Swiss Exports and the Real Exchange Rate: an Empirical Analysis

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The Swiss economy is highly dependent on influences from abroad. Exports account for 39 percent (1987) of Swiss GNP and some industries, such as watchmaking and chemicals, export three-fourths of total output. Particularly in 1978–79, the Swiss National Bank had intervened in foreign exchange markets to counter an appreciation of the Swiss franc which was viewed as harmful to exporters.

Irrespective of whether the Swiss National Bank adheres to a strict money stock target or gives the exchange rate some explicit consideration, it is nonetheless important to know how exchange rates affect the Swiss economy. Furthermore, if the policy's emphasis would be directed to the exchange rate, an estimate of how much Swiss exports respond to a change in the Swiss franc's value is essential to make such a policy successful. For example, if a ten percent increase in exports is the desired result of an intervention, it is necessary to know how much of a franc depreciation is required to elicit this export response. Moreover, the existence of the well-known J-curve effect, or the lag between a currency depreciation and a change in trade flows, means that policy makers must consider as well how quickly exports will respond to an exchange rate change.

Despite the importance of these two questions, however, little empirical research in recent years has been directed to the study of Swiss export demand[1]. Earlier studies point to a relatively low price elasticity (or price-inelastic) export demand[2]. In this article we use an error correction model to estimate the responsiveness both of total Swiss exports and Swiss exports to the U.S. to changes in foreign real income and the real Swiss franc exchange rate. In general, we find the volume of Swiss exports to the U.S. to respond quickly and by a substantial amount to a change in the real value of the Swiss franc. Total export volume, however, is only slightly responsive to changes in the real value of the Swiss franc. In both cases a strong influence of foreign real GNP was found.

Swiss Exports and the Exchange Rate: An Overview

Chart 1 plots real Swiss exports of goods and the real effective exchange rate of the Swiss franc over time. Exports show a trend growth of 3.9% per year in the period of 1973 to 1987, which reflects their rising share of Swiss gross domestic product (GDP) and the increasing integration of developed economies.

One can detect two major troughs in the export time series, the consequences of declining demand during the recessions of 1974 and 1982, respectively. Although the real exchange rate is much more volatile than exports, its time trend clearly indicates that Swiss exporters have had to cope with an appreciating domestic currency since the move to free-floating. During the sample period the real value of the Swiss franc rose by 33% in terms of the currencies of its major trading partners, reflecting not only the weakening of the US-Dollar since the beginning of the seventies but also a modest appreciation of the real Swiss franc vis-à-vis most European currencies.

Swiss exporters consider the real exchange rate an important determinant of their competitive

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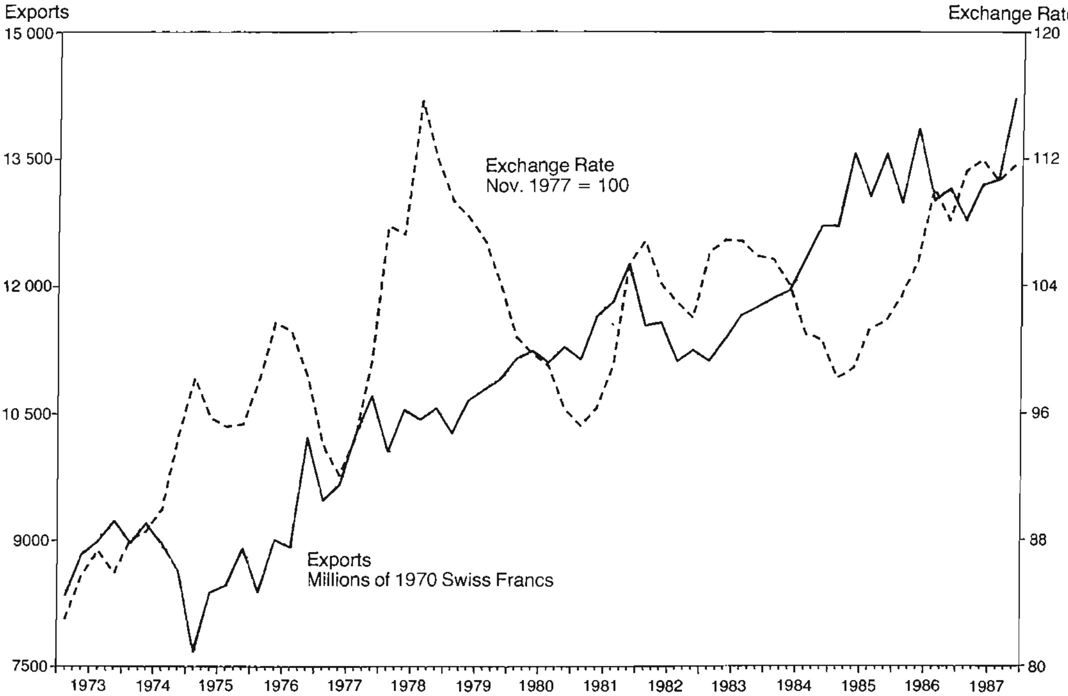
[1] One research effort, however, is that of Büttler and Schips (1987), who included export equations in their study of equilibrium exchange rates. These, however, were not published with the remainder of the study.

[2] See Mattei et al. (1976), Berwert and Kleinewerfers (1977), Ditzler et al. (1980) and Zenger (1982).

Real Swiss Exports and Real Effective Exchange Rate of the Swiss Franc



position. Chart 1 points to a negative relationship between the real effective exchange rate index of the Swiss franc and real Swiss exports. Weak export growth or even declining export volume seems to take place during or after periods of appreciating currency values, whereas relatively strong export growth typically is associated with periods of a depreciating currency. We estimate this relationship more precisely in the next section.

The Reduced-Form Export Equation

The observed quantity of Swiss exports at a moment in time will be determined by the intersection of the demand for Swiss products by foreigners and the supply of Swiss products for export. To derive an estimable export equation, these two functions were specified as simple relationships in a few variables. The demand for exports was assumed to depend on real foreign income, the price of Swiss goods relative to prices in the importing countries and the real exchange rate. Other things the same, higher foreign real income, lower Swiss prices and higher foreign currency values would be associated with a higher quantity of Swiss exports. The supply of Swiss exports is assumed to depend on the prices of Swiss goods produced for export relative to other (nontraded) Swiss goods and a measure of Swiss productive capacity utilisation. Positive relationships between export prices and export supply are expected because, as export prices rise, resources would be shifted into the production of goods for export. Export supply is expected to decrease as production costs increase the higher the level of capacity utilisation. Appendix A discusses the model in greater detail

By setting quantity supplied equal quantity demanded the following reduced form expression for Swiss exports was derived.

(1) $\ln EX_t = a_0 + a_1 \ln FGNP_t + a_2 \ln RER_t + a_3 \ln CAP_t$
where

EX = real Swiss exports of goods (total or to U.S. only)
FGNP = real foreign GNP (non-U.S. foreign or U.S. only)
RER = real Swiss franc exchange rate (trade-weighted index or Sfr/$ only)
CAP = measure of capacity utilization in Switzerland
ln = natural logarithm
a_0-a_3 = coefficients to be estimated

Our empirical analysis used quarterly, seasonally adjusted data over the interval I/1969 – IV/1987. The dependent variable was either real exports to the U.S. only or total Swiss exports; as the export measure was changed, the appropriate measures of foreign GNP and the exchange rate were changed correspondingly to represent the U.S. alone or a trade-weighted index of the 15 most important trading partners. Sources of data used are: Wirtschaftsspiegel (overall exports, capacity utilisation), Monatsbericht der SNB (RER) and the data bases maintained by the Swiss Federal Customs Office (Exports to the United States) and by the Board of Governors of the Federal Reserve System (FGNP). Real exports to the United States were measured by deflating nominal exports with the overall export deflator.

Unit Roots and Cointegration

Chart 1 suggests that real Swiss exports and the real effective exchange rate are not stationary time-series but exhibit some form of trend. Because of that, simply allowing for lags in the variables of equation (1) and estimating it in levels might not be correct under asymptotic theory. In particular, nonstationarity could generate results suggesting relationships among variables that were, in fact, not significant when the model is specified properly. This potential problem led us first to test all variables of our model for unit roots.

The results of these unit root tests are reported in table 1. They indicate that all variables are integrated of order one. This means that they follow a stochastic long-term trend but the first differences of the data are stationary. Since simple economic theory suggests they should share a stable long-term relation, there is a good chance of finding some of them to be cointegrated. That is, they share a stable long-term relationship.

The hypothesis of no cointegration can be tested by estimating equation (1) without allowing for any lags. If there is cointegration, the OLS-regression of (1) will estimate the long-term relationship between them and the residuals will be a stationary (I(0)) time series. A test for unit roots of the residuals gives some evidence that this is in fact the case (Table 2).[3] All coefficients show the expected sign and all, except the real exchange rate in the total exports equation, are highly significant. The estimated values of the long term price elasticity of Swiss exports to the United States and overall exports are .51 and .01 respectively. This result supports the common notion that exchange rate changes do not cause strong reactions in exports.

Although not reported, other estimations indicated that Swiss exports also respond strongly to changes in U.S. real income. For the U.S. alone, a one-percent increase in real income will increase Swiss exports to the U.S. by more than 2.3 percent. In fact, a one-percent increase in U.S. real GNP will raise total Swiss exports by 1.3 percent. More than the exchange rate, these results suggest the health of the U.S. economy is a dominant factor in explaining fluctuations in the volume of Swiss exports.[4] The model explains most of the variation of exports in both cases.

An Error Correction Model

Cointegration implies that the data can be represented by an error correction model. In an error correction model the first difference of the dependent variable is explained by the error term from the cointegrating regression (Table 2) and lagged differences of all variables of the model. Those differences model the short term dynamics. The lag lengths were determined according

[3] The measure of capacity utilization in Switzerland was dropped because the empirical evidence for unit roots is rather weak and it is not very plausible that capacity utilization is an integrated process.

[4] The result shows also that U.S. GNP would be a good proxy for world GNP.

Table 1: Order of Integration of the Variables Considered. Dickey-Fuller t-statistic for Unit Root Hypothesis $\varrho = 0$

$$\Delta X_t = \varrho X_{t-1} + \alpha_0 + \sum_{i=1}^{4} \alpha_i \Delta X_{t-i} + E_t$$

X	Level data ϱ	$t\varrho$	First Differences ϱ	$t\varrho$
Bilatyral case				
Exports	-.018	- .548	-1.135	-3.786***
GNP	.002	.131	- .592	-3.374**
RER	-.097	-1.992	- .487	-2.282
Capacity	-.162	-2.088	- .817	-3.814***
Multilateral case				
Exports	-.023	- .856	-1.157	-3.892***
GNP	-.005	-1.232	- .414	-3.562**
RER	.005	.321	- .799	-3.178*

Critical values:
10%: - 2.6   5%: - 2.93   1%: - 3.58

Table 2: Cointegration Regression and Test of No-Cointegration 1973.01 – 1987.4

	Exports to USA	Overall Exports
Constant	-17.671	- .801
	(-32.194)	(-1.320)
Respective Foreign GNP	2.388	1.151
	(35.069)	(8.745)
Respective Real exchange Rate	.510	.013
	(11.246)	(.205)
corrected r^2	.959	.938
DW	1.080	.600
ADF	-3.412*	-3.388*

Values of parameters are t-values of the coefficients. Critical values are taken from Engle and Yoo (1987) Table 3
* 10% significance

to the final prediction error criterion of Akaike (1973). The estimations show no influence from the variables that are included in the cointegrating regression, but an influence from the measure of Swiss capacity utilization (see Table 3).

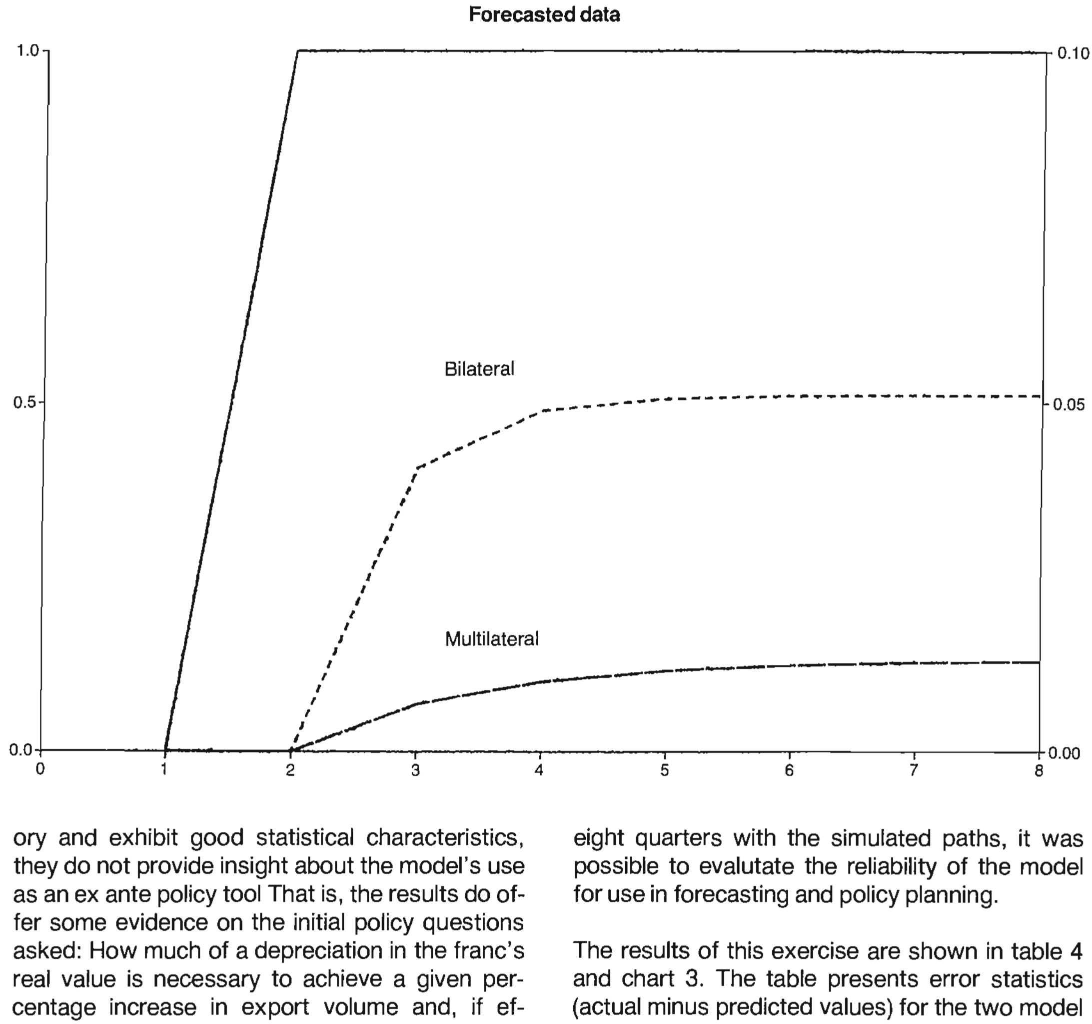
The question of how much and how quickly a move of the real exchange rate affects real exports can be addressed by transforming the error correction model into an equation that relates the real exchange rate to real exports (see appendix B). Figure 2 shows how real exports react to a permanent change in real exchange rates of a given size over time. For example, in the U.S.-Swiss bilateral case, a unit change in the Swiss franc-dollar real exchange rate causes a one-half unit response in export volume by the end of four quarters and that no further effect is realized after four quarters of adjustment. The figure also shows that exports to the United States react much more strongly and quickly to the exchange rate change than overall exports. In both cases, however, most of the reaction takes place within one year of the change.

Out of Sample Performance

Although the results reported in table 2 are in agreement with the predictions of economic the-

Table 3: Error Correction Model 1975.01 – 1987.04

	Exports to USA	Overall Exports
Constant	.009	.007
	(1.338)	(2.018)
Residual	- .797	- .522
	(-6.570)	(-5.005)
DLCAP (-1)	- .441	.422
	(-1.059)	(1.832)
DLCAP (-2)	1.681	.641
	(4.222)	(2.784)
corrected r^2	.503	.349
DW	1.646	2.011



ory and exhibit good statistical characteristics, they do not provide insight about the model's use as an ex ante policy tool That is, the results do offer some evidence on the initial policy questions asked: How much of a depreciation in the franc's real value is necessary to achieve a given percentage increase in export volume and, if effected, how much time would elapse between the depreciation and its full impact on exports? The results, however, do not reveal whether predictions of future export response to exchange rate changes are reliable for policy analysis. To make this judgment, analysis of the model's out of sample performance is required.

This analysis was performed by re-estimating equation (1) with data terminating at IV/1985. Using these new coefficients and actual values for the explanatory variables over I/1986-IV/1987, simulated ex ante paths for total exports and exports to the U.S. were constructed. Then, by comparing the actual paths of exports over these eight quarters with the simulated paths, it was possible to evalutate the reliability of the model for use in forecasting and policy planning.

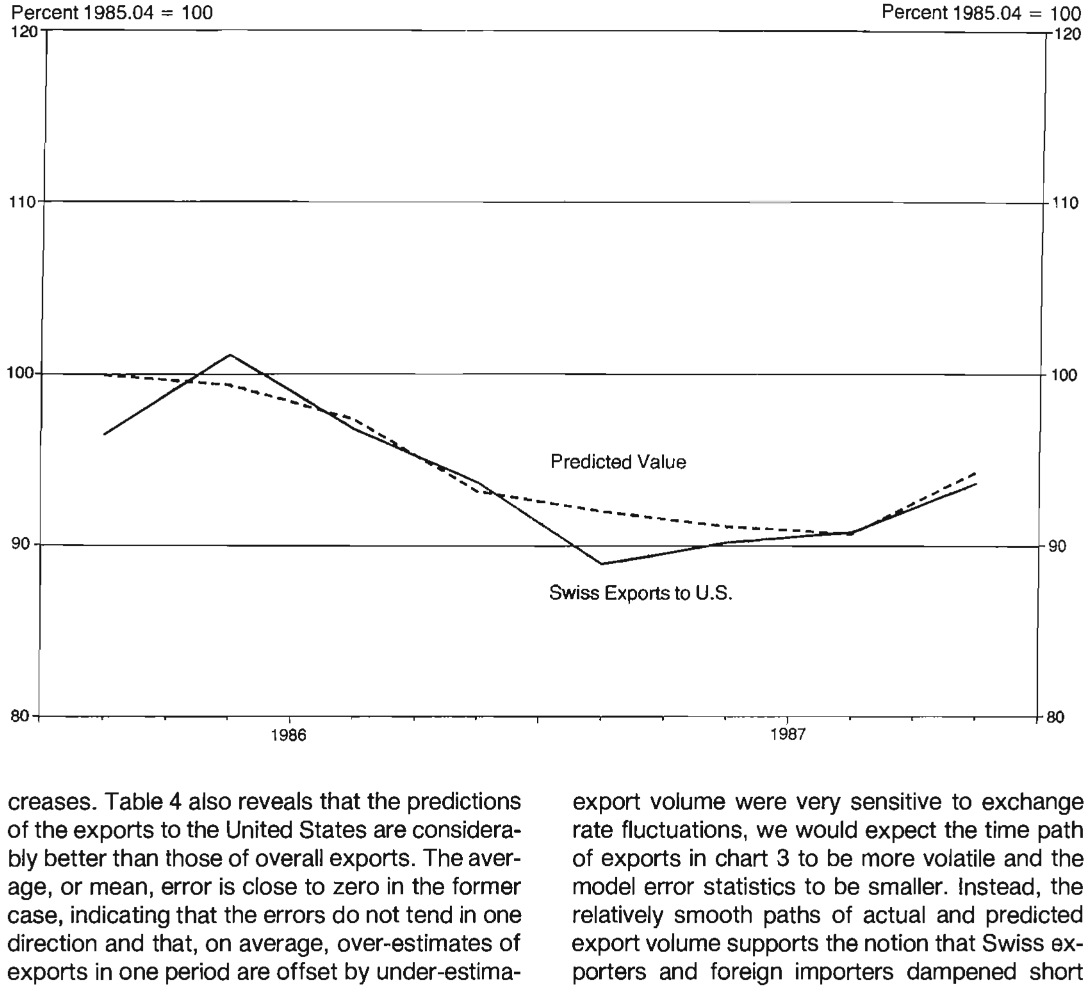
The results of this exercise are shown in table 4 and chart 3. The table presents error statistics (actual minus predicted values) for the two model simulations while the chart plots the actual and projected series.

In both cases the error of the forecast does not seem to increase as the forecasting horizon in-

Table 4: Summary error statistics for out-of-sample Swiss export projections, I/1985 – IV/1986 in percent

Model	Mean Error	Root mean Squared Error (RMSE)
Export to U.S.	.87	1.93
Total Swiss Exports	5.17	5.99

Actual and Predicted Swiss Exports to U.S.



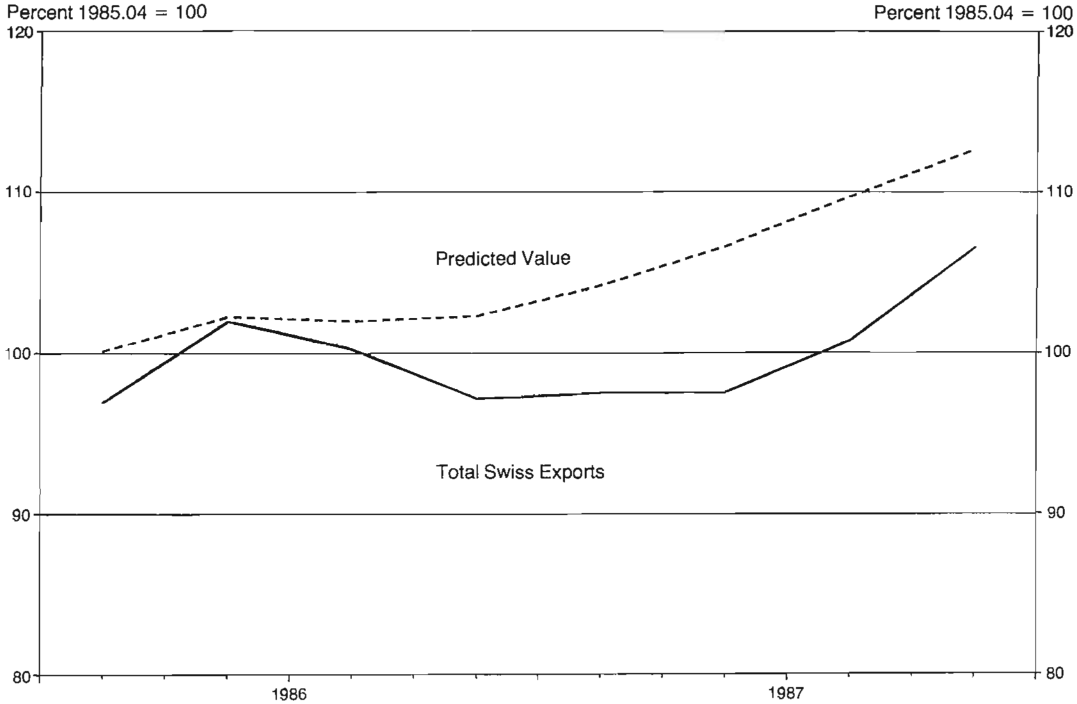
creases. Table 4 also reveals that the predictions of the exports to the United States are considerably better than those of overall exports. The average, or mean, error is close to zero in the former case, indicating that the errors do not tend in one direction and that, on average, over-estimates of exports in one period are offset by under-estimates in another. The forecasts for overall exports, however, seem to be biased upward. The root mean square error, which measures the dispersion of the simulation error irrespective of its direction, is larger than the mean error in both cases. Again the bilateral model performs better relative to this criterion as its RMSE is about one third the value generated by the model for total exports.

The test of the model with this simulation suggests that the real exchange rate, even if it could be chosen by discretion, would hardly be an appropriate instrument to control overall Swiss exports with any precision. The reasoning is this. If export volume were very sensitive to exchange rate fluctuations, we would expect the time path of exports in chart 3 to be more volatile and the model error statistics to be smaller. Instead, the relatively smooth paths of actual and predicted export volume supports the notion that Swiss exporters and foreign importers dampened short term variability of real exports by adjusting their profit margins in the 85–87 period. This pricing behavior would weaken the exchange rate effect on exports and account partly for the weak performance of the model in explaining recent data.

Conclusions

A simple error-correction model of real Swiss exports explains a substantial portion of the variation in total Swiss exports and exports to the U.S. The in-sample estimation indicated a strong export response to changes in the franc's real value in the bilateral case but a weak response of over-

Actual and Predicted Total Swiss Exports



all exports. In both cases a strong influence of foreign real GNP was found. Out-of-sample simulations, however, suggest that, even if the real exchange rate could be chosen by discretion, it would be an inappropriate instrument to control Swiss exports.

References

Batten, Dallas S. and Thornton, Daniel L. "How Robust Are The Policy Conclusions of the St. Louis Equation? Some Further Results", Federal Reserve Bank of St. Louis Review (June/July 1984), pp26–32.

Berwert, Peter and Kleinewerfers, Henner: Empirische Untersuchungen über die schweizerische Wettbewerbsfähigkeit und Aussenhandelsstruktur 1967 bis 1977, Bern, 1977.

Büttler, Hansjürg and Schips, Bernd: Equilibrium Exchange rates in a Multi-Country Model: An Econometric Study, Weltwirtschaftliches Archiv, 1987.

Ditzler, Christoph; Koellreuter, Christoph and Kugler, Peter: Einige empirische Ergebnisse bezüglich des Einflusses des Wechselkurses auf die schweizerische verarbeitende Industrie, in Schweizerische Zeitschrift für Volkswirtschaft und Statistik, 1980.

Engle, Robert F. and Yoo, Byung Sam: "Forecasting and Testing Co-Integrated Systems", Journal of Econometrics, 1987, pp. 143–159.

Goldstein, Morris and Moshin S. Khan. "The Supply and Demand for Exports: A Simultaneous Approach" Review of Economics and Statistics (May 1978), pp. 275–86.

Mattei, A., Rossi, A., Schiltknecht, K., Zweifel P.: Konjunktur 1950-1970. Eine ökonometrische Analyse schweizerischer Wirtschaft, Arbeitspapier 76/3 of the Institut für Wirtschaftsforschung at the Swiss federal Institute of Technology 1976.

Swiss National Bank: Monatsbericht, several issues

Der Wirtschaftsspiegel, several issues

Zenger, Christoph: Volkswirtschaftliche Wirkungen von Wechselkursänderungen, Bern 1982.

Appendix A

The reduced-form equation estimated in the text is based on earlier work by Goldstein and Khan (1978). For reference purposes, their derivations, with minor changes, are repeated below.

The demand for Swiss exports takes the form

(2) $\ln Q^d = a_0 + a_1 \ln (PX/PF) + a_2 \ln Y + a_3 \ln E$

Q^d = the quantity of exports demanded

PX = the price of Swiss exports
PF = the price of export goods in foreign countries
Y = foreign real income
E = the exchange rate (Price of foreign currency)

a_0 through a_3 are coefficients to be estimated

Because the model is written in logarithms, the a_i coefficients can be read as elasticities. The relative price elasticity, a_1, is expected to be negative: as Swiss export prices rise relative to prices in the potential importing countries, the quantity of exports will fall. The income (a_2) and exchange rate (a_3) elasticities are expected to be positive: as foreign incomes or the values of foreign currencies rise, the volume of Swiss exports should rise and vice versa.

The supply of Swiss exports is represented by:

(3) $\ln Q^s = B_0 + B_1 \ln(PX/P) + B_2 \ln CAP$

where:

Qs = quantity of Swiss exports supplied
P = Swiss domestic price index
CAP = a measure of Swiss capacity utilization.

B_1 and B_2 are coefficients to be estimated.

In this expression, B_1 is expected to be positive and B_2 to be negative. More goods will be offered for export as the price of goods sold for export rises relative to the price of goods sold domestically and as Swiss firms face an increase in idle capacity. It should be noted at this point that many export studies avoid the issue of specifying an export supply function by assuming that it is infinitely elastic. As Goldsein and Khan noted, this may be a reasonable assumption for world trade but not for the case of a single country that faces capacity constraints. Thus, the extra steps involved to specify a supply function and derive a reduced form are taken with this issue in mind.

Equation (3) can be solved for PX and then, with this result, a reduced form with quantity as the dependent variable is obtainable. We have, from (3):

(4) $\ln PX = b_0 + b_1 \ln Qs + b_2 \ln CAP + b_3 \ln P$

where:

$b_0 = -B_0/B_1$
$b_1 = 1/B_1$
$b_2 = -B_2/B_1$
$b_3 = 1$

Inserting equation (4) into (2) and solving yields:

(5) $\ln Q = (a_0+a_1b_0)/K - (a_1/K)\ln PF + (a_2/K)\ln Y + (a_1b_2/K)\ln CAP + (a_1b_3/K)\ln P + (a_3/K)\ln E$

where $K = 1 - a_1b_1$

Assuming $a_1 = -a_3$ the quantity of Swiss exports can be represented as a function of foreign income, the real exchange rate and Swiss productive capacity utilization:

(6) $\ln Q = (a_0\ a_1b_0)/K+(a_2/K)\ \ln Y+(a_1/K)\ \ln(P/(PF\ E))+(a_1b_2/K)\ln CAP.$

Appendix B

If the variables determining real exports in our model are exogenous. Then

(7) $(1\text{-}B)\ EX = \beta + \rho\ B\ (EX - \alpha_0 - \alpha_1\ RER - \alpha_2\ FGNP) + (1\text{-}B) \sum_{i=0}^{I} B^i\ CAP,$

(where B is the lag-operator; EX, RER, FGNP and CAP are logs of real exports, real exchange rate, foreign GNP and capacity utilization respectively and greek letters denote coefficients,) is the only relationship that exists between the variables. Assume the exogenous variables either are controlled by some agent or are non-autocorrelated random variables. Since we are interested in the reaction of real exports on variation in the real exchange rate, we set all coefficients except ρ and α_1 to zero. Then (7) simplifies to

(8) $(1\text{-}B)\ EX = \rho\ (B \cdot EX - \alpha_1\ B \cdot RER).$
Solving (8) for EX leads to the simulation equation (9):

$$(9)\ EX = -\rho\alpha_1 \sum_{i=0}^{\infty} (1+\rho)^i B^{i+1} RER.$$

The values for the coefficients ρ and α_1 are given in Tables 2 and 3.