Testing Endogenous Growth in South Korea and Taiwan

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1. Introduction

The promise of the endogenous growth models, to explain the diversity of growth rates across countries and time, has so far not materialized. Despite the sophistication of these models, attempts to apply them to country data have met with mixed success. For the industrial countries, Mankiw, Romer and Weil (1992) have argued that the conventional Solow growth model, extended to allow for human capital, provides a quite satisfactory explanation of growth. Jones (1995a,b) proposes a direct test of endogenous growth, whereby changes in policy should have permanent effects on the growth rate. This hypothesis is decisively rejected on data for the U.S. and other advanced countries.[1] The volume by Ito and Krueger (1995) contains evaluations of growth models applied to newly-industrialized countries, and even in these papers, there is a wide range of opinions on the sources of growth in these countries.[2] Ito and Krueger conclude that: "Clearly a great deal more research, especially on the microeconomic aspects of growth, will be required before the avenues by which rapid growth occurs are reasonably well understood" (p. 5).

This paper will present one micro-based test of the determinants of growth, focusing directly on the link between increased product variety and productivity. The idea that productivity is enhanced by increases in product variety is central to the endogenous growth models considered by Romer (1990) and Grossman and Helpman (1991). We will evaluate the link between product variety and productivity using sectoral data for South Korea and Taiwan.

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[1] Kocherlakota and Yi (1996, 1997) also reject the hypothesis that policy variables have permanent effects on the growth rate for the U.S. and U.K., with the possible exception of public structural capital.

[2] For example, Fukuda and Toya (1995) finds support for conditional convergence among the East Asian countries, once the differing shares of exports is controlled for, whereas Easterly (1995) argues that the rapid growth of the Asian "tigers" is not accounted for by cross-country convergence regressions. Of course, this difference of opinion on one narrow question reflects a much wider divergence of views on whether the Asian growth experience is unique at all: compare the World Bank (1993) and Krugman (1994).

Our empirical work relies on a direct measure of the variety of products *exported* from each sector. We shall test whether changes in export variety, for Taiwan relative to Korea, are correlated with the growth in total factor productivity (TFP) in each sector, again measured in Taiwan relative to Korea. It seems to us that this is the most direct test of endogenous growth, and it is worth asking why it has not been implemented before.

The answer seems to be that the disaggregate data necessary to construct measures of product variety is difficult to obtain, and also perhaps that the method of construction is not well understood. The measure of product variety we shall use is exact for an underlying CES aggregator function, as described in Feenstra (1994) and Feenstra and Markusen (1994), and is reviewed in section 2. The data used to measure product variety from South Korea and Taiwan are the disaggregate *exports* from these countries to the United States, and are described in section 3. While is would be preferable to use national *production* data from these countries, it is not available at a sufficiently disaggregate level. Despite the limitations of using *exports* to measure product variety, it has the incidental benefit of focusing on the link between trade and growth. In addition, while our principal analysis will deal with export variety in each industry, we will also construct measures of *upstream export variety*, i.e. the variety of exports produced by upstream industries. Correlating this with the productivity of the downstream industries will provide some indication of the importance of *input variety* in affecting productivity and growth.

In section 4 we analyze the relationship between changes in export variety and the growth in total factor productivity (TFP) across the two countries, in sixteen sectors over 1975-1991. Our results lend support to the endogenous growth model. We find that changes in relative export variety (entered as either a lag or a lead) have a positive and significant effect on TFP in nine of the sixteen sectors. Seven out of these sectors are what we classify as secondary industries, in that they rely on and produce differentiated manufactures, and therefore seem to fit the idea of endogenous growth. Among the primary industries, which rely more heavily on natural resources, we find mixed evidence: the correlation between export variety and productivity can be positive, negative, or is often insignificant. We also find evidence of a positive and significant correlation between *upstream* export variety and productivity in six sectors, five of which are secondary industries.

In sum, the sectoral regressions provide some degree of confirmation for the link between export variety and productivity, which is all the more surprising because these two variables are obtained from completely different data sets, so there is no possibility of correlation due to common trends as might arise among macroeconomic variables. These results are preserved when we correct TFP for the possible mismeasurement of the capital share due to imperfect competition, as recommended by Hall (1988, 1990), and also when we control for excess capacity (using electricity usage) or the growth in imports or exports within each sector. In section 5 we discuss the application of our methods to other East Asian countries, and present our conclusions.

2. Measuring Product Variety

2A. Input Variety

The endogenous growth models that rely on an increasing range of intermediate inputs (such as Romer, 1990) generally assume a CES production function defined over these inputs. In this section we show how the efficiency gain due to new *inputs* can be measured empirically, and in the next section we extend our results to consider new *outputs*.

A theoretical simplification of the endogenous growth literature is that all the inputs enter the production function symmetrically, in which case the *number* of inputs fully summarizes the information about variety. In empirical work this assumption is unacceptable, because some inputs may be more important than others, and any measure of product variety should take this into account. Feenstra (1994) and Feenstra and Markusen (1994) show how an exact measure of product variety can be constructed for a CES production function even when the inputs enter non-symmetrically, and we begin by reviewing these results.

We will consider two units of observation denoted by s and t. In this section we will think of them as successive points in time, but in later will treat them as two countries. Suppose that output y_t in period t is given by the production function:

$$y_t = f(x_t, I_t) = \left[\sum_{i \in I_t} a_i x_{it}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)}, \qquad (1)$$

where $\sigma>1$ is elasticity of substitution, x_{it} is the quantity of input i in period t, and the set of inputs available is denoted by I_t. For example, if the inputs are numbered 1 through N_t, then $I_t=\{1,\ldots,N_t\}$. The corresponding cost of producing one unit of y_t is:

$$c(p_t, I_t) = \left[\sum_{i \in I_t} b_i p_{it}^{1-\sigma} \right]^{1/(1-\sigma)}, \quad b_i = a_i^{\sigma}, \qquad (2)$$

where p_{it} are the prices of the inputs $i \in I_t$.

As usual, we define total factor productivity (TFP) as the difference between the growth of output and an index of the inputs. A common measure of an input index is the change in nominal expenditure (E_t/E_s) deflated by an input price index, where $E_t = \sum_{i\in I_t} p_{it}x_{it}$. We will suppose that this deflator is constructed by ignoring any change in set of inputs available. Thus, letting $I=I_s\cap I_t$ denote the set of goods common to both periods, we will suppose that the input price index is given by the Sato (1976)-Vartia (1976) formula,

$$P(p_s,x_s,p_t,x_t,I) \equiv \prod_{i\varepsilon I}(p_{it} / p_{is})^{w_i(I)} , \tag{3a}$$

where the weights $w_i(I)$ are constructed from the expenditure shares $e_{it}(I) \equiv p_{it}x_{it}/\sum_{i\varepsilon I} p_{it}x_{it}$ as,

$$w_i(I) \equiv \left(\frac{e_{it}(I)-e_{is}(I)}{\ln e_{it}(I)-\ln e_{is}(I)}\right)\Bigg/\sum_{i\varepsilon I}\left(\frac{e_{it}(I)-e_{is}(I)}{\ln e_{it}-\ln e_{is}(I)}\right) \quad . \tag{3b}$$

The numerator on the right of (3b) is a logarithmic mean of the expenditure shares e_{it} and e_{is}, and lies between these two values. The denominator ensures that the weight $w_i(I)$ sum to unity, so that the Sato-Vartia index is simply a geometric mean of the price ratios (p_{it}/p_{is}). This index is *exact* for the CES unit-cost function in (2) when the range of inputs in held constant, meaning that $P(p_s,x_s,p_t,x_t,I)=c(p_s,I)/c(p_t,I)$ provided that the inputs x_s and x_t are cost minimizing for the prices p_s and p_t, respectively.

Making use of this price index, the quantity index for intermediate inputs is measured by:

$$\tilde{Q}(p_s, x_s, p_t, x_t) = \frac{E_t / E_s}{P(p_{s,} x_s, p_t, x_t, I)} \quad .$$

Total factor productivity is defined as the difference between the growth of output and this input index, $TFP_{st} \equiv \ln(y_t / y_s) - \tilde{Q}(p_s, x_s, p_t, x_t)$, which can be simplified as follows:

$$TFP_{st} = \ln\left(\frac{y_t}{y_s}\right) - \ln\left(\frac{E_t / E_s}{P(p_{s,} x_s, p_t, x_t, I)}\right) \tag{4}$$

$$= -\ln\left(\frac{c(p_t, I_t) / c(p_s, I_s)}{P(p_{s,} x_s, p_t, x_t, I)}\right) \tag{5}$$

$$= \frac{1}{(\sigma - 1)} \Delta VAR_{st} \,, \tag{6}$$

where the change in input variety is defined as,

$$\Delta VAR_{st} = \ln\left(\frac{\sum_{i \in I_t} p_{it} x_{it} \Big/ \sum_{i \in I} p_{it} x_{it}}{\sum_{i \in I_s} p_{is} x_{is} \Big/ \sum_{i \in I} p_{is} x_{is}}\right). \tag{7}$$

Line (4) follows from the definition of the quantity index for inputs, while line (5) is obtained because input expenditure is $E_t = y_t c(p_t, I_t)$, and similarly for period s. Line (6) then follows from Feenstra (1994, Proposition 1), with the definition of product variety in (7).

To interpret this result, consider the case where the set of inputs is growing, and denote these sets by $I_s = \{1, \ldots, N_s\}$ and $I_t = \{1, \ldots, N_t\}$, with $N_t > N_s$. Then the common set of inputs supplied in both periods is $I = I_s$, and the denominator of (7) is unity. The numerator will exceed unity, indicating that product variety has increased. In the case where all inputs enter the production and unit-cost functions symmetrically, $a_i=a_j$, then expenditure on each input is identical, and the numerator in (7) is simply $N_t /N_s>1$, reflecting the growth in the number of inputs. Even without the symmetry assumption, (7) shows that it is still possible to construct an exact measure of product variety for the CES case. From (6), we see that this measure of product variety is correlated with TFP.

The coefficient on ΔVAR_{st} in (6), $1/(\sigma-1)$, reflects the degree of substitution between new and existing inputs, and is higher when the new inputs are more differentiated from existing ones. The impact of a single new input on productivity is illustrated in Figure 1, which shows the isoquants for the CES production function in (1). With $\sigma>1$, these isoquants touch the axis, with slope of zero or infinity. Initially suppose that only x_1 is available, so that with a total expenditure illustrated by the line AB, the firm would purchase the amount shown at A. Output is then y_1. When the second input x_2 is also available, then at the same level of expenditure the firm can hire the two inputs at the point C, and obtain the higher level of output y_2. Since expenditure has not changed, TFP will simply equal the ratio (y_2/y_1), the magnitude of which depends on the degree of convexity of the isoquants, or the value of σ.

2B. Output Variety

While we have so far focused on the case of new inputs, it will be important to extend our results to cover the case of new *outputs.* New outputs have received less attention in the literature on trade and endogenous growth, though it is worth noting that Grossman and Helpman (1991, chaps. 3, 9, 11) interpret the CES function (1) as the consumer's *utility* function, so that the differentiated goods x_{it} are indeed final goods rather than intermediate inputs. An expansion in the range of these goods raises utility, but has no direct impact of productive efficiency. Rather, there is an externality in the endogenous growth model between output variety and the fixed costs of new product creation, whereby the fixed costs are inversely proportional to the number of final goods already created. It is this externality that allows for continuous expansion in the range of final goods created.

In addition to this externality, we feel that a very modest extension of the model considered by Grossman and Helpman would allow for a direct impact of output variety on productive efficiency. In particular, their model assumes that all output varieties are produced with *equal amounts of a single factor, labor*. This Ricardian setup implies a linear transformation curve between outputs, so that the creation of a new output (at a price equal to the slope of the transformation curve) has no effect on the total value of output. However, if we suppose instead that output varieties are produced using several factors of production, and with different factor intensities, then the transformation curve will have the usual concave shape. In this case, the creation of a new output variety – holding fixed the total level of inputs – can be expected to *raise* the value of output, and in this sense raise productivity.

This situation is illustrated in Figure 2, which shows the transformation curve between the outputs x_1 and x_2. If initially only the first output x_1 is feasible to manufacture, then production would occur at A, and the value of production is represented by the budget line AB. If then the second output x_2 becomes feasible, with the same level of resources production would move to point C, and the value of production (represented by the budget line) has clearly increased.[3] This represents a productivity gain due to new output varieties. To measure this

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[3] The value of output will increase so long as the price of the new variety exceeds the marginal cost of producing the first unit of this good, as illustrated at the corner A in Figure 2.

gain, we can reinterpret (1) as a transformation function between the vector of output varieties x_t, and the scalar measure of resources y_t needed to produce these outputs. Changes in y_t act as a shift parameter moving the transformation curve in or out. In this case we consider values of $\sigma<0$, so that for a given level of resources y_t the transformation curve between the outputs x_1 and x_2 is strictly concave. Then TFP should be defined as the *negative* of (4), that is, the growth in real output less the growth in the scalar resources y_t. Then the expansion of output varieties would imply a growth in TFP, which is precisely correlated with the measure of output variety in (7): $TFP_{st} = -\Delta VAR_{st}/(\sigma-1) > 0$, since $\sigma<0$ and $\Delta VAR_{st}>0$ due to the new outputs. Thus, the measure of product variety that we derived for new inputs applies equally well to new outputs, provided that the transformation curve in strictly concave.

2C. Cross-Country Data

Our discussion above was aimed at developing a measure of changes in product variety that applies over time. But it can be equally important to compare the level of product variety across countries, for example, across South Korea and Taiwan in any given year. Given comparable data on the products available across countries, our results above can be re-interpreted as a cross-sectional comparison. Thus, suppose that the production (or transformation) function in (1) applies to either a South Korean industry (denoted by s) or the same industry in Taiwan (denoted by t). Then TFP_{st} in (6) represents the comparative productivity level of the Taiwanese relative to the Korean industry. The product variety measure in (7) would reflect the comparative input or output variety in Taiwan relative to Korea. A relatively higher level of variety in Taiwan, for example, would imply a higher level of productivity in that country.

We will also want to compare the level or change in product variety across countries *and* over time. For the cross-sectional variety index, we should choose the set of common goods I as the intersection of product supplied by each county in any year, but for a time-series index, we should choose the set I as the intersection of products supplied by any single country over two adjoining years. We will satisfy both these criterion by specifying the set I as *the intersection of products supplied by both Korea and Taiwan in two adjoining years*. To specify this more formally, let us denote the years by τ, while s and t still denote the countries. Then let $I_\tau \equiv I_{t\tau} \cap I_{s\tau}$ denote the set of goods supplied by both Taiwan and Korea in year τ, while $I \equiv I_{\tau-1} \cap I_\tau$ denotes the common goods in both years τ-1 and τ, across both the countries. The change in product variety in Taiwan relative to South Korea can then be expressed as:

$$\Delta VAR_\tau = \left[\ln\left(\frac{\sum_{i\in I_{t\tau}} p_{it\tau}x_{it\tau} \Big/ \sum_{i\in I} p_{it\tau}x_{it\tau}}{\sum_{i\in I_{s\tau}} p_{is\tau}x_{is\tau} \Big/ \sum_{i\in I} p_{is\tau}x_{is\tau}} \right) - \ln\left(\frac{\sum_{i\in I_{t\tau-1}} p_{it\tau-1}x_{it\tau-1} \Big/ \sum_{i\in I} p_{it\tau-1}x_{it\tau-1}}{\sum_{i\in I_{s\tau-1}} p_{is\tau-1}x_{is\tau-1} \Big/ \sum_{i\in I} p_{is\tau-1}x_{is\tau-1}} \right) \right]. \quad (8)$$

This change in relative product variety can be viewed as the difference between the cross-sectional product variety indexes computed in years τ and τ-1, or alternatively, as the difference between the time-series change in product variety for Taiwan and Korea. So long as the set of common goods I is consistently chosen as the intersection of goods produced in both countries across both years, then these interpretations are equivalent. Expression (8) measures the change in product variety in Taiwan relative to Korea, which we will take as a potential determinant of the growth of total factor productivity across the two countries.

3. Data and Estimating Equation

To contrast the product variety of South Korea and Taiwan, we will use disaggregate U.S. import statistics for 1972-1991. That is, we will be measuring the product variety of these countries using data on their *exports to the U.S.* By focusing on *export* variety, it is evident that we are measuring something closer to output variety (as considered in section 2B) than to input variety (as in section 2A). In order to measure output variety, it would be preferable to use industrial production data for each country rather than exports, but such data are not available (to us) at the same level of disaggregation as exports to the U.S.[4] Since the U.S. is the largest destination market for both countries (more than 30% of Korean exports and 40% of Taiwanese exports came into the U.S. in the last decade) their performances in this market may still reflect the features of their production quite well. Nevertheless, our use of export data to measure product variety has two key limitations.

First, the variety of exports from one country are in principle available to *other* countries through trade, so that productivity in each country does not depend on only the export variety from the same country: it would also depend on the matrix of *import* varieties from all of its trading partners. We do not have the data to measure this, however, and will simply correlate the relative export variety from Taiwan and South Korea on their relative productivities. Ignoring import variety is clearly a limitation of our approach.

Second, even after a new output is created domestically, it may take some time before it is exported to the United States. If the new output has an immediate impact on productivity, but

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[4] It is possible that industrial census data for any country is collected at the same level of disaggregation at trade statistics, but census data is not generally collected annually. Rather than using the U.S. import data, it would still be preferable to use the world-wide export data from each country, if it were available on the highly disaggregate harmonized commodity system, allowing comparability across countries. Our use of the U.S. import data is due to the ready accessibility of this data, as described in Feenstra (1996).

there is a lag before it is exported, this means that productivity will be correlated with the product variety of exports *in the future.* In other words, we should consider *lead* values of export variety as a determinant of productivity. Conversely, if the new output is exported quickly, but it takes some time for its appearance to influence productivity, then we would expect *lag* values of export variety to be a determinant of productivity. These considerations can be taken into account by allowing a flexible pattern of timing between the leads or lags of export variety, and productivity. We will introduce this structure into our estimating equation.

Despite the limitations of using *exports* to measure product variety, it has the incidental benefit of focusing on the link between trade and growth. Frankel and Romer (1996) and Frankel, Romer and Cyrus (1996) have argued that openness benefits growth in the context of the Solow growth model, and our results will provide further evidence on the importance of exports in an endogenous growth setting.[5] In addition, while our principal analysis will deal with export variety in each industry, we will also construct measures of *upstream export variety*, i.e. the variety of exports produced by upstream industries. Correlating this with the productivity of the downstream industries will provide some indication of the importance of *input variety* in affecting productivity and growth.

Features of the input-output tables are shown in Table 1, where we list the industries with their two-digit Standard Industrial Classification numbers (excluding petroleum). In the first columns of Table 1, we show the share of total (domestic plus imported) intermediate inputs that are purchased from each two-digit industry, and then from all other domestic manufacturing industries. (Since the shares were similar in Taiwan and South Korea, we report the simple

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[5] The link between exports and productivity is now also being examined using firm-level datasets, as in Aw, Chen and Roberts (1997) and Clerides, Lach and Tybout (1998).

average across these two countries).[6] For example, food products purchase 10.2% of inputs from its own industry and 5.3% of inputs from other domestic manufacturing industries. We have divided the industries into two broad groups of primary and secondary products. The primary products generally purchase more inputs from themselves than from any other manufacturing industry.[7] This reflects their reliance on natural resources as inputs, and their weak upstream linkages to manufacturing. The secondary industries have stronger upstream linkages, generally purchasing more from other supplying industries than from themselves. An exception is chemicals and plastics (SIC 28), which purchases a large amount from itself because it is highly aggregated and includes some primary products, thought we have still classified it as secondary.[8] While the classification between primary and secondary industries is somewhat arbitrary, it will be useful as a way to summarize our results. In particular, we would expect the hypothesis of endogenous growth to apply more to secondary than to primary industries.

Turning to the trade data, U.S. import statistics for 1972-1988 distinguish commodities from each country according to their 7-digit Tariff Schedule of the United States (TSUSA) numbers, that number over 10,000 each year; for later years the commodities are classified according to the 10-digit Harmonized System (HS), that distinguishes even a larger number of commodities. In order to measure the product variety of U.S. imports from Taiwan (denoted by t) relative to South Korea (denoted by s), we construct indexes of product variety for each year in our sample period. In the fourth column of Table 1 we report the average *level* of product variety

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[6] The data in column 1 are computed from the 1981 input-output table for Taiwan (*Statistical Yearbook of the Republic of China, 1986*. Supplementary Table 6), and the 1983 *Input-Output Table for South Korea* (Transaction Table at Producer Prices. 64x64). These tables were aggregated to the two-digit industries that we use, and then the shares were averaged over the two countries.

[7] An exception is leather products (SIC3 31), which we have classified as primary despite the fact that it purchases more from upstream domestic industries (principally rubber, for footwear) than from itself.

over 1972-1991 in Taiwan relative to South Korea, which is constructed as a cross-sectional index of product variety in the two countries for each year (as in eq. (7), multiplied by 100). Positive (negative) values for this index indicate higher product variety in Taiwan (Korea). We see that Taiwan has greater product variety than Korea in a number of industries, with the principal exceptions of basic metals and transportation equipment, and several other industries that have indexes near zero. This confirms the same result found for a more limited time period and using slightly different methods in Feenstra, Huang and Hamilton (1998).[9] Indeed, it was the realization that the product variety of exports from these countries were measurably different that provided the motivation for the present study.

After taking first differences our sample period becomes 1973-1991, and in the fifth column of Table 1 we report the average over this period of the *change* in the product varieties, for Taiwan relative to Korea (constructed as in (8) and multiplied by 100). Despite the relatively small values for these average changes over the sample, the year-to-year changes in product variety, as measured by $\Delta \mathrm{VAR}_{\tau}$ in (8), are often quite substantial.[10] It is these year-to-year changes that will be the key explanatory variable in our estimating equation.

The data on total factor productivity for South Korea are taken from Zeile (1993) and Madani (1996,1997), who construct TFP for a panel of 52 industries. Here they are aggregated into sixteen sectors, to match the productivity data for Taiwan, taken from Liang (1989) and Jorgenson and Liang (1995). For both countries TFP is measured as a Divisia (or Tornqvist)

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[8] Another exception is electronic products (SIC 36), which we have classified as primary despite the fact that it purchases less from upstream domestic industries than from itself. Like chemicals, this probably reflects the highly aggregated nature of the sector.

[9] These authors measure product variety at a more disaggregate level than the two-digit sectors in Table 1, and only for 1978-1988. They attribute the greater product variety of Taiwan relative to South Korea as arising from the differing structure of business groups in the two countries: Korea has much larger and more vertically-integrated

index, namely, the rate of growth of output minus a weighted average of the growth of inputs, where the weights are average of the expenditure shares on the inputs in the two years. The inputs included intermediate goods (aggregated from the input-output tables), energy, labor, and several kinds of capital. In Table 1 we show the average growth of TFP for each of the countries over the sixteen industries, where for convenience we have multiplied each annual change by 100, so the growth rates are in percent. In the last column, we show the *difference* between the TFP growth rate in Taiwan and South Korea. This difference in the growth rates across the two countries for each industry k and year τ is denoted by $\mathrm{TFP}_{k\tau}$, and will be the dependent variable in our estimating equation.

We shall estimate the relation between TFP and export variety as,

$$\mathrm{TFP}_{k\tau} = \alpha_k + \beta_k \mathrm{Year81} + \gamma_k \Delta \mathrm{VAR}_{k\tau-\ell} + \varepsilon_{k\tau} \ , \qquad (9)$$

where α_k is a constant term for each industry k, and β_k is the estimated impact of the 1981 depreciation of the New Taiwan dollar, which will be significant for a number of industries.[11] The *change in relative* export variety across the two countries – adjusted for the lag or lead denoted by ℓ – is used as explanatory variable for the *difference in the growth* of TFP across the countries. This is the specification consistent with the endogenous growth equation in (6), from which we see that the coefficient γ_k equals $1/(\sigma_k\text{-}1)$, where σ_k is the elasticity of substitution between differentiated products in industry k. We will experiment with using either lead or

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business groups than Taiwan, which are apparently focusing on a narrower range of product varieties. This outcome is predicted from the theoretical model developed in Feenstra, Yang and Hamilton (1997).

[10] Graphs of the data are shown in our working paper, and all the data is available on request.

[11] The New Taiwan dollar began a large depreciation in 1981, after several years of stability since it was floated in 1978. In addition to this dummy-variable, we also considered including a time-trend in (9), but found that it was significant for only one industry (Food products) where including it lowered the standard errors on the other coefficients but otherwise had little impact.

lagged values for the change in relative export variety, since as argued above, there may be time taken to export products time taken for new inputs to influence productivity. Including *both* leads and lags creates too much multi-collinearity, and the results are difficult to interpret. Instead, we shall use the Akaike information criterion to select the best (single) value of ℓ from among the annual values {-2,-1,0,1,2}.

It should be noted that in (9) we are correlating the growth rate of TFP with the change in *export* variety in the *same* industry, rather than in the upstream supplying industries. As noted above, we are therefore testing the relationship between *output* variety and productivity. After using this as the basic specification, we will experiment with including the export variety of the principal upstream supplying industry as a determinant of TFP. This will more directly test the importance of *input* variety as contributing to productivity.

The error term in (9) reflects all other factors that would influence TFP across the industries and countries. One of these is the presence of imperfect competition and pure profits. As argued by Hall (1988, 1990), in the presence of pure profits the capital share would be overstated, and therefore potentially bias the measure of TFP. To see this, recall that TFP is measured as the difference between the growth in output and a share-weighted average of the growth in inputs. If the capital share is overstated, this will have an impact on TFP whenever capital is growing at a different rate from the other inputs. Thus, the correction proposed by Hall is to regress TFP on a variable that is the difference between the growth of capital and the growth of the other inputs, averaged over those inputs.

An alternative suggested by Domowitz, Hubbard and Petersen (1988), as we shall follow, is to use the *difference between output growth and capital growth* in each industry as an additional regressor. We will denote this variable by $X_{k\tau}$, which is measured as a difference between Taiwan and South Korea, and is included on the right of (9):

$$\mathrm{TFP}_{k\tau} = \alpha_k + \beta_k \mathrm{Year81} + \gamma_k \Delta\mathrm{VAR}_{k\tau-\ell} + \delta_k X_{k\tau} + \varepsilon_{k\tau} \ . \qquad (10)$$

The industry-specific coefficient on $X_{k\tau}$ is interpreted as $\delta_k = (\mu_k - 1)$, where μ_k is the price-cost ratio in each industry. The variable $X_{k\tau}$ clearly needs to be treated as endogenous, since it is constructed from the same data used to construct $\mathrm{TFP}_{k\tau}$, so that (9) will be estimated using instrumental variables. The instruments used are growth in manufacturing level nominal and the change in manufacturing sector wholesale price indices for South Korea and Taiwan, as well as a lagged value of $X_{k\tau}$.[12]

Control variables will also be added to (10) to correct for possible spurious correlation because TFP is pro-cyclical, and export variety might be also. The cyclical nature of TFP occurs because labor and capital are difficult to reduce in downturns without extra costs to the firm, so that they are employed with excess capacity during these periods. In upturns they can again be fully employed, but their measured quantity will change by less, so it will appear that output is rising faster than inputs. One correction that can be made in our panel data is to include year fixed-effects within (10), which will control for any pro-cyclical movements in TFP that are common across industries. A second approach is to include *electricity usage* as a control variable in each industry regression, since these input can be easily adjusted over the business

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[12] The instruments were obtained from the same sources as the TFP data. We also experimented with using the growth of apparent consumption for all manufacturing, and the change in national exchange rates, as alternative instrumental variables. These gave similar overall results, though they do not provide as good a fit in the first-stage

cycle and should therefore correct for any cyclical movement in TFP.[13] We will make use of both corrections in our estimation. In addition, we shall experiment with including the growth of imports and exports as additional control variables,

4. Estimation Results

Table 2 reports the Akaike information criterion from regression (9) run on each sector, where we consider one or two-year leads or lags of the export variety variable. This criterion adjusts the sum of squares residuals from each regression to account for differing numbers of observations, and can be used as a basis for model selection.[14] We have computed this criterion for the regressions run over 1973-1991, and also over 1975-1991; the latter results are more stable, due to the erratic movements in TFP for some sectors in the early years. According, in Table 2 and all following results we use the 1975-1991 sample, though similar results are obtained when we include the earlier years.

The minimum values of the Akaike information criterion for each industry are shown in bold in Table 2. There are several industries where a unique minimum values does not occur: in clothing and apparel, the minimum is obtained with either a two-year lag or a two-year lead of export variety; while for electronic products, and transportation equipment, the criterion is at a

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regressions. The import and export series come from the *Economic Statistics Yearbook of the Republic of Korea*, and the *Taiwan Statistical Data Book*

[13] Burnside, Eichenbaum and Rebelo (1995) also use electricity consumption to control for excess capacity of capital, while Harrison (1994) uses total energy use. Our data for Taiwan is obtained from the *Taiwan Statistical Data Book*, 1995, Republic of China, and for South Korea is obtained from *Economic Statistics Yearbook of the Republic of Korea*, various years, Bank of Korea. In both cases, electricity consumption by industry is measured in thousands of kilowatts, and we use the difference in the log of this variable, for Taiwan relative to Korea, as a control variable in (10). Note that for Taiwan the industry breakdown did not correspond exactly to our own classification, so some substitutions were made: for rubber and leather, we used the electricity use of chemicals; for electrical equipment and transportation we used the electricity use of all manufacturing; while for wood and paper products, electricity use was missing and no substitute industry was available, so that only the Korean data was used.

[14] The Akaike information criterion equals ln(SSR/N)+(2K/N), where SSR is the sum of squared residuals, N is the number of observations, and K is the number of estimated coefficients.

minimum for a zero, one, or two-year lag. The latter industries are cases where export variety is essential unrelated to productivity, as we shall report below. We chose the lag or lead for export variety that minimizes the Akaike information criterion shown in Table 2.[15] The industry regressions using these leads or lags estimated with ordinary least squares (OLS), and also seeming unrelated regressions (SUR), are in Table 3.

Of principal interest in Table 3 is the coefficient γ_k on the change in relative export variety between Taiwan and South Korea, as shown in the third column (for OLS estimation) and the fifth column (for SUR estimation). This coefficient equals $1/(\sigma_k-1)$, where σ_k is the elasticity of substitution between the differentiated products in industry k. For values of this elasticity greater than two, then γ_k will be less than unity. Shown in bold-face are all values of this coefficient that are significantly different from zero at the 90% level. There are six such industries in the OLS estimation, and twelve in the SUR estimation, and in most of the cases the value of γ_k is positive and less than unity. There are three cases where γ_k is negative and significant: leather products, paper and printing, and electrical products. Only in leather is the correlation consistently negative in both OLS and SUR estimation, and in that case the coefficient is unusually large. This is an industry where we would not expect differentiated products to make a difference, and the negative correlation between export variety and productivity is evidently spurious.

Of the nine industries with positive and significant correlations between export variety and productivity under SUR, seven of them are within the group of secondary industries, where it

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[15] For clothing and apparel we use the two-year lag rather than the two-year lead for the regression in Table 3 and following tables, while for electronic products and transportation equipment we use the current value for product variety.

seems more likely that endogenous growth would apply. We are interpreting export variety as a proxy for domestic output variety, so its positive correlation with productivity is supportive of endogenous growth as applied to output variety. There are two industries – electrical products and transportation equipment – where we would expect to find evidence of endogenous growth, but for which we do not find a significant correlation between productivity and export variety. In both these cases our export variety measures for these two industries are very stable as compared to the productivity variables. We believe there is probably too much aggregation within these industries to allow for a meaningful measure of export variety.[16]

One potential problem with the regression results in Table 3 is that the TFP variable can be mismeasured due to the inclusion of pure profits in the capital share. As discussed above, a correction for this bias is to include the difference between output growth and capital growth in each industry as an additional regressor in (10), where this variable is treated as endogenous. The coefficient δ_k on this variable equals (μ_k-1), where μ_k is the price-cost ratio in industry k. In this regression we also include the electricity use by each industry (measured as a change over time and between Taiwan and Korea), as a control variables for capacity utilization and the pro-cyclicality of TFP. The results from re-estimated the regression for each industry, using three stage least-squares (3SLS) and including these additional regressors, are shown in Table 4.

In the third column of Table 4 we report the coefficient on the imperfect competition variable, which is an estimate of the markup (i.e. the price-cost ratio minus unity). Positive and

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[16] For example, in the first column of Table 1 we see that Taiwan has much *less* export variety than Korea in transportation equipment. This is most likely due to the fact that South Korea exports finished automobiles in large quantities, while Taiwan does not export these products at all. It is precisely this kind of product that is exported by one country and not the other, that will influence that export variety index. But it does not follow that Korea's export of finished automobiles should have a predictable impact on relative productivities across the two countries. In other words, when the export variety measure is constructed over very different products in the two countries, the link between variety and productivity may be lost.

significant estimates are obtained for eleven out of the sixteen industries, and a negative and significant coefficient is found in only one case. The magnitudes of the markups vary quite a bit across industries, which may be due to the aggregate level of these sectors.[17] For electricity usage, a positive and significant correlation with TFP is found only in six industries. What is most notable is that the inclusion of these control variable has a relatively small impact on the coefficients for export variety: there are still nine industries with positive and significant coefficients, and seven of these are within the secondary industries, as in the SUR estimation. There are a few cases where export variety changes from being significant to insignificant, or vice-versa, but the general results supporting endogenous growth remain much the same.

As a further specification test, we also control for the growth of imports and exports in each industry. These variables are often used as determinants of productivity, and we would like to see whether their inclusion has a significant impact on the export variety coefficients. In Table 5, we include the growth rates of imports and exports industry (measured as a change over time and between Taiwan and Korea).[18] The regressions are again estimated with 3SLS, correcting for the endogeneity of the correction for imperfect competition. The inclusion of the trade variables has only a small effect on the coefficients for export variety. These coefficients are reported in the second columns of Table 5, and are quite similar to what was found in Table 4: nine industries have positive and significant coefficients, and seven of these are secondary industries. These results emphasize that our export variety measure is picking up much more than just the growth of exports, since variety remains significant when the trade variables are included.

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[17] Madani (1996, 1997) obtains less diverse estimates across 52 industries for South Korea, using more disaggregate data.

[18] Similar results are obtained when instead we measure imports as a *share of domestic consumption* (equals to production plus imports), and measure exports as a *share of domestic production.*

In our final set of results, we extend the measurement of export variety to encompass the *upstream supplying* industries. For each industry, we take the share of domestic intermediate inputs purchased from all other industries, and form a weighted average of the export varieties of the supplying manufacturing industries using these shares.[19] This gives us a measure of product variety that is closer to *input* variety. The usefulness of this measure in explaining productivity in each industry will depend, however, on the share of total intermediates purchased from other domestic industries. This data is shown in the third column of Table 1. For example, food products purchase only 5% of inputs from other domestic manufacturing industries, so that we *do not* expect the export variety of these upstream industries to be correlated with productivity within foods. Rather, the upstream export variety should be correlated with productivity for industries that make substantial upstream purchases.

In Table 6 we report the regression of TFP on own-industry export variety (as used in Table 3-5), and also upstream industry export variety (constructed as described above). The latter variable is used as a proxy for input variety, so this is a direct test of the endogenous growth hypothesis. Both the OLS and the SUR estimates are shown. Focusing on the latter, there are ten industries with positive and significant coefficients on own-industry export variety, and eight of these are secondary industries. Furthermore, there are six industries with positive and significant coefficients on upstream export variety, and five of these are secondary industries. Upstream variety is significant in a number of industries that have the largest share of inputs purchased from other domestic manufacturing industries: apparel (purchasing from textiles), rubber products (purchasing from chemicals), fabricated metals, machinery and transportation equipment (all purchasing from primary metals). In addition, there are two industries – primary

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[19] These weights are the average of those obtained from the 1981 input-output table for Taiwan and the 1983 input-

metals and chemicals – for which upstream variety is important despite the limited range of upstream purchases. Overall, we feel that the SUR results in Table 6 support the idea of *input* variety as being important, in addition to *export* variety.

5. Conclusions

Despite the extensive theoretical work on endogenous growth, there have been relatively few attempts to formally test the appropriateness of these models outside of the industrial countries. This paper is a first attempt to directly test the connection between export variety and productivity at a disaggregate level for two newly-industrialized countries, South Korea and Taiwan. Our interest in these economies is partly motivated by the finding of Feenstra, Yang and Hamilton (1998) that there are differences in the export variety of exports from these countries to the U.S., with Taiwan having a higher level of export variety than Korea in a number of industries.

At the outset, we divided the sample into primary and secondary industries. This division was made on the basis of the input-output table, and was intended to capture the degree to which industries would rely on other manufactured inputs. It was expected that the secondary industries would better fit the hypothesis of endogenous growth due to differentiated *inputs,* and this might also apply to differentiated *outputs.* We found that the primary industries do not really support the structure of the endogenous growth model, and gave mixed results for various industries and estimation methods. For the secondary industries, however, the results provide quite strong support for the hypothesis of endogenous growth. Seven out of the nine industries in this group indicate a positive and significant impact of export variety on productivity. Furthermore, five of

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output table for South Korea, as described in note 6.

these industries showed a positive and significant impact of *upstream* export variety on productivity. We explored the sensitivity of our results by including a correction for imperfect competition, as suggested by Hall (1988, 1990), and also by including electricity usage and the growth of imports and exports. These control variables have only a small influence on the estimated impact of export variety.

As a directions for further research, it would be important to explore whether these results continue to hold over a wider sample of East Asian and other countries. We have computed the cross-sectional export variety index for a number of pairs of East Asian countries. Comparing Hong Kong and Singapore, for example, we find that Hong Kong has greater export variety in its exports to the U.S. than does Singapore in the following sectors: textile mill products; clothing and apparel; paper and printing; leather products; stone, clay and glass products; fabricated metal products; and instruments and misc. Conversely, Singapore has greater export variety in primary metals, while the following sectors do not provide a consistent ranking over the years: chemicals and plastics, rubber products, machinery, and electrical products, and transportation equipment. The result that Hong Kong leads Singapore in export variety for a number of sectors matches the finding of Young (1992), that Hong Kong has rapid productivity growth while Singapore has essentially none. Young also stresses that Singapore has *moved through* the range of products at an unusually rapid rate. It would be interesting indeed to see whether the export variety measures developed here could pick up these dynamic changes in the commodity composition of trade, and serve as an explanation for the contrasting productivity performance of these economies.

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Table 1

Averages of Data, 1973-1991

Industry (SIC numbers)	Share of intermediates (%)		Export Variety, Taiwan relative to Korea		Korean TFP (%)	Taiwan TFP (%)	Difference in Taiwan and Korea TFP
	From own industry	*From other home man.*	*Level*	*Change*			
Primary products:							
Food Products (20)	10.2	5.3	37.3	-3.2	2.55	3.01	0.50
Textile mill products (22)	29.8	26.4	13.2	1.3	3.39	2.19	-1.19
Wood products (24+25)	15.3	8.8	10.3	2.4	0.48	-11.96	-11.08
Paper & printing (26+27)	39.4	10.2	23.9	-2.8	1.51	-7.26	-9.09
Leather products (31)	15.7	19.2	-1.2	0.0	0.10	2.09	2.31
Stone, clay & glass (32)	14.7	10.1	-3.8	-0.1	2.52	0.71	-2.49
Primary metals (33)	44.5	3.9	-50.2	1.1	1.22	-1.20	-1.84
Secondary products:							
Beverages & tob. (208+21)	6.9	24.5	13.8	-9.0	-1.18	2.07	2.55
Apparel (23)	4.3	59.9	-0.3	0.9	1.76	-3.06	-4.06
Chemicals & plastics (28)	32.8	7.8	25.3	6.4	1.52	1.10	-0.34
Rubber products (30)	7.5	23.8	3.7	0.6	4.46	-1.46	-5.46
Fabricated metal prod. (34)	8.3	37.3	-5.9	-2.8	1.71	-1.19	-3.65
Machinery (35)	11.2	34.2	15.3	1.5	2.79	-0.59	-3.28
Electrical products (36)	20.1	18.4	4.1	-0.6	4.14	2.06	-2.74
Transportation equip. (37)	16.0	31.7	-38.8	-8.3	3.43	-1.42	-3.01
Instruments, misc.(38+39)	8.0	40.8	7.8	1.4	4.13	0.72	-3.41

Sources: See the text.

Table 2

Akaike Information Criterion from Regressions of TFP on Export Variety, 1975-1991

Industry (SIC numbers)	Two-year lag on Variety	One-year lag on Variety	Current Variety	One-year lead on Variety	Two-year lead on Variety
Primary products:					
Food Products (20)	3.79	4.03	3.80	**3.73**	3.99
Textiles (22)	3.89	**3.88**	3.91	3.94	4.01
Wood products (24+25)	5.43	5.51	5.49	**5.24**	5.32
Paper & printing (26+27)	4.41	4.42	**4.38**	4.45	4.51
Leather products (31)	5.42	5.42	**5.13**	5.47	5.69
Stone, clay & glass (32)	2.84	2.78	**2.74**	2.92	2.94
Primary metals (33)	3.20	3.39	**2.99**	3.47	3.26
Secondary products:					
Beverages & tob. (208+21)	**3.80**	4.72	4.85	4.93	4.99
Apparel (23)	**5.01**	5.21	5.28	5.10	**5.01**
Chemicals & plastics (28)	5.30	**4.98**	5.17	5.34	5.20
Rubber products (30)	5.29	5.26	**5.24**	5.32	5.39
Fabricated metal prod. (34)	4.62	4.71	4.68	4.71	**4.33**
Machinery (35)	3.06	2.98	3.06	**2.35**	2.84
Electrical products (36)	**4.62**	**4.62**	**4.62**	4.71	4.78
Transportation equip. (37)	**4.54**	**4.54**	**4.54**	4.62	4.68
Instruments, misc. (38+39)	4.80	4.85	4.83	**4.70**	4.95

Note: Regressions also include a dummy variable for 1981. The Akaike information criterion equals ln(SSR/N)+(2K/N), where SSR is the sum of squared residuals, N is the number of observations, and K is the number of estimated coefficients. The minimum values for each industry are shown in bold.

Table 3

Regressions of TFP on Export Variety, 1975-1991

Industry (SIC numbers)	N	*Estimated with OLS*		*Estimated with SUR*	
		Export Variety	R^2	Export Variety	R^2
Primary Products:					
Food Products (20)	16	0.11	0.38	**0.12**	0.47
		(0.87)		**(2.36)**	
Textile mill products (22)	17	-0.01	0.54	-0.01	0.37
		(-0.11)		(-1.12)	
Wood products (24+25)	16	0.02	0.08	-0.14	0.01
		(0.05)		(-0.70)	
Paper & printing (26+27)	17	-0.50	0.03	**-0.49**	0.13
		(-1.43)		**(-4.52)**	
Leather products (31)	17	**-2.98**	0.53	**-2.71**	0.49
		(-3.17)		**(-5.16)**	
Stone, clay & glass (32)	17	0.04	0.51	0.04	0.51
		(0.14)		(1.14)	
Primary metals (33)	17	0.14	0.71	**0.14**	0.61
		(1.58)		**(12.8)**	
Secondary products:					
Beverages & tob. (208+21)	17	**0.20**	0.69	**0.20**	0.67
		(3.36)		**(21.4)**	
Apparel (23)	17	**0.84**	0.34	**0.83**	0.27
		(3.06)		**(7.84)**	
Chemicals & plastic (28)	17	**0.22**	0.43	**0.22**	0.32
		(3.16)		**(9.59)**	
Rubber products (30)	17	0.27	0.45	**0.29**	0.28
		(1.17)		**(3.79)**	
Metal products (34)	15	**0.27**	0.67	**0.28**	0.66
		(2.09)		**(6.13)**	
Machinery (35)	16	0.23	0.84	**0.24**	0.44
		(1.42)		**(31.9)**	
Electrical products (36)	17	-0.15	0.36	**-0.17**	0.35
		(-0.44)		**(-1.66)**	
Transportation equip. (37)	17	-0.002	0.61	0.007	0.59
		(-0.06)		(1.25)	
Instruments, misc. (38+39)	16	**0.72**	0.32	**0.76**	0.28
		(1.86)		**(3.77)**	

Note: T-statistics are in parentheses, and coefficients on export variety that are significant at the 90% level are in bold. Regressions also include industry fixed-effects, yearly fixed-effects, and an industry dummy variable for 1981, which are not reported. The Durbin-Watson statistics fluctuate around 2 across industries.

Table 4

3SLS Regressions of TFP on Export Variety and Controls, 1975-1991

Industry (SIC numbers)	Export Variety	Imperfect Competition	Electricity Use	R^2, N
Primary products:				
Food Products (20)	**0.28**	0.001	0.82	0.46, 16
	(5.53)	(0.003)	(1.70)	
Textiles (22)	**-0.05**	0.42	-0.15	0.74, 17
	(-2.47)	(7.71)	(-0.49)	
Wood products (24+25)	-0.21	0.01	-0.44	0.07, 16
	(-1.13)	(0.11)	(-1.30)	
Paper & printing (26+27)	**-0.35**	0.03	1.83	0.26, 17
	(-2.95)	(0.22)	(3.46)	
Leather products (31)	**-2.68**	0.31	1.11	0.64, 17
	(-7.53)	(3.28)	(2.66)	
Stone, clay & glass (32)	**0.21**	0.16	-0.19	0.64, 17
	(3.95)	(2.32)	(-1.36)	
Primary metals (33)	0.02	0.26	-0.12	0.74, 17
	(1.15)	(4.47)	(-0.60)	
Secondary products:				
Beverages & tob. (208+21)	**0.18**	0.12	0.22	0.75, 17
	(9.57)	(2.70)	(0.52)	
Apparel (23)	**1.23**	0.42	0.17	0.43, 17
	(8.02)	(2.89)	(0.23)	
Chemicals & plastic (28)	**0.15**	0.72	1.45	0.87, 17
	(6.41)	(9.93)	(4.68)	
Rubber products (30)	0.02	0.91	2.90	0.47, 17
	(0.13)	(7.40)	(3.54)	
Metal products (34)	**0.29**	0.20	0.27	0.75, 15
	(5.21)	(2.30)	(0.79)	
Machinery (35)	**0.11**	0.15	-0.36	0.35, 16
	(2.34)	(2.88)	(-1.36)	
Electronic products (36)	-0.20	-0.03	1.71	0.38, 17
	(-0.80)	(-0.25)	(1.06)	
Transportation equip. (37)	**0.02**	0.47	-1.19	0.73, 17
	(1.85)	(4.02)	(-1.07)	
Instruments, misc. (38+39)	**1.24**	-0.52	0.80	0.18, 16
	(3.19)	(-1.76)	(2.20)	

Note: T-statistics are in parentheses, and coefficients on export variety that are significant at the 90% level are in bold. Regressions also include industry fixed-effects and an industry dummy variable for 1981, which are not reported. The Durbin-Watson statistics fluctuate around 2 across industries.

Table 5

3SLS Regressions of TFP on Export Variety and Controls, 1975-1991

Industry (SIC numbers)	Export Variety	Imperfect Competition	Import Growth	Export Growth	R^2, N
Primary Products:					
Food Products (20)	**0.12**	0.33	0.08	0.18	0.69, 16
	(2.33)	(1.58)	(2.03)	(3.79)	
Textile mill products (22)	**-0.06**	0.46	-0.09	-0.12	0.79, 17
	(-3.61)	(9.17)	(-1.50)	(-2.36)	
Wood products (24+25)	0.02	-0.04	0.24	0.11	0.15, 16
	(0.08)	(-0.34)	(2.71)	(1.26)	
Paper & printing (26+27)	-0.18	0.14	-0.11	0.19	0.26, 17
	(-1.31)	(1.34)	(-1.94)	(3.19)	
Leather products (31)	**-2.66**	0.35	-0.005	0.004	0.61, 17
	(-7.19)	(4.01)	(-0.33)	(0.13)	
Stone, clay & glass (32)	**0.28**	0.07	-0.05	-0.08	0.66, 17
	(5.29)	(1.17)	(-3.01)	(-3.47)	
Primary metals (33)	**-0.08**	0.59	0.05	0.26	0.75, 17
	(-2.26)	(5.55)	(2.25)	(4.33)	
Secondary products:					
Beverages & tob. (208+21)	**0.18**	0.05	0.06	0.02	0.75, 17
	(10.88)	(0.82)	(1.57)	(1.15)	
Apparel (23)	**2.09**	0.91	0.07	-0.33	0.64, 17
	(11.63)	(7.53)	(4.67)	(-7.40)	
Chemicals & plastics (28)	**0.18**	0.58	0.12	-0.02	0.83, 17
	(6.96)	(10.12)	(4.00)	(-0.36)	
Rubber products (30)	**0.17**	0.55	0.19	0.07	0.62, 17
	(2.00)	(7.65)	(2.83)	(1.07)	
Fabricated metal prod. (34)	**0.29**	0.23	-0.01	-0.01	0.73, 15
	(5.65)	(2.74)	(-0.22)	(-0.24)	
Machinery (35)	**0.17**	0.09	0.03	-0.04	0.51, 16
	(6.39)	(2.05)	(1.79)	(-1.11)	
Electrical products (36)	-0.24	-0.04	0.11	0.05	0.40, 17
	(-1.07)	(-0.30)	(0.87)	(0.35)	
Transportation equip. (37)	0.01	0.42	-0.003	-0.06	0.74, 17
	(1.30)	(4.57)	(-0.09)	(-2.03)	
Instruments, misc. (38+39)	**0.55**	-0.55	-0.01	0.45	0.48, 16
	(3.65)	(-2.91)	(-0.20)	(4.49)	

Note: T-statistics are in parentheses, and coefficients on export variety that are significant at the 90% level are in bold. Regressions also include industry fixed-effects and an industry dummy variable for 1981, which are not reported. The Durbin-Watson statistics fluctuate around 2 across industries.

Table 6

Regressions of TFP on Own and Upstream Export Variety, 1975-1991

Industry (SIC numbers)	N	*Estimated with OLS* Export Variety *Own Industry*	 *Upstream Industries*	R^2	*Estimated with SUR* Export Variety *Own Industry*	 *Upstream Industries*	R^2
Primary Products:							
Food Products (20)	16	0.28	-0.56	0.50	**0.28**	**-0.64**	0.50
		(1.50)	(-1.38)		**(5.19)**	**(-5.11)**	
Textile mill products (22)	17	-0.008	0.007	0.50	-0.003	0.007	0.48
		(-0.10)	(0.05)		(-0.21)	(0.05)	
Wood products (24+25)	16	0.01	-0.15	0.16	0.08	0.08	0.07
		(0.03)	(-0.67)		(0.37)	(0.37)	
Paper & printing (26+27)	17	-0.54	-0.33	0.10	**-0.43**	-0.21	0.09
		(-1.58)	(-1.40)		**(-2.69)**	(-1.44)	
Leather products (31)	17	**-3.03**	-0.36	0.53	**-2.42**	-0.15	0.51
		(-3.28)	(-1.59)		**(-5.23)**	(-1.05)	
Stone, clay & glass (32)	17	-0.006	-0.31	0.55	-0.002	**-0.27**	0.56
		(-0.02)	(-0.78)		(-0.05)	**(-3.51)**	
Primary metals (33)	17	**0.20**	0.14	0.75	**0.20**	**0.16**	0.74
		(1.80)	(0.36)		**(10.9)**	**(2.35)**	
Secondary products:							
Beverages & tob. (208+21)	17	**0.20**	0.06	0.69	**0.20**	0.02	0.69
		(2.98)	(0.22)		**(10.5)**	(0.19)	
Apparel (23)	17	**0.80**	0.04	0.42	**0.79**	**0.11**	0.39
		(2.91)	(0.41)		**(4.91)**	**(1.93)**	
Chemicals & plastics (28)	17	**0.19**	**0.73**	0.55	**0.18**	**0.82**	0.56
		(2.69)	**(2.16)**		**(6.50)**	**(6.73)**	
Rubber products (30)	17	0.25	0.29	0.53	**0.22**	**0.21**	0.51
		(1.10)	(1.29)		**(3.34)**	**(2.02)**	
Fabricated metal prod. (34)	15	0.21	**0.24**	0.79	**0.20**	**0.26**	0.78
		(1.60)	**(2.09)**		**(4.76)**	**(5.85)**	
Machinery (35)	16	0.23	0.07	0.84	**0.24**	**0.04**	0.83
		(1.38)	(0.49)		**(12.5)**	**(1.99)**	
Electrical products (36)	17	-0.25	-0.07	0.32	**-0.29**	-0.16	0.33
		(-0.59)	(-0.18)		**(-2.69)**	(-1.21)	
Transportation equip. (37)	17	0.02	**0.59**	0.78	**0.03**	**0.57**	0.78
		(0.76)	**(2.73)**		**(4.64)**	**(7.83)**	
Instruments, misc. (38+39)	16	-0.16	-6.98	0.41	**0.74**	-0.13	0.37
		(0.51)	(-0.73)		**(4.32)**	(-0.75)	

Note: T-statistics are in parentheses, and coefficients on export variety that are significant at the 90% level are in bold. The regressions also include a constant term and year-dummy for 1981, which are not reported. The Durbin-Watson statistics fluctuate around 2 across industries.