

Dynamic analysis of the constraints to Growth: The Case of Brazil

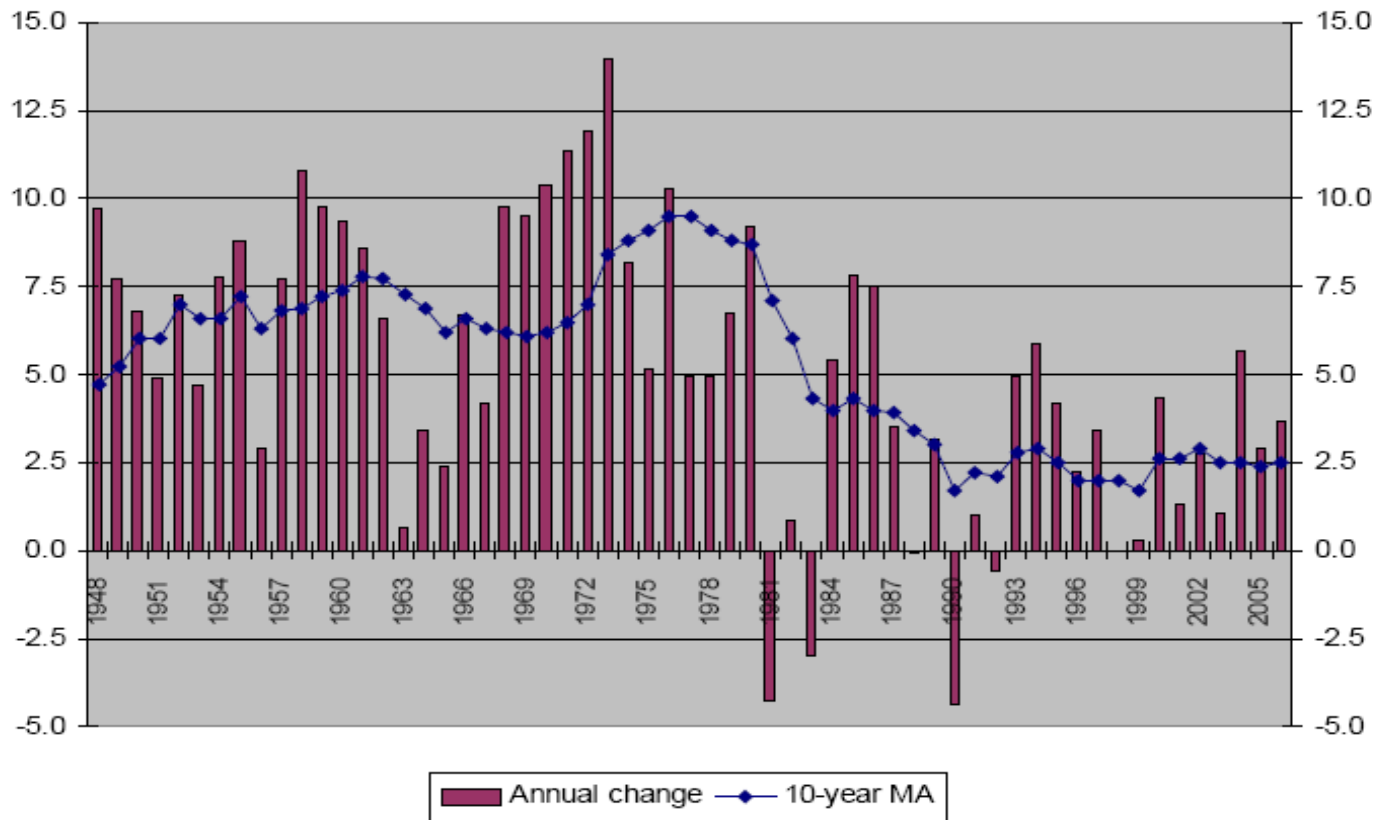
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12/14/09

1. Research problem

Real GDP percent growth, 1950-2005



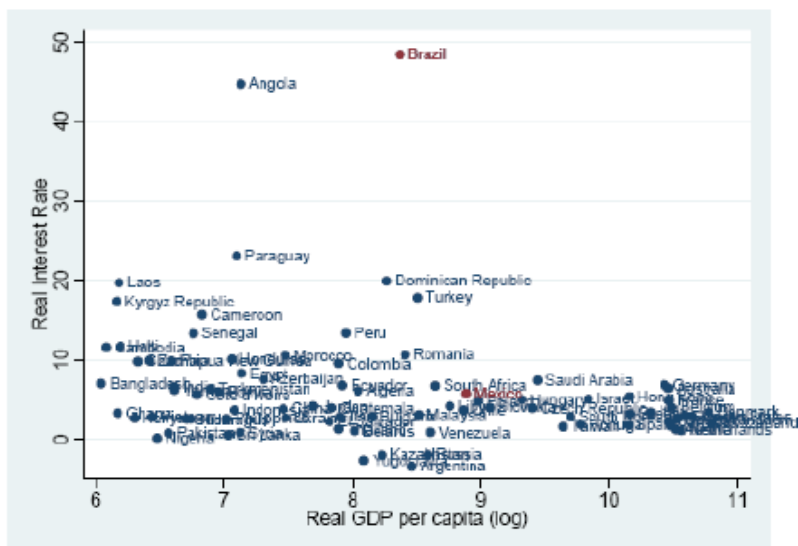
Source: IBGE

Growth Diagnostic: Hausman, Rodrik & Velasco (HRV)

I. Low Domestic Savings

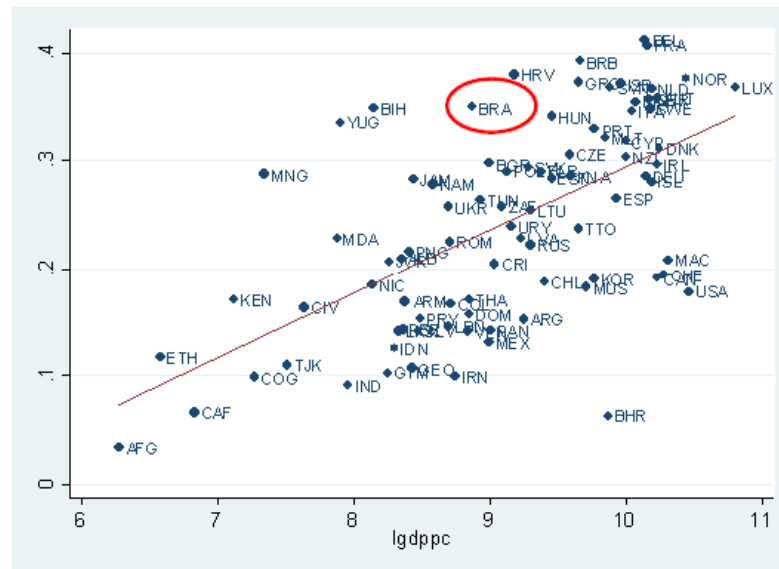
High real interest rates

Real Interest Rates vs GDP per capita, 2005



Source: EIU. Real interest rate is taken as the lending interest rate minus inflation (change in consumer prices).

High tax burden on capital

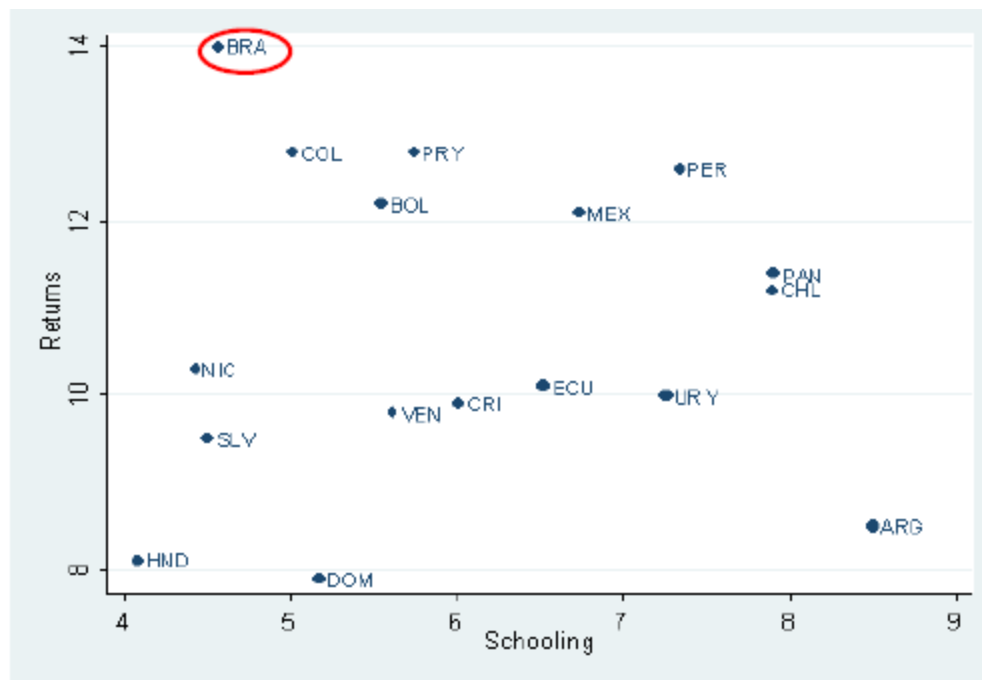


Source: IBPT, WDI and PWT

Growth Diagnostic continues (HRV)

► Low stock of Human Capital

Returns to education and years of schooling



Source: Years of schooling of population age 25 and over are taken from the Barro-Lee dataset. Returns to education are taken from Menezes-Filho (2001).

Inadequate infrastructure: Blyde et al.

Year	1971-1980	1981-1989	1990-94	1995-96	1997-98	1999	2000
Total	23.5	18.0	14.9	17.0	16.4	16.1	16.5
Residential building	4.95	4.71	4.03	3.99	4.24	3.97	3.60
Petroleum	0.95	0.88	0.39	0.35	0.36	0.45	0.51
Public Sector (excludes Transport) ²	3.00	1.43	1.86	1.65	1.68	1.10	1.20
Infrastructure	5.42	3.62	2.16	1.79	2.77	2.70	2.58
Electricity	2.13	1.47	0.85	0.52	0.79	0.77	0.67
Telecommunication	0.80	0.43	0.50	0.66	0.98	1.17	1.07
Transport	2.03	1.48	0.69	0.48	0.68	0.56	0.63
Sanitation	0.46	0.24	0.07	0.13	0.32	0.20	0.21
Others	9.18	7.36	6.46	9.22	7.35	7.88	8.61

Source: Bielschowsky (2002: 25-29).



Dynamics of a multisector Ramsey type model

- ▶ Insight into the dynamics of an economy in transition to long run equilibrium
- ▶ Understand forces of economic growth on structural transformation across multiple sectors.
- ▶ Disaggregated model, fit to data and solves forward and backward.
- ▶ Need for an inter-temporal Ramsey model to measure economy-wide impact of relaxing HRV's constraints to growth.



2. Model: the SAM in 2001 millions USD

SAM of Brazil		Expenditures															
		1. Activities		2. Comm				3. Factors				4. Institu				5. Cap. 6. Fore	
Receipts:		Industry	Ag.	Transport	Services	Industry	Ag.	Transport	Services	K	Lu	Ls	T	HH	KA	WT	TT
1. Activities	Industry					275312										0	275312
	Agriculture						101504									11983	113487
	Transport							27611								0	27611
	Service								471850							0	471850
2. Commod	Industry	123632	11478	8687	41846									73728	27944		287295
	Agricu	4205	38292	125	7748									50843	291		101504
	Transp	4763	2174	3628	5408									11639	0		27611
	Service	42857	18103	3994	82450									264762	61863		471850
3. Factors	K	51007	28493	1771	131177												210448
	Lu	42165	13309	7928	115121												178523
	Ls	6884	1391	1499	88099												97872
	T	0	4248	0	0												4248
4. Institutio	HH									210448	178523	97872	4248				491091
5. Cap. Acc	KA													90119			90119
6. Foreign	1WT					11983	0	0	0								11983
7. Total	TT	275312	113487	27611	471850	287295	101504	27611	471850	210448	178523	97872	4248	491091	90119	11983	

Behavior of households

▶ Infinitely-lived Ramsey household

$$\int_{t \in [0, \infty)} u(q_m, q_a, q_t, q_s) e^{(n-\rho)t} dt$$

▶ Intra-temporal problem:

$$\varepsilon = \mathbf{E}(p_m, p_a, p_t, p_s)q \equiv \min_{q_m, q_a, q_t, q_s} \left\{ \sum_{j=q_m, q_a, q_t, q_s} p_j q_j \mid q \leq u(q_m, q_a, q_t, q_s) \right\}$$

▶ Budget constraint:

$$\dot{k} = \frac{1}{p_k} (w_u l_u + w_s l_s + k r^k (1-\tau) + \pi_a H_a - \mathbf{E}(p_m, p_a, p_t, p_s)q) - k(n + \delta) + \mathbf{T}$$

▶ Euler condition:

$$\frac{\dot{\hat{\varepsilon}}}{\hat{\varepsilon}} = \frac{r^k (1-\tau)}{p_k} - \delta - \rho - x + \frac{\dot{p}_k}{p_k}$$



Firms

- ▶ Manufacture, transportation and service employ technology:

$$\text{Min} \left\{ f^j (A(t)l_{uj}, A(t)l_{sj}, k_j), \frac{\hat{y}_{mj}}{\sigma_{mj}}, \frac{\hat{y}_{aj}}{\sigma_{aj}}, \frac{\hat{y}_{tj}}{\sigma_{tj}}, \frac{\hat{y}_{sj}}{\sigma_{sj}} \right\} \quad j = m, t, s \quad A(t) = e^{xt}$$

- ▶ Total cost functions in units per effective worker:

$$TC_j = \left(C^j(\hat{w}_u, \hat{w}_s, r^k) + \sum_{i=m,a,t,s} \sigma_i \right) \hat{y}_j \quad j = m, t, s.$$

- ▶ Agriculture technology

$$\text{Min} \left\{ f^a (A(t)l_{ua}, A(t)l_{sa}, k_a, \mathbf{B}(t)h_a), \frac{\hat{y}_{ma}}{\sigma_{ma}}, \frac{\hat{y}_{aa}}{\sigma_{aa}}, \frac{\hat{y}_{ta}}{\sigma_{ta}}, \frac{\hat{y}_{sa}}{\sigma_{sa}} \right\}$$

- ▶ Value added function

$$\pi^a(p_{va}, \hat{w}_u, \hat{w}_s, r^k)h_a \equiv \max_{l_{ua}, l_{sa}, k_a} \left\{ p_{va} F^a(l_{ua}, l_{sa}, \hat{k}_a; h_a) - \hat{w}_u l_{ua} - \hat{w}_s l_{sa} - \hat{k} r^k - \pi^a h_a \right\}$$



Equilibrium Characterization

A competitive equilibrium is defined by the positive prices

$\{\hat{w}_u, \hat{w}_s, r^k, p_t, p_s\}_{t \in [0, \infty)}$, households consumption $\{q_m^*, q_a^*, q_t^*, q_s^*\}_{t \in [0, \infty)}$

and production plans

$$\{\hat{y}_m^*, \hat{y}_a^*, \hat{y}_t^*, \hat{y}_s^*, \hat{k}_m^*, \hat{k}_a^*, \hat{k}_t^*, \hat{k}_s^*, l_{um}^*, l_{ua}^*, l_{ut}^*, l_{us}^*, l_{sm}^*, l_{sa}^*, l_{st}^*, l_{ss}^*, \}_{t \in [0, \infty)}$$

given initial endowments $\hat{k}(0), L_u(0), L_s(0), H$ such that,

- ▶ discounted present value of household utility is maximized,
 - ▶ firms maximize profit subject to their technology at each instant of time t ,
 - ▶ markets clear for all inputs and outputs.
-



Inter-temporal equilibrium

We have three differential equations that are linear in the dot variables,

- ▶ Euler equation:

$$\mathbf{E}(p_t, p_s, \dot{p}_s) \equiv \dot{\hat{\varepsilon}} = \hat{\varepsilon} \left(\frac{\tilde{r}(p_t, p_s)}{c^k(p_m, p_a, p_s)} - \delta - \rho - x + \lambda_{sk} \frac{\dot{p}_s}{p_s} \right)$$

- ▶ Budget Constraint:

$$\begin{aligned} \tilde{K}(p_t, p_s, \hat{k}) \equiv \dot{\hat{k}} &= \frac{1}{c^k(p_m, p_a, p_s)} [\tilde{w}^u(p_t, p_s) \ell_u + \tilde{w}^s(p_t, p_s) (\ell_s) + \\ &\hat{k} \tilde{r}(p_t, p_s) + \tilde{\pi}^a(p_t, p_s) h_a - \mathbf{E}(p_m, p_a, p_t, p_s) q] - \hat{k}(n + \delta + x) \end{aligned}$$

- ▶ Home good market clearing:

$$\hat{\varepsilon} = \frac{p_s}{\lambda_s} \left[y_s - \sum_{j \in m, t, s} \sigma_{sj} \tilde{y}^j(p_t, p_s, \hat{k}) - \sigma_{sa} \tilde{y}^a(p_t, p_s) - \tilde{y}^{sk}(p_t, p_s) \left(\dot{\hat{k}} + \hat{k}(x + n + \delta) \right) \right]$$



Comparative statics

- ▶ Stolper-Samuelson like effects
- ▶ Rybczynski-like effects

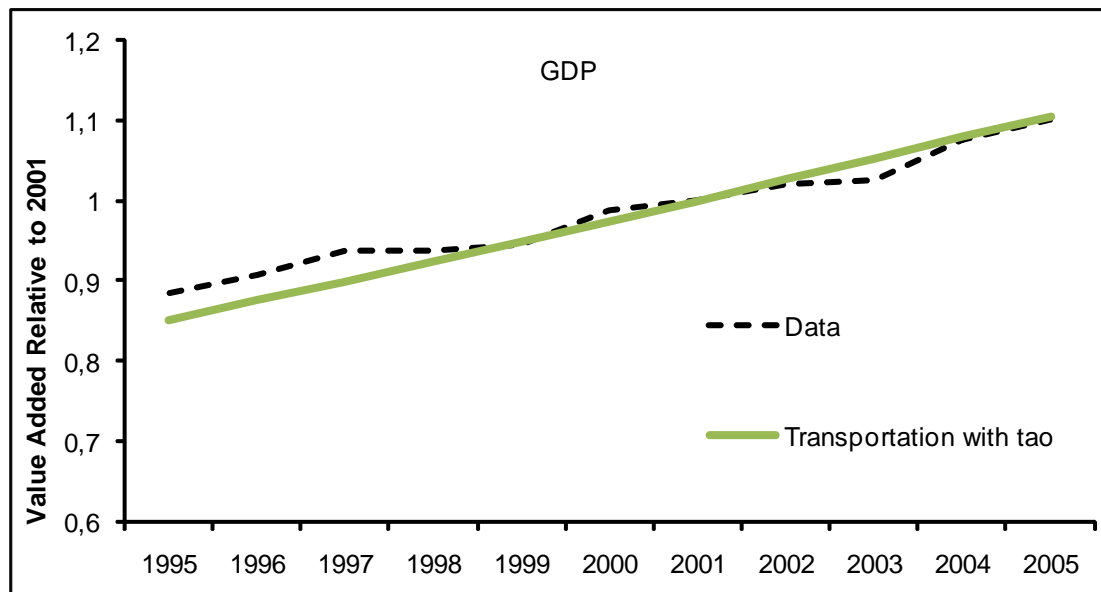
Sector factor Intensities

	Industry	Agriculture	Transp.	Serv
K intensity	1,04	1,40	0,19	0,65
Lu intensity	0,73	0,41	2,42	0,53
Ls intensity	0,07	0,03	0,15	0,36



3. Validation

- ▶ ex-post performance evaluations of applied general equilibrium models are essential if policy makers are to have confidence in the results produced by them (Kehoe 2003).



4 Base Model Results

- ▶ Basic forces of transition
- ▶ Change in economy structure and resource allocation

Year	Sector Share in GDP				Unskilled Labor Share in				Skilled Labor Share in				Capital Share in			
	Industry	Ag.	Transport	Service	Industry	Ag.	Transport	Service	Industry	Ag.	Transport	Service	Industry	Ag.	Transport	Service
1991	0,203	0,109	0,020	0,676	0,205	0,054	0,032	0,528	0,013	0,002	0,002	0,162	0,258	0,111	0,007	0,624
2001	0,183	0,128	0,021	0,668	0,194	0,061	0,034	0,531	0,013	0,003	0,003	0,163	0,242	0,126	0,008	0,625
2011	0,174	0,138	0,021	0,664	0,188	0,065	0,035	0,532	0,012	0,003	0,003	0,163	0,234	0,133	0,008	0,625
2021	0,169	0,142	0,021	0,663	0,185	0,066	0,035	0,532	0,012	0,003	0,003	0,163	0,231	0,136	0,008	0,625
2031	0,167	0,145	0,021	0,662	0,184	0,067	0,036	0,533	0,012	0,003	0,003	0,163	0,229	0,138	0,008	0,625
2041	0,166	0,146	0,021	0,662	0,183	0,068	0,036	0,533	0,012	0,003	0,003	0,163	0,228	0,139	0,008	0,625
2051	0,165	0,146	0,021	0,661	0,183	0,068	0,036	0,533	0,012	0,003	0,003	0,163	0,228	0,139	0,008	0,625
	-	+	=	-	-	+	+	+	-	=	=	+	-	+	=	=



5 Constraints to Growth

▶ Reduce financial tax

TAX Year	Sector Share in GDP				Unskilled Labor Share in				Skilled Labor Share in				Capital Share in			
	Industry	Ag	T	Service	Industry	Ag	T	Service	Industry	Ag	T	Service	Industry	Ag	T	Service
2001	1,001	1,000	0,933	1,002	1,000	1,000	0,970	1,002	0,999	1,000	0,969	1,001	0,999	1,000	0,969	1,001
2011	0,937	1,080	0,940	0,996	0,966	1,066	0,997	1,004	0,963	1,063	0,995	1,002	0,962	1,063	0,994	1,001
2021	0,902	1,118	0,943	0,993	0,948	1,097	1,010	1,005	0,945	1,094	1,007	1,002	0,943	1,092	1,005	1,001
2031	0,883	1,136	0,945	0,992	0,939	1,112	1,016	1,006	0,936	1,108	1,012	1,003	0,934	1,106	1,010	1,001
2041	0,874	1,144	0,946	0,991	0,934	1,120	1,019	1,006	0,931	1,116	1,015	1,003	0,929	1,113	1,013	1,001
2051	0,869	1,149	0,946	0,991	0,932	1,123	1,020	1,006	0,929	1,119	1,016	1,003	0,927	1,117	1,014	1,001
	-	+	+	-	-	+	+	+	-	+	+	+	-	+	+	=



Constraints to Growth

- ▶ Increase country's productivity / skill labor

Compared to baseline results

skill/Base	GDP	GDP growth	Uwage payments	Swage payments	returns to K	land rents	Expenditures
2001	1,003		1,042	0,859	1,003	1,000	1,000
2011	1,011	1,178	1,050	0,866	1,012	1,009	1,007
2021	1,015	1,126	1,054	0,870	1,015	1,015	1,012
2031	1,017	1,081	1,056	0,871	1,017	1,019	1,015
2041	1,017	1,047	1,057	0,872	1,018	1,020	1,016
2051	1,018	1,025	1,057	0,872	1,018	1,021	1,017

Year	Sector Share in GDP				Unskilled Labor Share in				Skilled Labor Share in				Capital Share in			
	Industry	Ag	T	Service	Industry	Ag	T	Service	Industry	Ag	T	Service	Industry	Ag	T	Service
2001	1,0329	0,9568	0,9907	1,0206	0,9923	0,9372	0,9732	0,9564	1,2033	1,1366	1,1801	1,1598	1,0306	0,9735	1,0108	0,9933
2011	1,0231	0,9743	0,9918	1,0193	0,9867	0,9504	0,9787	0,9569	1,1962	1,1522	1,1866	1,1601	1,0244	0,9867	1,0162	0,9935
2021	1,0178	0,9820	0,9923	1,0187	0,9838	0,9563	0,9812	0,9571	1,1926	1,1592	1,1895	1,1602	1,0213	0,9927	1,0186	0,9935
2031	1,0152	0,9855	0,9925	1,0184	0,9825	0,9590	0,9824	0,9572	1,1909	1,1625	1,1908	1,1603	1,0197	0,9954	1,0197	0,9935
2041	1,0139	0,9872	0,9926	1,0182	0,9818	0,9604	0,9830	0,9573	1,1900	1,1641	1,1915	1,1603	1,0190	0,9967	1,0202	0,9935
2051	1,0132	0,9880	0,9927	1,0182	0,9815	0,9610	0,9833	0,9573	1,1896	1,1648	1,1918	1,1603	1,0186	0,9974	1,0205	0,9935
	-	+	+	-	-	+	+	+	-	+	+	+	-	+	+	+



Constraints to Growth

► Increase transport productivity

Year	Sector Share in GDP				Unskilled Labor Share in				Skilled Labor Share in				Capital Share in			
	Industry	Ag	T	Service	Industry	Ag	T	Service	Industry	Ag	T	Service	Industry	Ag	T	Service
2001	1,013	0,979	1,051	0,991	1,012	1,005	0,738	1,012	1,004	0,997	0,732	1,004	1,003	0,996	0,732	1,003
2011	1,003	0,994	1,052	0,990	1,006	1,017	0,743	1,013	0,998	1,009	0,737	1,004	0,996	1,008	0,736	1,003
2021	0,998	1,001	1,052	0,989	1,003	1,023	0,745	1,013	0,994	1,015	0,739	1,004	0,993	1,013	0,738	1,003
2031	0,995	1,004	1,052	0,989	1,001	1,026	0,747	1,013	0,993	1,017	0,740	1,005	0,991	1,016	0,739	1,003
2041	0,994	1,005	1,052	0,989	1,001	1,027	0,747	1,013	0,992	1,019	0,741	1,005	0,991	1,017	0,740	1,003
2051	0,993	1,006	1,052	0,988	1,000	1,028	0,747	1,013	0,992	1,019	0,741	1,005	0,990	1,018	0,740	1,003
	-	+	=	-	-	+	+	=	-	+	+	+	-	+	+	=



THANK YOU

