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**Trade composition and total factor productivity  
Evidence for Chile**

**Dierk Herzer**

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# Trade Composition and Total Factor Productivity: Evidence for Chile

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## **Abstract**

This paper examines the long-run impact of capital goods imports, intermediate goods imports, and exports of manufactured and primary goods on total factor productivity in Chile. Using cointegration techniques, we find productivity-enhancing effects of capital and intermediate goods imports as well as manufactured exports, and productivity-limiting effects of primary exports.

*Keywords:* Trade Composition, Productivity, Cointegration

*JEL classification:* O47; F41; C22

## **1. Introduction**

A large body of literature argues that trade increases economic productivity. The basic explanation is that imports of capital and intermediate goods embody knowledge and technology (Grossman and Helpman 1991), while exports create economies of scale and learning-by-exporting-based knowledge spillovers (Chuang 1998).

However, many authors have objected that primary products possess no sustainable potential for generating knowledge spillovers and that an increase in primary exports can draw resources away from the externality-generating manufacturing sector (Sachs and Warner 1995). In addition, primary exports are subject to extreme fluctuations. Increasing primary exports may therefore lead to increasing GDP variability and macroeconomic uncertainty, which may, in turn, reduce the quantity as well as the efficiency of investments (Dawe 1996). From this it follows that the productivity effects of primary exports and manufactured exports should differ significantly.

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To date, there have been no empirical investigations of how these effects differ. Of course, the link between trade and productivity has been examined numerous times, and almost all studies have found a statistically significant positive relationship between trade and total factor or labor productivity. But the empirical literature on trade and aggregate productivity, which is mostly based on cross-country regressions, generally uses aggregate measures of international trade, such as, the ratio of imports plus exports to GDP, usually referred to as openness (see, for example, Miller and Upadhyay 2000, Alcalá and Ciccone 2004).

This study differs from previous works in two main ways: first, given the problems inherent to cross-country studies, such as simultaneity bias and parameter heterogeneity, we have chosen to use time series analysis. Second, given that aggregate trade measures may mask important differences between different trade categories - in particular between primary and manufactured exports - we disaggregate trade into capital goods imports, intermediate goods imports, manufactured exports, and primary exports.

In order to investigate the productivity impacts of capital goods imports, intermediate goods imports, manufactured exports, and primary exports, we use Chilean time series data from the period 1960 - 2001. Chile is an interesting case because (i) total factor productivity has played an important role in the Chilean growth process, especially in the period 1975 - 1981 and since 1985, according to Chumacero and Fuentes (2005) (ii) Chilean trade has grown very rapidly since the trade liberalization of 1974, and (iii) Chilean exports rely heavily on primary products, in particular copper, although the share of manufacturing exports in goods exports rose from about 7 percent in 1973 to 44 percent in 2001.

The rest of the paper is organized as follows. Section 2 describes the empirical model and the data. The estimation results are presented in Section 3. A final section concludes.

## 2. Model and data

Our objective is to investigate if and how increasing capital goods imports, intermediate goods imports, manufactured exports and primary exports affect total factor productivity in Chile. To this end, we assume that factor productivity,  $TFP_t$ , at time  $t$  can be expressed as a Cobb-Douglas function of capital goods imports,  $CM_t$ , intermediate goods imports  $IM_t$ , manufactured exports,  $IX_t$ , primary exports  $PX_t$ , and other factors  $C_t$ :

$$TFP_t = C_t CM_t^\alpha IM_t^\beta IX_t^\delta PX_t^\gamma . \quad (1)$$

Taking natural logs (ln) of both sides of equation (1) gives the estimable linear function

$$\ln TFP_t = c + \alpha \ln CM_t + \beta \ln IM_t + \delta \ln IX_t + \gamma \ln PX_t + e_t, \quad (2)$$

in which all coefficients are elasticities,  $c$  is a constant parameter, and  $e_t$  is the usual error term.

Before estimation, we calculate  $\ln TFP_t$  on the basis of a constant-returns-to-scale Cobb-Douglas production function,

$$Y_t = TFP_t K_t^{(a-1)} L_t^a, \quad (3)$$

where  $Y_t$  denotes the aggregate production, and  $TFP_t$ ,  $K_t$ ,  $L_t$  stand for the level of total factor productivity, capital stock, and labor, respectively. From the growth accounting point of view, the factor-output elasticities are given by the capital and labor shares from the national income accounts. The average labor share in the period 1960 - 2001 was calculated to be  $a = 0.5$ . But this share fails to account for the income of most self-employed workers, who make

up a large fraction of the Chilean labor force. As shown by Gollin (2002), for countries where there are data to adjust for this mismeasurement, the actual labor share tends to be close to 0.7. Therefore, following Chumacero and Fuentes' (2005) study on the determinants of Chilean economic growth, we choose the conventional value of two-thirds.<sup>1</sup> Hence, the natural logarithm of total factor productivity is calculated according to

$$\ln TFP_t = \ln Y_t - 0.333 \ln K_t - 0.667 \ln L_t. \quad (4)$$

To calculate  $\ln TFP_t$  and to estimate equation (2), we use annual data from the Chilean Central Bank.  $Y_t$  is represented by GDP. The capital stock,  $K_t$ , was computed using the perpetual inventory method.  $L_t$  is measured by the number of employees. All other variables are expressed in constant 1996 Chilean pesos.

### 3. Results

In the first step, we investigate the integration properties of  $\ln TFP_t$ ,  $\ln CM_t$ ,  $\ln IM_t$ ,  $\ln IX_t$ , and,  $\ln PX_t$  by applying the standard ADF test. However, it is well known that standard unit root tests are biased in favor of identifying data as integrated in the presence of structural breaks. For all the series there is indeed a strong likelihood that structural discontinuities are present, e.g., the socialist government of President Allende (1970 - 1973) which pursued a highly inward-oriented economic policy; the 1975 economic crisis; and the deep 1982 recession. Therefore, we use the unit root test recently developed by Kapetanios (2005) in addition to the ADF test. The Kapetanios procedure permits a formal evaluation of the time series properties in the presence of an unspecified number of structural breaks, where the break dates are

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<sup>1</sup> Chumacero and Fuentes (2005) also calculated the factor productivity based on  $a = 0.5$  with similar growth accounting results.

<sup>2</sup> The estimation results do not change qualitatively when the total factor productivity is calculated based on  $a = 0.5$ , see Herzer (2005).

identified endogenously through the testing procedure itself. Table 1 shows the results of the ADF and Kapetanios tests. Both these tests suggest that all variables are integrated of order one. Therefore, the next step in our analysis is an investigation of the cointegration properties of the variables.

We use the Johansen (1995) technique for this purpose. An impulse dummy variable,  $i90$ , is included in the VAR model to control for a large outlier in 1990 ( $i90$  is 1 in 1990 and 0 elsewhere).<sup>3</sup> Note that such a dummy variable has no impact on the asymptotic distribution of the test statistics for the cointegration rank. Table 2 reports the results.

Comparing both the trace and the maximum-eigenvalue statistics with the corresponding critical values, it can be seen that a cointegration rank  $r = 0$  is clearly rejected, but not the null of at most one cointegrating vector. We therefore proceed under the assumption of a single cointegrating vector. This vector is estimated after normalizing on  $\ln TFP_t$ , so that we obtain the following long-run relation (t-statistics in parenthesis):

$$\ln TFP_t = 0.164 \ln CM_t + 0.047 \ln IM_t + 0.030 \ln IX_t - 0.077 \ln PX_t + 3.161 \quad (5)$$

(15.728)      (4.314)      (2.717)      (-2.881)

Since the null hypothesis of weak exogeneity of  $\ln TFP_t$  is decisively rejected (see Table 2), we infer from equation (5) that the level of total factor productivity increases by 0.164 percent in response to a one percent increase in capital goods imports. A one percent increase in intermediate goods imports leads to a 0.046 percent increase in total factor productivity. With an increase of manufactured exports by one percent factor productivity increases by 0.056 percent. In contrast, a one percent increase in primary exports leads to a 0.125 percent decrease in total factor productivity.

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<sup>3</sup> The dummy captures the fact that in 1990 total factor productivity growth slowed from an average of 7.2% for the previous four year to about 0.2% as a result of tight monetary policy aimed at reducing inflation.

Admittedly, the Johansen procedure is very sensitive to the specification of the statistical model and the choice of the lag length. We therefore check the robustness of the results by means of the Stock (1987) approach, regressing  $\Delta \ln TFP_t$  on  $\ln TFP_{t-1}$ ,  $\ln CM_{t-1}$ ,  $\ln IM_{t-1}$ ,  $\ln IX_{t-1}$ , and  $\ln PX_{t-1}$ , the differences of  $\ln CM_{t-1}$ ,  $\ln IM_{t-1}$ ,  $\ln IX_{t-1}$ , and  $\ln PX_{t-1}$  up to lag order two, the lagged difference of  $\ln TFP_{t-1}$  also up to lag order two, an intercept term, and the impulse dummy  $i90$ . The following equation results when applying the general-to-specific approach (t-statistics in parenthesis beneath the estimated coefficients):<sup>4</sup>

$$\begin{aligned}
\Delta \ln TFP_t = & -0.762 \ln TFP_{t-1} + 0.125 \ln CM_{t-1} + 0.037 \ln IM_{t-1} \\
& (-6.537) \quad (6.521) \quad (2.628) \\
& + 0.025 \ln IX_{t-1} - 0.067 \ln PX_{t-1} \\
& (2.904) \quad (-3.013) \\
& + 0.073 \Delta \ln CM_t - 0.071 \Delta \ln CM_{t-1} + 0.063 \Delta \ln IM_t + 0.071 \Delta \ln IM_{t-1} \\
& (5.233) \quad (-4.354) \quad (3.030) \quad (3.669) \\
& + 0.028 \Delta \ln IX_{t-1} + 2.473 - 0.047 i90 + \hat{\epsilon} \\
& (-2.270) \quad (6.678) \quad (-2.672) \\
\bar{R}^2 = & 0.818 \quad SE = 0.016 \quad JB = 1.217 (0.544) \\
Arch(1) = & 0.139(0.711) \quad Arch(2) = 0.253(0.778) \quad Arch(4) = 0.501(0.735) \\
LM(1) = & 0.002(0.961) \quad LM(2) = 0.344(0.711) \quad LM(4) = 1.275(0.307) \quad (6)
\end{aligned}$$

A significant negative lagged dependent level variable,  $\ln TFP_{t-1}$ , indicates cointegration. Critical values are given in Ericsson and MacKinnon (2002). Since the absolute value of the estimated t-statistic, -6.537, is higher than the absolute value of the one percent critical value of -4.583, we reject the null of no cointegration. Normalizing on the coefficient of  $\ln TFP_{t-1}$  finally yields the equation

<sup>4</sup> The numbers in parentheses after the values of the diagnostic test statistics are the corresponding  $p$ -values,  $JB$  is the Jarque-Bera test for normality,  $LM(p)$ ,  $p = 1, 2, 3$ , are  $LM$  tests for autocorrelation based on 1, 2, 4 lags,



$$\ln TFP_t = 0.158 \ln CM_t + 0.049 \ln IM_t + 0.033 \ln IX_t - 0.087 \ln PX_t + 3.247 \quad (7)$$

which is very close to the result of the Johansen procedure and the result of the Stock and Watson (1993) DOLS approach reported in Table 3 (*t*-statistics in parentheses beneath the estimated coefficients). From this, it follows that the coefficient estimates are fairly robust to different estimation techniques.

#### 4. Conclusions

Our estimation results can be interpreted as evidence of (i) productivity-enhancing effects of capital goods imports, intermediate goods imports, and manufactured exports and (ii) productivity-limiting effects of primary exports in Chile. The latter may be due to the problem of fluctuating copper export prices and earnings, under which the Chilean economy has suffered several times. In addition, manufactured exports might offer greater potential for economies of scale and knowledge spillovers. The largest productivity effects, however, come from imports, in particular capital goods imports. This suggests that knowledge and technology is embodied in machinery and equipment and therefore transferred through international trade.

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Arch(*p*) is an LM test for autoregressive conditional heteroscedasticity of order *p* = 1, 2, 4.

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Table 1  
Unit root tests

ADF unit root test			Kapetanios (2005) unit root test					
			$m = 1$			$m = 2$		
Variables	Test statistic	5% critical value	Break year	Test statistic	5% critical value	Break years	Test statistic	5% critical value
<i>Levels</i>								
$\ln TFP_t$	-1.37	-3.52	1974	-2.49	-4.93	1974, 1981	-3.78	-5.685
$\ln CM_t$	-1.65	-3.52	1970	-2.75	-4.93	1970, 1981	-3.70	-5.685
$\ln IM_t$	-2.03	-3.52	1974	-3.04	-4.93	1974, 1982	-4.68	-5.685
$\ln IX_t$	-2.58	-3.52	1973	-3.94	-4.93	1973, 1981	-3.95	-5.685
$\ln PX_t$	-2.16	-3.52	1970	-3.87	-4.93	1970, 1980	-4.01	-5.685
<i>First differences</i>								
$\Delta(\ln TFP_t)$	-5.49	-3.52						
$\Delta(\ln CM_t)$	-5.90	-3.52						
$\Delta(\ln IM_t)$	-5.52	-3.52						
$\Delta(\ln IX_t)$	-5.41	-3.52						
$\Delta(\ln PX_t)$	-8.32	-3.52						

Note: The lag length was chosen using the Schwarz information criterion. Critical values for the ADF test from MacKinnon (1991). Critical values for the Kapetanios unit root test from Kapetanios (2005). The possibility was considered that up to two break points occurred over the relevant period:  $m = 1$ ,  $m = 2$ . These breaks were restricted to the intercept of the trend function, denoted as case A by Kapetanios (2005).

Table 2  
Cointegration analysis

A. Johansen cointegration tests					
Hypothesised no. of cointegrating vectors	Trace statistics		Maximum-eigenvalue statistics		
	Statistics	Critical value 0.01% (0.05%)	Statistics	Critical value 0.01% (0.05%)	
None	85.417	76.07 (68.52)	53.821	38.77 (33.46)	
At most 1	31.596	54.46 (47.21)	13.522	32.24 (27.07)	
B. Tests for weak exogeneity					
Variable	$\ln TFP_t$	$\ln CM_t$	$\ln IM_t$	$\ln IX_t$	$\ln PX_t$
$\chi^2$	24.667	0.122	8.346	0.871	6.157
(p-value)	(0.000)	(0.727)	(0.004)	(0.351)	(0.013)

Note: The lag length  $k$  was chosen using the Schwarz information criterion,  $k = 1$ . Critical values from Osterwald-Lenum (1992). The model includes an unrestricted constant.

Table 3

Dynamic OLS: Model:  $\ln TFP_t = c + \alpha \ln CM_t + \beta \ln IM_t + \delta \ln IX_t + \gamma \ln PX_t + \varepsilon_t$

$\hat{\alpha}$	$\hat{\beta}$	$\hat{\delta}$	$\hat{\gamma}$
0.150	0.068	0.022	-0.073
(20.05)	(7.794)	(2.703)	(-3.885)

$SE = 0.013$   $JB = 1.749$  (0.417)  $Arch(1) = 0.009$  (0.923)  $Arch(2) = 0.166$  (0.858)  $Arch(4) = 0.147$  (0.962)  
 $LM(1) = 2.353$  (0.137)  $LM(2) = 1.134$  (0.338)  $LM(4) = 0.714$  (0.591)

Note: The DOLS equation was estimated with up to two leads and lags ( $k = 2$ ). We then followed the general-to-specific method of sequentially removing the insignificant terms. The numbers in parentheses after the values of the diagnostic test statistics are the corresponding  $p$ -values.  $JB$  is the Jarque-Bera test for normality,  $LM(p)$ ,  $p = 1, 2, 3, 4$ , are  $LM$  tests for autocorrelation based on 1, 2, 4 lags,  $Arch(p)$  is an LM test for autoregressive conditional heteroscedasticity of order  $p = 1, 2, 4$ .