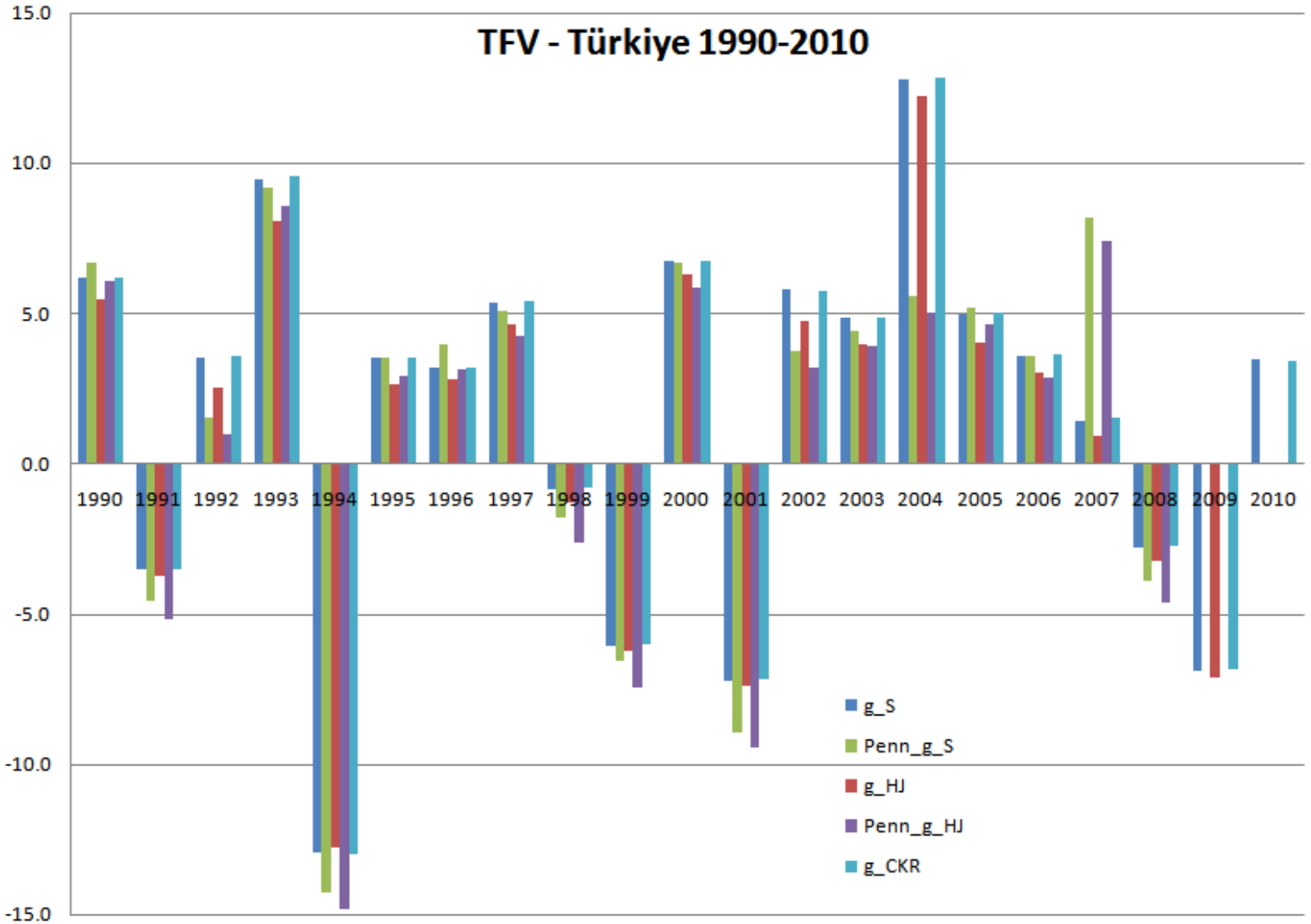
Results : Penn 7.0 and Barro-Lee (2010) V

country	years	g.S	g.HJ
Romania	2000s	6.74	6.54
China	2000s	6.28	5.55
Bulgaria	2000s	5.06	4.82
Peru	2000s	3.03	2.70
India	2000s	3.24	2.62
Poland	2000s	2.75	2.54
Turkey	2000s	2.72	2.08
Mexico	2000s	0.87	2.05
Indonesia	2000s	2.63	1.95
Thailand	2000s	2.47	1.61
Hungary	2000s	1.80	1.53
Rep. of Korea	2000s	1.79	1.42
Argentina	2000s	1.34	1.06
Finland	2000s	1.63	0.86

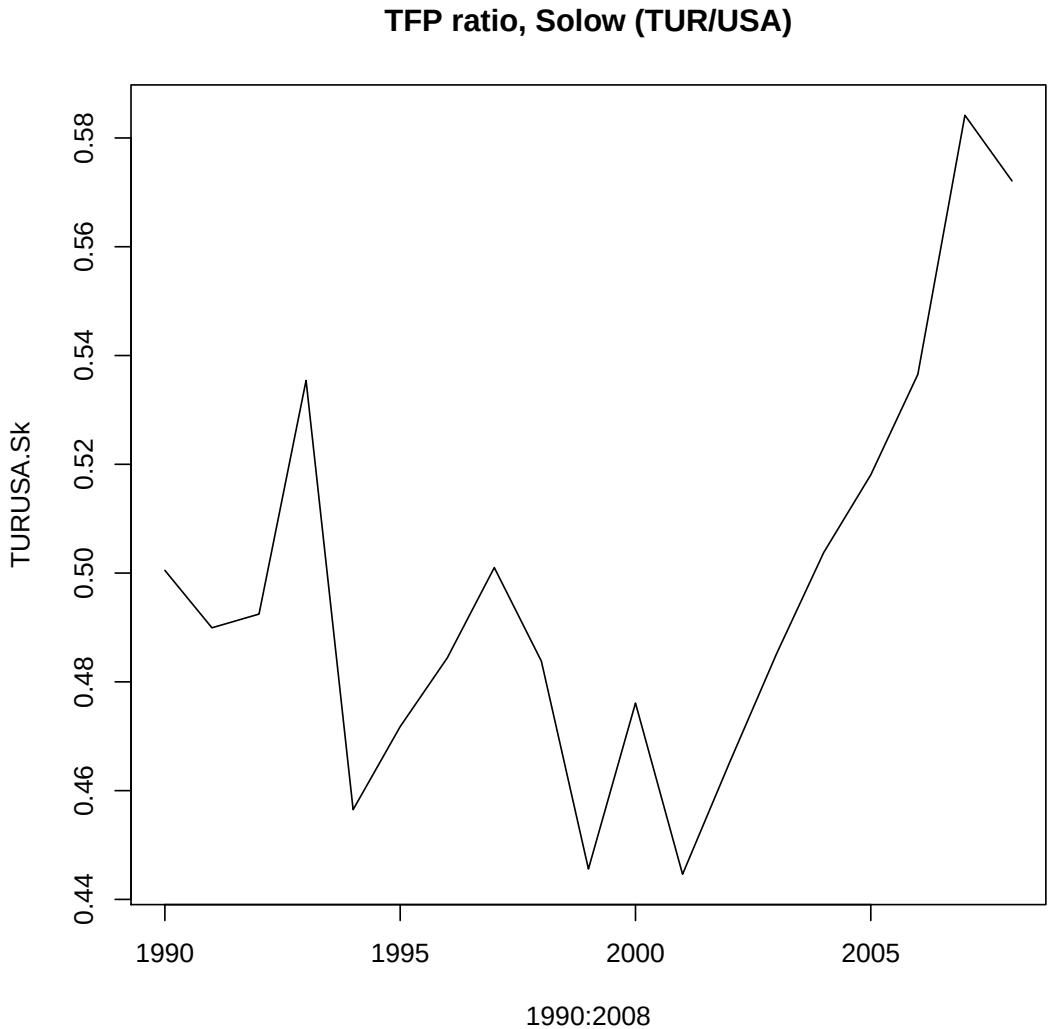
Results : Penn 7.0 and Barro-Lee (2010) VI

Iran	2000s	1.92	0.77
Sweden	2000s	0.96	0.69
Israel	2000s	0.50	0.40
Chile	2000s	0.77	0.28
Brazil	2000s	1.17	0.27
Ireland	2000s	0.53	0.20
United States	2000s	-0.06	0.17
Taiwan	2000s	0.77	0.14
France	2000s	0.37	-0.09
Italy	2000s	-0.61	-1.04
Portugal	2000s	-0.64	-1.06

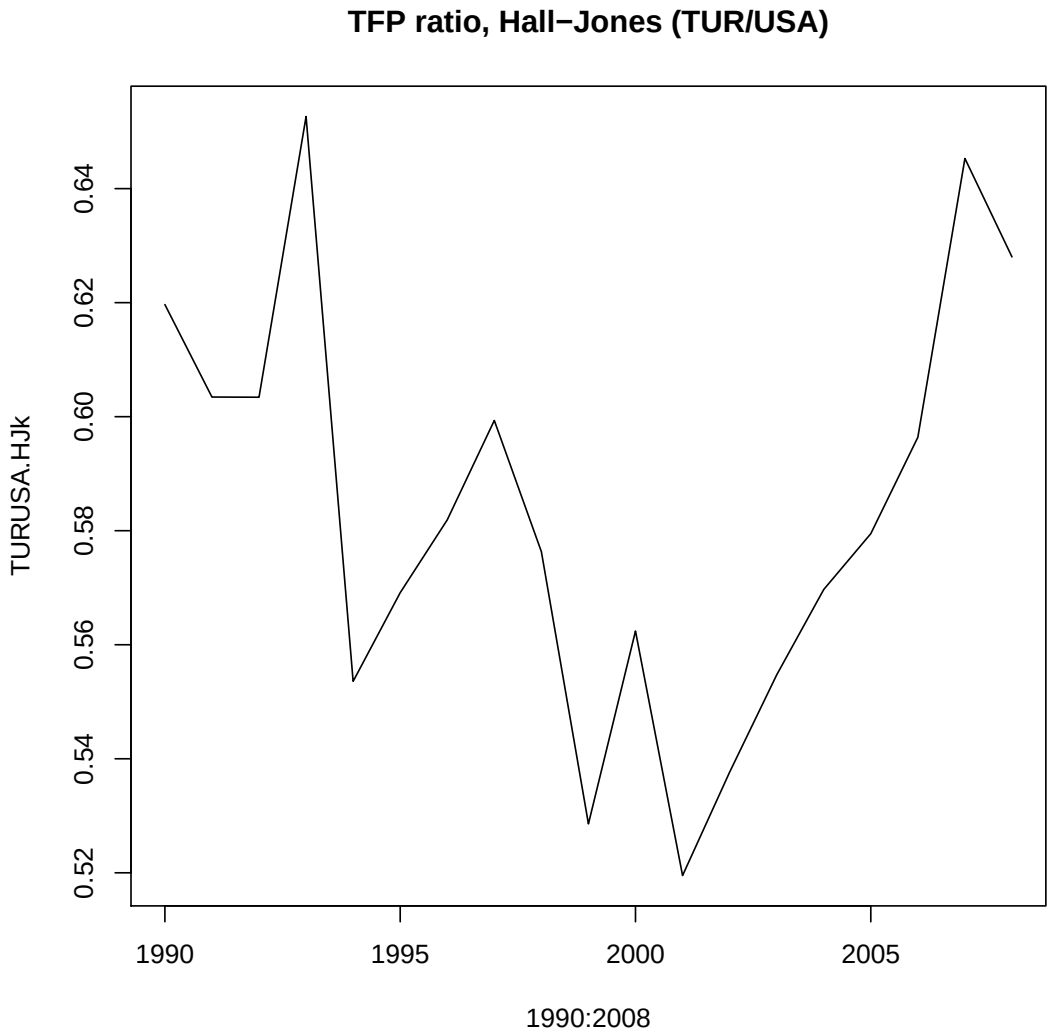
Results : Penn 7.0 and Barro-Lee (2010) VII



Results : Penn 7.0 and Barro-Lee (2010) VIII



Results : Penn 7.0 and Barro-Lee (2010) IX



Results : Turkish Data

Table: TFP in Turkey : different approaches

	g.S	g.S.Penn	g.HJ	g.HJ.Penn	g.CKR
1990-2008	1.78	1.15	1.18	0.47	1.81
1990-1999	0.19	-0.43	-0.37	-1.14	0.21
2000-2008	2.97	2.24	2.31	1.63	3.00
2002-2010	2.51		1.25		2.04

- *g.S* : Standard TFP using Turkish data (Solow)
- *g.S.Penn* : Standard TFP using Penn 7.0 (Solow)
- *g.HJ* : TFP adjusted for human capital using Turkish data (Hall-Jones)
- *g.HJ.Penn* : TFP adjusted for human capital using Penn 7.0 (Hall-Jones)
- *g.CKR* : TFP using Turkish data following Conesa-Kehoe-Ruhl approach.

Results : Sectoral data -Turkey I

- We would like to calculate sectoral capital/labor shares for each sector. We need mixed income (operating surplus of private unincorporated enterprises, *OSPUE*) in each sector/industry to get reliable measures. But, no data...
- Gollin (2002): no systematic differences between rich and poor countries in factor shares. So we use capital share, $\alpha = 0.55$ for AGRICULTURE, $\alpha = 1/3$ for INDUSTRY and SERVICES sectors following Valentinyi and Herrendorf (2008) who measures sectoral income shares for USA.
- Data: GDP by kind of economic activity in constant prices - 1987 and 1998 (TurkStat); Household Labor Force Survey 1988-2010 (TurkStat); Gross Fixed Investments by Sectors 1963-2009 (SPO).

Results : Sectoral data -Turkey II

- For sectoral GDP 1998 based series are used as main source, for previous years the growth rates from 1987 series are used.
- Results:

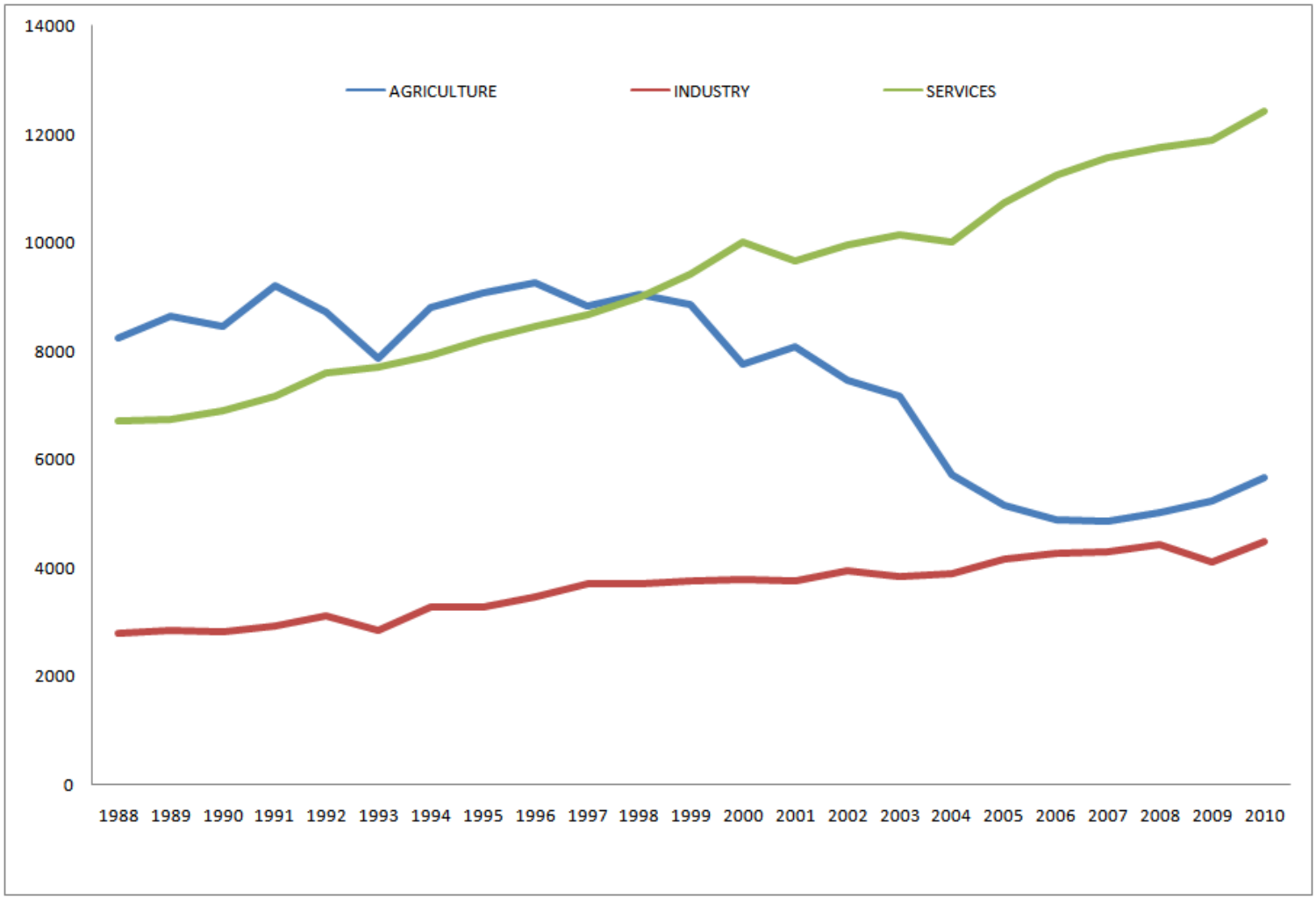
Table: Sectoral TFP

	Agr.S	Ind.S	Ser.S	Agg.HJ	Ind.HJ	Ser.HJ
1990-2009	1.25	0.84	0.03	1.06	0.48	-0.30
1990-1999	-0.63	0.66	-1.09	-0.83	0.32	-1.38
2000-2009	1.94	0.57	1.05	1.67	0.20	0.64
2002-2009	2.43	2.08	1.35	2.12	1.73	1.03

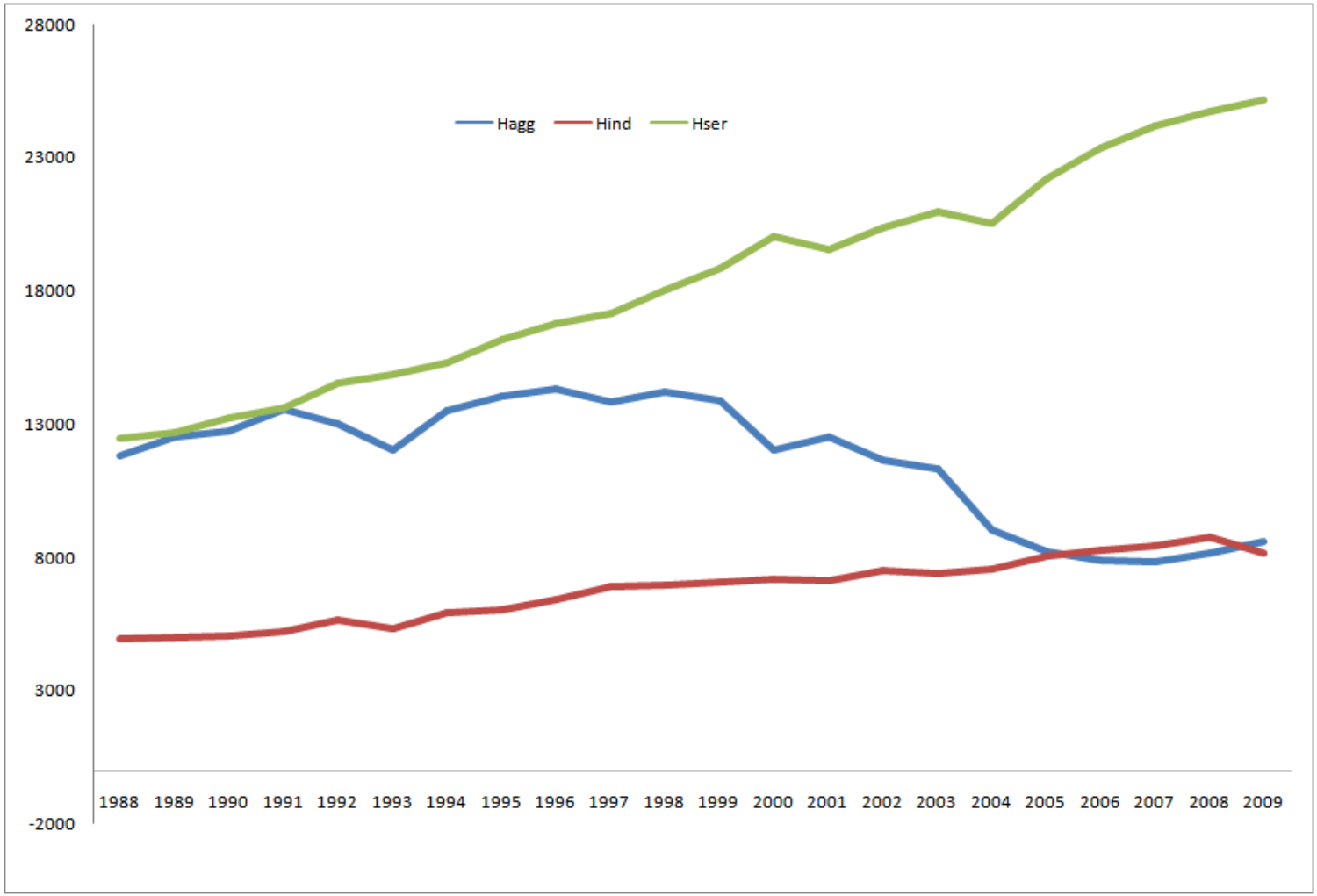
Results : Sectoral data -Turkey III

- These results are qualitatively consistent with previous work by Saygili, Cihan ve Yurtoglu (2005): "Turkiye Ekonomisinde Sermaye Birikimi, Verimlilik ve Buyume: 1972-2003": Increasing TFPG for agriculture, decreasing trend for industry and services.
- Probably hidden unemployment may be helpful in explaining these results. We see an important decrease in agricultural employment without negative effects on sectoral value-added.

Results : Sectoral data -Turkey IV



Results : Sectoral data -Turkey V



Results : Sectoral data -Turkey VI

Average sectoral growth rates				
	Agg	Ind	Ser	Period
g.Y	1.01	4.06	3.57	1990-1999
	1.11	3.20	3.73	2000-2009
g.K	2.57	3.72	7.07	1990-1999
	2.08	6.14	4.10	2000-2009
g.L	0.53	3.22	3.55	1990-1999
	-4.25	0.90	1.94	2000-2009
g.H	0.98	3.74	4.00	1990-1999
	-3.67	1.45	2.56	2000-2009

Some remarks on data I

- SPO provides macro data that is valuable for TFP analysis (Ekonomik ve Sosyal Göstergeler, 1950 - 2010).
- However, sectoral investment and employment data are not compatible to do an industry level TFP.

TABLO 8.10 :	TABLO 2.9 :
İSTİHDAMIN SEKTÖREL DAĞILIMI	SEKTÖRLER İTİBARIYLA SABİT SERMAYE YATIRIMLARI
TARIM-AGRICULTURE	TARIM
SANAYİ-INDUSTRY	
Madencilik-Mining	MADENCİLİK
İmalat Sanayi-Manufacturing	İMALAT
Elektirik,Gaz ve Su-Energy	ENERJİ
HİZMETLER-SERVİCES	ULAŞTIRMA
İnsaat-Construction	TURİZM
Ulaştırma-Transportation	KONUT
Ticaret-Trade	EĞİTİM
Mali Kurumlar-Financial Inst.	SAĞLIK
Diğer Hizmetler-Other Services (2)	DİĞER HİZMETLER

- Input-Output Tables contain detailed information on value added, factor incomes. But...

Some remarks on data II

- To get reliable estimates for factor shares we need either industry level self-employment statistics and/or OSPUE.
- For cross-country studies Penn World Tables are available. However, there may be some problems with Penn data. The following graphic illustrates such an example: big differences in investment shares between national accounts and Penn World Table 7.0

Some remarks on data III