Productivity: National vs. Domestic

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Warning: The results presented here are very tentative and incomplete!

Motivation

• The Swiss growth puzzle; Kohli (2002b, 2005).
• Switzerland has experienced lower growth than most other Western countries for the past 100 years.
• Knowing that it was a poor country in the 19th century, how come it is today one of the richest countries in the world with a high standard of living?
• There are several possible explanations that come to mind.

• Investment in public and club goods: Switzerland invests a lot in public and club goods (infrastructure, protection of the environment): the resulting returns are not part of GDP, but they increase the quality of life.

• Trading gains: terms-of-trade and real-exchange-rate effects: Switzerland has experienced significant improvements in its terms of trade over the years; these contribute to increase real gross domestic income (GDI), but they are not captured by real GDP; Kohli (2002b, 2004, 2005).

• PPP exchange rates: international comparisons are often made on the basis of PPP exchange rates; these might not fully take quality differences into account; yet, higher quality contributes to welfare.

• Furthermore, even real GDI is an unsatisfactory measure of real income since it does not take net foreign factor income from abroad into account; real GNI is thus to be preferred; Kohli (2005).
Exporting productivity?

- Switzerland has a large current account surplus and a large capital account deficit: it invests large amounts abroad.
- This is often criticized in Switzerland, for foreign investments do not increase productivity in Switzerland.
- These commentators usually mean labour productivity, anyway, which is a poor measure of productivity; Kohli (2010).
- Yes, but so what?
- The name of the game is to maximize national income, not to maximize productivity or domestic production!
Exporting jobs?

• Moreover, say the critics, Swiss foreign investments do not create new jobs in Switzerland.
• It might even destroy some (relocation abroad).
• Yes, but under full employment, relocation might be a win-win situation, with bad jobs being exported and new good jobs being created.

Producing abroad

• Switzerland is a large net international creditor.
• Swiss firms hold foreign direct investments for about 800 billion francs, compared to about 1’200 billion domestically.
• Swiss firms employ about 2.7 million people abroad, compared to about 3.4 million domestically.
• Swiss direct investments capital abroad thus adds significantly to Swiss production possibilities.
TFP: national vs. domestic

- TFP refers to domestic production, not national production.
- National production (income) is more important.
- One needs a national concept of TFP; Kohli (2006).

Net vs. gross

- GNI is a somewhat of a hybrid concept.
- It includes domestic capital income and capital income from abroad.
- But the former is a gross concept whereas the latter is a net concept, i.e. after depreciation.
- Net national income (NNI) is therefore to be preferred.
Figure 2
Real NDP, real NDI, and real NNI
Switzerland, 1991-2010

Figure 3
Capital stocks at home and abroad
Switzerland, 1991-2010
Figure 4
Employment, at home and abroad
Switzerland, 1991-2010

Figure 5
Capital/labour ratios at home and abroad
Switzerland, 1991-2010
Investing abroad

• There are several effects one needs to consider.
• First, more capital obviously increases income: real GNI (NNI) increases, whether the capital is invested at home or abroad.
• Second, assuming that domestic firms use the same technology at home and abroad, investing abroad leads to a more efficient allocation of resources if relative capital intensity is higher at home than abroad.
• Third, other things equal, a leverage effect applies to domestic TFP growth, so that national TFP growth exceeds domestic TFP growth.
• Fourth, an increase in foreign real wages tends to reduce real GNI.

Purpose of this research

• Attempt to derive a national, rather than domestic, measure of TFP.
• To identify the various effects at work, and particularly the TFP leverage effect.
• Major difficulties:
• Incomplete data on foreign production by Swiss firms.
• Caveats: the analysis ignores portfolio income received from the rest of the world, capital income paid to the rest of the world, and net labour income received from the rest of the world; Kohli (1993, 2002a).
2. Preliminary analysis

- Production function approach.
- The Swiss technology abroad is the same as the technology in Switzerland (multinationals tend to export their technology; Markusen).
- The product and its price are the same at home and abroad.
- Cobb-Douglas production function (the elasticity of substitution between labour and capital seems to be close to one in Switzerland; this is not so in the United States, for instance).

Definition of the variables

\[ y \quad \text{domestic output (real NDP)} \]
\[ y^* \quad \text{foreign output by domestic firms} \]
\[ z \quad \text{real net national income (NNI)} \]
\[ k \quad \text{domestic capital stock} \]
\[ k^* \quad \text{domestic capital stock held abroad} \]
\[ \kappa^* \quad \text{real profits received from abroad} \]
\[ n \quad \text{domestic employment} \]
\[ n^* \quad \text{employment by domestic firms abroad} \]
\[ w \quad \text{domestic real wage rate} \]
\[ w^* \quad \text{foreign real wage rate} \]
\[ r \quad \text{real net marginal product of domestic capital} \]
\[ r^* \quad \text{real net marginal product of domestic capital held abroad} \]
\[ t \quad \text{time period} \]

Additional variables will be defined as we go along.
Data

• We have data on $y$, $z$, $k$, $k^*$, $\kappa$, $n$, $n^*$, $w$, $r$, $r^*$, and $t$.
• We do not have data on $y^*$ and $w^*$.
• Difficult to construct, since Swiss firms are probably present in well over 100 countries.
• However, $y^*$ and $w^*$ can be recovered given the assumption that the technology and the output price is the same at home and in the foreign subsidiary.

Domestic production (real NDP):

$$y_t = y(k_t, n_t, t)$$

Domestic TFP growth:

$$Y_{A,t, t-1}^{(L)} = \frac{y(k_{t-1}, n_{t-1}, t)}{y(k_{t-1}, n_{t-1}, t-1)} .$$

$$Y_{A,t, t-1}^{(P)} = \frac{y(k_t, n_t, t)}{y(k_t, n_t, t-1)} .$$

$$Y_{A,t, t-1} = \sqrt{Y_{A,t, t-1}^{(L)} \cdot Y_{A,t, t-1}^{(P)}} .$$
In the Cobb-Douglas case:

\[ y_t = a_t k_t^\alpha n_t^{1-\alpha} \]

\[ Y_{A,t,t-1}^{CD} = \sqrt{Y_{A,t,t-1}^{CD(L)} \cdot Y_{A,t,t-1}^{CD(P)}} = \sqrt{\frac{a_t k_t^\alpha n_t^{1-\alpha}}{a_{t-1} k_{t-1}^\alpha n_{t-1}^{1-\alpha}} \cdot \frac{a_t k_t^\alpha n_t^{1-\alpha}}{a_{t-1} k_{t-1}^\alpha n_{t-1}^{1-\alpha}}} = \frac{a_t}{a_{t-1}}. \]

Estimates of NDP TFP growth (Solow residuals) based on the Cobb-Douglas functional form are reported in Table 1. For comparison purposes we also report in Table 2 estimates based on the Törnqvist index that is exact for a Translog production function:

\[ Y_{A,t,t-1}^{T} = \frac{Y_{t,t-1}^{T}}{Y_{X,t,t-1}^{T}}, \]

where \( Y_{t,t-1} = y_t / y_{t-1} \) and \( Y_{X,t,t-1}^{T} \) is a Törnqvist index of the domestic factor quantities:

\[ Y_{X,t,t-1}^{T} = \exp \left[ \frac{1}{2} (s_{K,t} + s_{N,t}) \ln \frac{x_{K,t}}{x_{K,t-1}} + \frac{1}{2} (s_{N,t} + s_{N,t-1}) \ln \frac{x_{N,t}}{x_{N,t-1}} \right]. \]
Table 1
Domestic TFP
Cobb-Douglas and Törnqvist functional forms, indices
Switzerland, 1991-2010

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<td>1991-2010</td>
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</table>

Production by Swiss firms abroad:

$$y_t^* = y(k_t^*, n_t^*, t) = a_t k_t^* \alpha n_t^* ^{1-\alpha}.$$  

Implied foreign real wage rate:

$$w_t^* = (1 - \alpha) y_t^* / n_t^*.$$  

Real net capital income received from abroad:

$$\kappa_t^* = \alpha y_t^*.$$
Real net national income (NNI):

\[ z_t = y_t + \kappa_t^* = y_t + \alpha y_t^* \]

Potential domestic production if all capital were kept in Switzerland:

\[ \hat{y}_t = a_t (k_t + k_t^*)^\alpha n_t^{1-\alpha} \]

The difference between \( \hat{y}_t \) and \( y_t \) reflects the increase in (domestic) output made possible by the increase in the capital stock; the difference between \( z_t \) and \( \hat{y}_t \) shows the additional efficiency gain that is obtained by investing abroad rather than at home if capital intensity is lower in the rest of the world.

### Table 2
**Domestic and national production**
Cobb-Douglas aggregation, indices
Switzerland, 1991-2010

<table>
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3. Real NNP function approach

Real net national income function:

$$z_t = z(w^*, k_t, k^*, n_t, t) = \max_{y^*, n^*} \left\{ y + y^* - w^* n^* : (y^*, n^*, k_t, k^*, n_t) \in T(t) \right\}$$

where $T(t)$ is the production possibilities set at times $t$. It is assumed to be a convex cone. Domestic and foreign production may be joint or nonjoint.

National TFP:

$$Z^{(L)}_{A,t,t-1} = \frac{z(w^*_{t-1}, k_{t-1}, k^*_{t-1}, n_{t-1}, t)}{z(w^*_{t-1}, k_{t-1}, k^*_{t-1}, n_{t-1}, t-1)}$$

$$Z^{(P)}_{A,t,t-1} = \frac{z(w^*_t, k_t, k^*_t, n_t, t)}{z(w^*_t, k_t, k^*_t, n_t, t-1)}$$

$$Z_{A,t,t-1} = \sqrt{Z^{(L)}_{A,t,t-1} \cdot Z^{(P)}_{A,t,t-1}}$$
3.1 Nonjoint production: Cobb-Douglas production function

\[ z_t = z(w_t^*, k_t, k_t^*, n_t, t) = \max_{y_t, n_t} \{ y + y_t - w_t^* n_t^* : y = a_t k_t^* n_t^{1-\alpha}, \ y_t = a_t k_t^* n_t^{(1-\alpha)} \} \]

\[ = a_t k_t^* n_t^{1-\alpha} + z_t^* (w_t^*, k_t, t) \]

where \( z_t^* = z^*(w_t^*, k_t^*, t) = \max_{n_t} \{ a_t k_t^* n_t^{1-\alpha} - w_t^* n_t^* \} \)

First-order condition:

\[ a_t k_t^* (1-\alpha) n_t^{\alpha} - w_t^* = 0 \]

This yields:

\[ n_t^* = a_t^{1/\alpha} (1-\alpha)^{1/\alpha} w_t^{* - 1/\alpha} k_t^* \]

\[ y_t^* = a_t k_t^* n_t^{1-\alpha} = a_t^{1/\alpha} (1-\alpha)^{(1-\alpha)/\alpha} w_t^{* - (1-\alpha)/\alpha} k_t^* \]

Thus,

\[ z_t = z(w_t^*, k_t, k_t^*, n_t, t) = y_t + \alpha y_t^* = a_t k_t^* n_t^{1-\alpha} + \alpha a_t^{1/\alpha} (1-\alpha)^{(1-\alpha)/\alpha} w_t^{* - (1-\alpha)/\alpha} k_t^* \]
Note the leverage effect that is contained in the second term: national TFP growth is therefore larger than domestic TFP growth (as long as $a_i/a_{i-1} > 1$)! Estimates are reported in Table 3.

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3.2 Joint production

We now relax the assumptions of nonjoint production and of a Cobb-Douglas technology. In the general case, and assuming profit maximization and factor mobility, we have the following first-order conditions:

\[
\frac{\partial \ln z(w^*, k, k^*, n, t)}{\partial \ln w^*} = s_{w^{*,j}}
\]

\[
\frac{\partial \ln z(w^*, k, k^*, n, t)}{\partial \ln k} = s_{k^{,j}}
\]

\[
\frac{\partial \ln z(w^*, k, k^*, n, t)}{\partial \ln k^*} = s_{k^{*,j}}
\]

\[
\frac{\partial \ln z(w^*, k, k^*, n, t)}{\partial \ln n} = s_{n^{,j}}
\]

\[
\frac{\partial \ln z(w^*, k, k^*, n, t)}{\partial t} = \mu_t
\]

where the \( s_{i,j} \)'s are the output and input shares in net national income:

\[
s_{w^{*,j}} = -\frac{w^*_t n_t^*}{z_t^{}} < 0
\]

\[
s_{k^{,j}} = \frac{r_t k^*_t}{z_t^{}} > 0
\]

\[
s_{k^{*,j}} = \frac{r_t k^*_t}{z_t^{}} > 0
\]

\[
s_{n^{,j}} = \frac{w_t n_t}{z_t^{}} > 0
\]

and

\[
\mu = \frac{\partial z_t^{}}{\partial t} > 0 \text{ is the instantaneous rate of growth of nominal national income.}
\]

Note that \( s_{k^{,j}} + s_{k^{*,j}} + s_{n^{,j}} = 1. \)
Following Diwet and Morrison (1986), one can show that the following Törnqvist measure of TFP is exact if the true real net national income function is Translog:

\[ Z_{i,j,t-1} = \frac{Z_{j,t-1}}{Z_{i,t-1}^I \cdot Z_{x,t-1}^I} \]

where:

\[ Z_{i,j,t} = \frac{z_i}{z_{ij,t}} \]

\[ Z_{i}^I = \exp \left[ \frac{1}{2} (s_{i,j} + s_{i,j-1}) \ln \frac{w_i}{w_{ij,t}} \right] \]

and

\[ Z_{x,t-1}^I = \exp \left[ \frac{1}{2} (s_{x,j} + s_{x,j-1}) \ln \frac{k_i}{k_{i,t-1}} + \frac{1}{2} (s_{v,j} + s_{v,j-1}) \ln \frac{k_i}{k_{i,t-1}} + \frac{1}{2} (s_{a,j} + s_{a,j-1}) \ln \frac{n_i}{n_{i,t-1}} \right] \]

Results for domestic and national TFP are shown in Figure 6 and Table 4; the leverage effect is again clearly visible.
An increase in foreign wages has an adverse effect on national income (this is similar to a terms-of-trade effect). Other things equal, the effect can be captured by the following index:

\[ Z_{W^*, t, t-1} = \sqrt{\frac{z(w^*_t, k^*_{t-1}, k^*_t, n_{t-1}, t-1)}{z(w^*_t, k^*_t, k^*_t, n_t, t)} \cdot \frac{z(w^*_t, k^*_t, k^*_t, n_t, t)}{z(w^*_{t-1}, k^*_t, k^*_t, n_{t-1}, t-1)}} \]

One can show that if the true real net national income function is Translog, then \( Z_{W^*, t, t-1}^F \) defined above is an exact measure of \( Z_{W^*, t, t-1} \).
The contributions of capital and labour to real NNI growth can be captured by the following indices:

$$Z_{K,j,t-1} = \sqrt{\frac{z(w_{i,t-1}^o, k_i, k_{i-1}^o, n_{t-1}, t-1)}{z(w_{i,t-1}^o, k_i, k_{i-1}^o, n_{t-1}, t-1)} \cdot \frac{z(w_i^o, k_i, k_i^o, n_t, t)}{z(w_i^o, k_i, k_i^o, n_t, t)}}}$$

$$Z_{K^*,j,t-1} = \sqrt{\frac{z(w_{i,t-1}^o, k_i, k_{i-1}^o, n_{t-1}, t-1)}{z(w_{i,t-1}^o, k_i, k_{i-1}^o, n_{t-1}, t-1)} \cdot \frac{z(w_i^o, k_i, k_i^o, n_t, t)}{z(w_i^o, k_i, k_i^o, n_t, t)}}}$$

$$Z_{N,j,t-1} = \sqrt{\frac{z(w_{i,t-1}^o, k_i, k_{i-1}^o, n_{t-1}, t-1)}{z(w_{i,t-1}^o, k_i, k_{i-1}^o, n_{t-1}, t-1)} \cdot \frac{z(w_i^o, k_i, k_i^o, n_t, t)}{z(w_i^o, k_i, k_i^o, n_t, t)}}}$$

One can show that if the true real NNI function is Translog, then these three factors can be measured exactly by the following indices:

$$Z^T_{i,j,t-1} = \exp\left[\frac{1}{2}(s_{i,j} + s_{i-1,j})\ln\frac{x_{i,j}}{x_{i-1,j}}\right], \ i \in \{K, K^*, N\}, \ x_{i,j} \in \{k_i, k_i^*, n_t\}$$

It can then be seen that:

$$Z^T_{K,j,t-1} = Z^T_{K,j,t-1} \cdot Z^T_{K^*,j,t-1} \cdot Z^T_{N,j,t-1}$$

so that the following gives a complete decomposition of real NNI growth:

$$Z_{j,t-1} = Z^T_{A,j,t-1} \cdot Z^T_{W,j,t-1} \cdot Z^T_{K,j,t-1} \cdot Z^T_{K^*,j,t-1} \cdot Z^T_{N,j,t-1}$$
4. Tentative conclusions

- Over the 1991-2010 period, Swiss national TFP has been growing by about 0.3% more rapidly than Swiss domestic TFP.
- This is made possible by a leverage effect resulting from the ownership of capital abroad.
- In terms of real NNI, this leverage effect can be more than offset by increases in foreign real wages.
- The efficiency gains resulting from investing abroad will, however, remain positive for as long as capital intensity abroad is lower than at home.
References


Thank you for your attention!