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PRICES AND FACTOR DEMAND IN AN ENDOGENIZED INPUT – OUTPUT MODEL

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Abstract:
This paper combines factor demand functions and price equations derived from a *Generalized Leontief* cost function with the traditional input – output price model. At the first level of aggregation *Generalized Leontief* cost functions for the factors intermediate input and labour are set up for the manufacturing industries of the Austrian economy. These functions determine factor demand for materials and labour as well as output prices for given input prices. At the second level of aggregation the intermediate demand input is split up according to the input – output structure. There the repercussion of domestic prices on input prices as described in the traditional input – output – price model is taken into account. Model simulations reveal the link between the technical coefficients and the econometric equations for domestic prices, input prices and factor demand.

Key words: Input – output price model, Generalized Leontief cost functions, endogenous technical coefficients

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Introduction

Several authors have presented input – output (i – o) models with endogenous technical coefficients, where the coefficients by themselves depend on (input) prices. The most prominent recent example of a fully endogenized i - o model of this type can be found in Tokutsu (1994), where CES and Cobb Douglas production functions are used to describe the substitution processes between capital, energy, other materials (intermediate inputs) and labour. Tokutsu (1994) sets up a model with production functions and the corresponding dual cost functions, where the price of each bundle is derived as the cost aggregate. He does not take into account the repercussions of output prices on the price of intermediate demand as described in the traditional i – o price model.

As Truchon (1984) has shown, when endogenizing technical coefficients by production/cost functions, it may be important to take into account these repercussions of output prices on input prices in the i – o price model. Endogenizing of technical coefficients therefore becomes a two step task. The first step consists in describing the cost function by which the input quantities of intermediate demand depend on the price for intermediate inputs. In the second step it must be taken into account that the output prices derived from the cost function again change the price for intermediate inputs given the i – o matrix. That requires a nested cost/production function structure in intermediate demand.

An important aspect of an i - o supply model with endogenized technical coefficients also stressed by Tokutsu (1994) is, that it changes also the demand side. If we ignore the difference between imported and domestic goods we could write the traditional static i – o model for quantities and prices as:

(1) $\mathbf{X} = [\mathbf{I} - \mathbf{A}]^{-1}\mathbf{F}$

(2) $\mathbf{p} = \mathbf{p}\,\mathbf{A} + \mathbf{w}\,\mathbf{L/X} + \mathbf{c}$

where **X** is a column vector of output and **F** is a column vector of final demand, **p** is a row vector of output prices and **w**, **L/X**, and **c** are row vectors of wage rates, labour input coefficients and other value added categories respectively.

In this model both demand and supply are determined independent from prices. Introducing cost functions with labour and intermediate demand for example would allow to write input demand depending on relative input prices:

(3) $\mathbf{A} = \mathbf{A}\ (\mathbf{p/w})$; $\mathbf{L/X} = \mathbf{L/X}\ (\mathbf{w/p})$

Inserting this factor demand in the traditional i – o model now shows that this change in the supply side of the model (2a) also changes the demand side. In (1a) intermediate demand as a part of the (goods) demand has become endogenous and depends on prices now. Final demand could additionally be thought of depending on prices **p** what is actually a well known field of i – o modelling.

(1a) $\mathbf{X} = [\mathbf{I} - \mathbf{A}\ (\mathbf{p/w})]^{-1}\ \mathbf{F}$

(2a) $\mathbf{p} = \mathbf{p}\ \mathbf{A}\ (\mathbf{p/w}) + \mathbf{w}\ \mathbf{L/X}\ (\mathbf{w/p}) + \mathbf{c}$

This paper sets up a model of extended *Generalized Leontief* cost functions for industrial activities in Austria and incorporates them into an i – o price model. That includes modelling of the influence of input prices on input demand as well as of the repercussions of output prices on input prices, both expressed by the term $\mathbf{p} = \mathbf{p}\ \mathbf{A}\ (\mathbf{p/w})$ in (2a). In section 1 extended Generalized Leontief functions with a deterministic trend for technical progress and the capital stock as a quasi-fixed factor as introduced by Morrison (1990) and Meade (1998) are derived and estimated. The exogenous variables are factor prices for intermediate demand and labour, capital input and the output level. These functions determine factor demand for materials and labour as well as output prices given the mechanism for price setting. In section 2 the second level of aggregation is introduced, where the influence of domestic prices on the prices for intermediate demand as described in the traditional i – o price model is taken into account. The emphasis of this part is on the feedbacks of the factor demand functions as well as of the traditional i – o price model. A change of total intermediate input by industry changes the technical coefficients and the changing domestic prices change the price for intermediate demand by industry.

Section 3 presents the results of model simulations of a simultaneous import price/export demand shock. First the results of the export demand shock of the static open Leontief model according to (1) are calculated. Then the changes brought about by the import price shock on the price of intermmediate demand and consequently on factor demand coefficients according to (3) and on output prices according to (2a) are derived. It can then be shown that the impact of the export demand shock on output according to (1a) differs from the results of the static open Leontief model, although the important reactions of final demand and imports to prices have not been taken into account in this partial model.

1. *Input demand and output prices*

Industrial organizations literature nowadays generally treats price setting behaviour of firms in an overall model of goods and factor markets. The seminal paper for this approach is Appelbaum (1982), a recent empirical application for various industrial sectors in Austria can be found in Aiginger, Brandner, Wüger (1995). Besides that numerous studies treating with factor demand derived from cost functions also included a price equation, which was estimated simultaneously with the factor demand equations in one system.
Important examples for this line of research mainly using the flexible cost functions ‚*Translog*‘ and ‚*Generalized Leontief*‘ are Berndt – Hesse (1986), Morrison (1989, 1990), Meade (1998) and Conrad - Seitz (1994). The price setting equations combined with the factor demand equations differ in these studies. Some start from the perfect competition assumption, so that prices equal marginal costs as is the case in Berndt – Hesse (1986), Morrison, (1988, 1990) and Meade (1998). An example for a ‚mark up pricing‘ equation combined with factor demand corresponding to the market form of monopolistic competition can be found in Conrad - Seitz (1994).

An interesting common feature of the cited studies is the treatment of the capital stock as a fixed or quasi – fixed factor. The theoretical reasoning behind this assumption is the existence of a short and a long run cost function (s.: Meade (1998), who shows the relationship between these cost functions). In the short run (during one period) the capital stock is fixed and can only be adjusted in the next period. This approach allows two extensions: the derivation of a capacity utilization measure (Morrison (1990), Meade (1998)) and the inclusion of an investment equation in the model, where investment describes the adjustment process of the actual to the desired capital stock (Allen, Hall (1997)).

Starting from that approach total costs C of an industry are made up of variable costs G for the use of variable inputs and the fixed costs, $Z_k X_k$, for the fixed inputs X_k as is described in (4). Here Z_k stands for the ‚shadow price‘ of the fixed input k , which must be equal to the impact of the input quantity of k on variable costs as derived in (5). The ‚shadow price‘ measures cost savings for variable inputs brought about by an unit increase in the input quantity of the fixed factor.

(4) $C = G + \sum_k Z_k X_k$

(5) $Z_k = - \delta G / \delta X_k$

In this study the variable factors are the inputs of intermediate demand of an industry, V, with price p_v and labour input L with wage rate w and capital stock K is the fixed factor.

The price p for output X shall be determined by a constant mark up μ on variable costs as in Conrad, Seitz (1994), which corresponds to the model of monopolistic competition in the markets. At perfect competition the price would equal marginal costs (p=MC) like in Berndt, Hesse (1986) and Meade (1998).

(6) $G = p_v V + wL \quad ; \quad C = p_v V + wL + Z_k K \quad ; \quad p = (1 + \mu)(p_v V/X + wL/X)$

In this study an extension of the *Generalized Leontief* – cost function, which is based on the work of Morrison (1990) is used. Actually this is the same approach as Meade (1998) uses in his study to derive factor demand functions for the INFORUM model.

The original *Generalized Leontief* – cost function was first proposed by Diewert (1971). Different concepts of extending the function for technical progress variables and fixed factors have been developed since then , an example for the extension by fixed factors is Mahmud (1987). Extensions to take into account technical progress have first been presented by Parks (1971), Woodland (1975) and Diewert, Wales (1987).

Morrison (1989, 1990) has developed different extensions of the *Generalized Leontief* function by technical progress and fixed factors and has demonstrated various applications of this approach. Meade (1998) has first used this approach in the context of a large i – o – model (INFORUM).

The *Generalized Leontief* cost function suggested by Morrison (1990) with variable factors indexed i,j and a fixed factor k can be written as:

$$(7) \quad G = X[\sum_i \sum_j \alpha_{ij} (p_i p_j)^{½} + \sum_i \delta_{it} p_i t^{½} + \sum_i \gamma_{tt} p_i t] + X^{½}[\sum_i \beta_{ik}\, p_i x_k^{½} + 2\sum_i \gamma_{tk} p_i t^{½} x_k^{½})] + \sum_i p_i \gamma_{kk} x_k$$

This function describes the variable costs part of (4) with a deterministic trend (t) for technical progress. Both x_k and t enter in root transformation as well as in level and there are interaction terms between the fixed factor k and technical progress. The use of Shephard's Lemma yields factor demand , as the partial derivatives of the cost function to factor prices (p_v , w) give the input quantities (V, L) :

$$(8)\ (V/X) = \alpha_{VV} + \alpha_{VL}\, (w/p_v)^{½} + \delta_{Vt} t^{½} + \gamma_{tt} t + \beta_{VK}\, (K/X)^{½} + 2\, \gamma_{tK} t^{½}\, (K/X)^{½} + \gamma_{KK}\, (K/X)$$

$$(9)\ (L/X) = \alpha_{LL} + \alpha_{VL}\, (p_v/w)^{½} + \delta_{Lt} t^{½} + \gamma_{tt} t + \beta_{LK}\, (K/X)^{½} + 2\, \gamma_{tK} t^{½}\, (K/X)^{½} + \gamma_{KK}\, (K/X)$$

Symmetry concerning α_{VL} is assumed ($\alpha_{VL} = \alpha_{LV}$). Other restrictions apply for one parameter for technical progress (γ_{tt}), the parameter for the interaction term of the fixed factor and technical progress (γ_{tK}) as well as for one parameter for the fixed factor (γ_{KK}) which are forced to be the same in the two factor demand equations.

Price setting could follow different rules given the cost function (7). The assumption of perfect competition in the markets would imply that prices equal marginal costs ($p = \delta G/\delta X$). This hypothesis is not followed here. Instead a fixed mark up μ on marginal costs is introduced representing the model of monopolistic competition. As an alternative one could work with a variable mark up μ set on marginal costs implicitly including the ‚conjectual variations‘ of the oligopolistic model (s.: Aiginger, Brandner, Wüger (1995)). This variable mark up then would depend on the competitive price (usually approximated by the import price p_m), and the input prices p_v and w.

Marginal costs $\delta G/\delta X$ are in our case given with:

$$(10)\ \delta G/\delta X = \alpha_{VV}\, p_v + \alpha_{LL} w + 2\alpha_{VL}\,(p_v w)^{1/2} + \delta_{vt} p_1 t^{1/2} + \delta_{Lt} p_2 t^{1/2} + \gamma_{tt}(p_v + w)t + 1/2(\beta_{VK}\, p_v (K/X)^{1/2} + \beta_{LK} w (K/X)^{1/2} + 2\gamma_{tK}(p_v + w)\, t^{1/2}(K/X)^{1/2})$$

So with a fixed mark up one would get:

$$(11)\ p = [1 + \mu]\,[\alpha_{VV}\, p_v + \alpha_{LL} w + 2\alpha_{VL}\,(p_v w)^{1/2} + \delta_{vt} p_1 t^{1/2} + \delta_{Lt} p_2 t^{1/2} + \gamma_{tt}(p_v + w)t + 1/2(\beta_{VK}\, p_v (K/X)^{1/2} + \beta_{LK} w (K/X)^{1/2} + 2\gamma_{tK}(p_v + w)\, t^{1/2}(K/X)^{1/2})]$$

From the Generalized Leontief – functions one can derive cross- and own price elasticities. The relationship between the traditional cross- and own price elasticities and the ‚Allen elasticities of substitution‘ (AES) $\sigma(ij)$ is given with $\varepsilon(ij) = \sigma(ij)\, S_j$, where S_j represents the cost share of factor j. For AES the symmetry condition: $\sigma(ji) = \sigma(ij)$ holds.
The elasticities in this 2 factor– model are given with:

$$(12)\ \varepsilon(LL) = (\delta L/\delta w)\,(w/L)$$
$$\varepsilon(VV) = (\delta V/\delta p_v)\,(p_v/V)$$
$$\varepsilon(VL) = (\delta V/\delta w)\,(w/V)$$
$$\varepsilon(LV) = (\delta L/\delta p_v)\,(p_v/L)$$

As microeconomic theory states, that the compensated price elasticities must sum up to zero, in this 2 factor model we have: $\varepsilon(LL) = -\varepsilon(LV)$ and $\varepsilon(VV) = -\varepsilon(VL)$. Elasticities can be directly derived from the input – output equations (8) and (9), where the inputs of V and L are functions of input prices w and p_v . This gives for cross- and own - price elasticities:

$$(13)\quad \varepsilon(LL) = -(\alpha_{VL}/2)\,(Y/L)\,(p_v/w)^{1/2}$$
$$\varepsilon(VV) = -(\alpha_{VL}/2)\,(Y/V)\,(w/p_v)^{1/2}$$
$$\varepsilon(VL) = (\alpha_{VL}/2)\,(Y/V)\,(w/p_v)^{1/2}$$
$$\varepsilon(LV) = (\alpha_{VL}/2)\,(Y/L)\,(p_v/w)^{1/2}$$

These are the short run elasticities for input price changes for a given level of capital stock. Morrison (1990) and Meade (1998), who are interested in a capacity utilization measures also derive the long run price elasticities, i.e. taking into account the adjustment of the capital stock.

The system consisting of (8), (9) and (11) has been estimated for the following 12 manufacturing industries of the Austrian economy, which represent the industries 8 to 21 (excluding 13 and 20 due to lack of reliable time series data) in the classification of 32 industries used in the E3ME model (Barker, et.al. (1999)):

8 Ferrous & Non Ferrous Metals
9 Non-metallic Mineral Products
10 Chemicals
11 Metal Products
12 Agricultural & Industrial Machines
13 Office Machines
14 Electrical Goods
15 Transport Equipment
16 Food, Drink & Tobacco
17 Textiles, Clothing & Footwear
18 Paper & Printing Products
19 Rubber & Plastic Products
20 Recycling, Emission Abatement
21 Other Manufactures

The data for gross output, value added and investment at current and constant prices have been taken from the National Accounts databank of the Austrian Statistical Office. Capital stock by industry has been approximated by cumulated investment. A system estimator (SURE) has been applied to time series data (1976 – 94) using *Eviews*.

Table 1 shows the cross – price elasticities derived from the parameter estimates and calculated with the sample means of Y/V, Y/L, w/p_v and p_v/w . All elasticities have the expected signs and summing up to zero is also fulfilled. The magnitude of the elasticities differs significantly between industries for the two factors V and L but can in general be described as rather low.

Table 1: Cross price elasticities between V (intermediate demand) and L (labour)

8 Ferrous & Non Ferrous Metals			
	e(ij)	L	V
	L	-0,217	0,217
	V	0,077	-0,077
9 Non-metallic Mineral Products			
	e(ij)	L	V
	L	-0,108	0,108
	V	0,058	-0,058
10 Chemicals			
	e(ij)	L	V
	L	-0,164	0,164
	V	0,034	-0,034
11 Metal Products			
	e(ij)	L	V
	L	-0,022	0,022
	V	0,011	-0,011
12 Agricultural & Industrial Machines			
	e(ij)	L	V
	L	-0,292	0,292
	V	0,119	-0,119
14 Electrical Goods			
	e(ij)	L	V
	L	-0,257	0,257
	V	0,100	-0,100
15 Transport Equipment			
	e(ij)	L	V
	L	-0,431	0,431
	V	0,149	-0,149

16 Food, Drink & Tobacco

e(ij)	L	V
L	-0,137	0,137
V	0,032	-0,032

17 Textiles, Clothing & Footwear

e(ij)	L	V
L	-0,629	0,629
V	0,281	-0,281

18 Paper & Printing Products

e(ij)	L	V
L	-0,098	0,098
V	0,041	-0,041

19 Rubber & Plastic Products

e(ij)	L	V
L	-0,243	0,243
V	0,139	-0,139

21 Other Manufactures

e(ij)	L	V
L	-0,220	0,220
V	0,097	-0,097

The estimation results, which can not be fully reproduced here in general yield significant parameter estimates, especially for the price parameters α_{VL}. That means that the elasticities presented in Table 1 all rely on significant parameter estimates. In some industries the restrictions for the fixed factor and technological progress parameters, especially for γ_{tt} and γ_{tK} raised some problems. Experiments have shown, that in some but not all of these cases a less restrictive approach gave better results.

Another important result are significant mark up parameters in all industries with reliable magnitudes for the implicit mark up ranging from about 15 to 35 %.

2. Prices of intermediate demand

In the last section a model with exogenous factor prices p_v and w, as well as exogenous capital coefficient and output level was set up. The wage rate will kept as exogenous in this study as there will be no labour market block attached. The price of intermediate demand an industry faces shall be endogenized by linking the factor demand and price equations of the last section with the traditional i – o price model. We know, that in the i – o price model for given technical coeffient matrizes for domestic and imported inputs the vector of domestic prices (**p**) is determined by domestic output prices themselves (**p**) and import prices ($\mathbf{p_m}$), which can be written as an extension of (2):

(14) $\mathbf{p} \; = \; \mathbf{p\,A(d)} + \mathbf{p_m\,A(m)} + \mathbf{w\,L/X} + \mathbf{c}$

Here the technical coefficients matrix is split up into a domestic (**A(d)**) and an imported (**A(m)**) matrix. It will be shown in this section, how the i – o model can be used to introduce disaggregation in intermediate demand and thereby endogenizing the price p_v .
From i – o tables we know, that total intermediate demand of industry i, V_i , equals the sum of inputs produced by other domestic industries (V_{ji}(d)) and imported inputs (V_{ji}(m)):

Industry (i,j)

1 ....n

1

.

. V_{ji}

.

n

Σ V_1 ....V_n

The input coefficient along the column of an industry (V_i / X_i), which was modelled in the last section with the help of the *Generalized Leontief* function ((5), (7)) is given as the total of the two column sums for *i* of technical coefficient matrizes (derived from i – o tables) for domestic and imported goods (**A(d)** , **A(m)**):

Industry (i,j)

1 ....n

1

.

. V_{ji} / X_i = A

.

n

Σ V_1/X_1 .... V_n /X_n

From the traditional i – o – price model we can now write the intermediate input coefficient at current prices (p_vV/X) as a matrix multiplication of a row vector of domestic prices **p** and a row vector of import prices $\mathbf{p_m}$ with **A(d)** and **A(m)** to get the the row vector $\mathbf{p_v V/X}$:

(15) $(\mathbf{p_v V/X}) = (\mathbf{p_m\, A(m)} + \mathbf{p\, A(d)})$

In analogy to that we can introduce the i – o level of disaggregation in the factor demand equations described in the last section by treating the column sum V/X as a bundle of *n* inputs.

At this second stage we could have well defined production functions with corresponding elasticities of substitutions as in Tokutsu (1994), who assumes Cobb Douglas functions and further splits the bundle of *n* inputs into energy and other intermediate demand. This could yield a structure of nested production functions as is used in general equilibrium models with totally flexible input – output coefficients as in Conrad, Schmidt (1998). This method is not followed here as the model presented here is an econometric model relying on time series data. In Austria time series data of i – o matrizes are not available. The emphasis of this study is on the consequences of changes in the price model for i – o coefficients and therefore for the solution of the quantity model, which often is not so clear and explicitly described in general equilibrium models.

Assuming a constant structure for the *n* inputs within V/X given by matrizes Φ with elements V_{ji}/V_i each for domestic (d) and imported (m) inputs, $\mathbf{p_v}$ becomes:

(16) $\mathbf{p_v} = (\mathbf{p_m}\,\mathbf{\Phi(m)} + \mathbf{p}\,\mathbf{\Phi(d)})$

This relationship (16) now introduces together with (11) the feedback of output price changes on output prices. Another consequence is a change in the technical coefficients matrix, as the a_{ji} – elements of **A(d)** and **A(m)** are the product of fixed coefficients in **Φ** and changing coefficients (V_i/X_i) :

(17) $a_{ji} = (V_i/X_i)\,(V_{ji}/V_i)$.

Equation (16) solves exactly for the i – o years, in other years the price index of National Accounts for $\mathbf{p_v}$ may deviate from the value calculated with (16) using fixed matrices of the base year for **Φ(m)** and **Φ(d)** . With fixed matrizes **Φ** derived from the i – o table 1990 and time series (1976 – 94) of the vectors **p** and $\mathbf{p_m}$ a vector representing the price – index of intermediate demand $\mathbf{p_v^*}$ according to (16) was constructed.
Simple regressions for the elements of $\mathbf{p_v^*}$ have been used to explain $p_{v,t}$, where a time index is introduced and u_t is the residual with the usual statistical properties:

$$(18)\ (p_{v,t} - p_{v,t-1}) = a_0 + a_1 (p^*_{v,t} - p^*_{v,t-1}) + u_t$$

In this model the price of intermediate demand and the i – o technical coefficients have been endogenized with exogenous import prices p_m and exogenous intermediate demand structures given by fixed matrizes **Φ**.

3. Simulations of an import price/export demand shock

Starting point for the simulations is the static open Leontief model with domestic and imported goods, where output is given as:

$$(19)\ \mathbf{X} = [\mathbf{I} - \mathbf{A(d)}]^{-1}\ \mathbf{F(d)}$$

The first extension to this static model in this study are the factor demand and output price equations:

$$(8)\ (V/X) = \alpha_{VV} + \alpha_{VL} (w/p_v)^{½} + \delta_{Vt}t^{½} + \gamma_{tt}t + \beta_{VK} (K/X)^{½} + 2\ \gamma_{tK}t^{½} (K/X)^{½} + \gamma_{KK} (K/X)$$

$$(9)\ (L/X) = \alpha_{LL} + \alpha_{VL} (p_v/w)^{½} + \delta_{Lt}t^{½} + \gamma_{tt}t + \beta_{LK} (K/X)^{½} + 2\ \gamma_{tK}t^{½} (K/X)^{½} + \gamma_{KK} (K/X)$$

$$(11)\ p = [1 + \mu]\ [\alpha_{VV}\ p_v + \alpha_{LL}w + 2\alpha_{VL} (p_v w)^{½} + \delta_{vt}p_1t^{½} + \delta_{Lt}p_2t^{½} + \gamma_{tt}(p_v + w)t + ½(\beta_{VK}\ p_v (K/X)^{½} + \beta_{LK}w(K/X)^{½} + 2\gamma_{tK}(p_v + w)\ t^{½}(K/X)^{½})]$$

The feedback on output prices, endogenous intermediate demand prices and the repercussions on matrix **A** are determined by:

(16) $\mathbf{p_v} = (\mathbf{p_m}\,\boldsymbol{\Phi}(\mathbf{m}) + \mathbf{p}\,\boldsymbol{\Phi}(\mathbf{d}))$

(17a) $a_{ji} = (V_i/X_i)\ (V_{ji}/V_i)$; $a_{ji}\,(d) = a_{ji}\, d_{ji}$; $a_{ji}\,(m) = a_{ji}\, m_{ji}$

In (17a) the total technical coefficient a_{ji} is split up into a domestic and an imported coefficient by applying constant domestic and import shares (d_{ji} , m_{ji})for each cell of the matrix. The matrix **A(d)** in (1a) is made up of the resulting coefficients a_{ji} (d) , so that changes in the price model have a direct impact on the solution of the quantity model. This impact is treated as an open end of the model presented here. Important mechanisms *not* described in this partial model are (i) the impact of import prices on imported and domestic demand (ii) the impact of prices on the level and structure of final demand and (iii) the impact of employment and price changes on wage formation.

The simulation exercise presented assumes that all import prices of goods 8 to 21 as described in the classification above would have been 10% below their actual level in 1990 and that all exports of the same goods would have been 10% above their actual level in 1990.
The first step consists in calculating the output effects of the static open Leontief model with the help of (19) inserting a new final demand vector with the export increase. In a second step, the whole price/factor demand model is solved to derive a new coefficient matrix **A(d)**. Then the static open Leontief model is solved again with this new technical coefficient matrix. The purpose of the simulation exercise is to quantify the importance of endogenizing i – o coefficients for simulations and to show links between the consistent formulated price model, which could stand alone and the quantity model.

Table 2 shows the impact of the import price shock on the prices of intermediate demand, on output prices and on the intermediate demand input coefficient (V_i/X_i). One can observe, that a 10% import price fall has a strong impact on the price of intermediate demand in some industries and also on the output price. The latter depends on the size of the mark up μ in (11). In general the output price effect is slightly below the input price effect. Given the low own price elasticities the impact on the total input coefficient is small.

Table 3 compares the results of the two model versions in terms of the induced effects on gross output in 1990 at constant prices of 1983. For this purpose I use the Austrian i – o table for 1990 of the Austrian Statistical Office in Austrian classification (Betriebssystematik 1968), where all domestic rows have been deflated with the corresponding gross output deflator and all import rows with the corresponding import deflator. This has been done at the most disaggregated level (3 digits), where data are available. The resulting table is then transformed into NACE classification using classification converters relying on the classification correspondance tables and the full census of the Austrian economy (1995) in double classification, both published by the Austrian Statistical Office. As for the factor demand and price equations I used the National Account database remaining differences between the deflated i – o table 1990 in NACE and the National Accounts row and column sums have been considered by rows and columns of ‚statistical difference‘ (= industry 32: Unallocated).

In the first column of Table 3 the effect of an equiproportional export rise of 10% in industries 8 to 21 is calculated in the static open Leontief model, the second column shows the gross output results of the endogenized i – o model. As we would already expect from the results for the input coefficients in Table 2 the differences in gross output between the two model solutions are rather small in absolute terms. An interesting result for i – o analysis is that the differences between the two solutions are lower in the industries directly affected (8 to 21). In this sense it may seem important to take into account the i – o price model changes into the quantity model.

Table 2: Price and intermediate demand effects of an import price shock (- 10%) in 1990: Changes (in %) of input price (p_v), output prices (p) and input coefficient (V/X)

	p_v	p	V/X
8 Ferrous & Non Ferrous Metals	-4,0	-3,9	0,4
9 Non-metallic Mineral Products	-2,4	-1,9	0,1
10 Chemicals	-8,8	-8,4	0,4
11 Metal Products	-1,5	-1,6	0,0
12 Agricultural & Industrial Machines	-4,3	-4,0	0,5
13 Office Machines	-	-	-
14 Electrical Goods	-2,0	-1,6	0,2
15 Transport Equipment	-2,1	-1,7	0,3
16 Food, Drink & Tobacco	-0,8	-0,7	0,0
17 Textiles, Clothing & Footwear	-4,3	-3,2	1,3
18 Paper & Printing Products	-9,0	-7,0	0,4
19 Rubber & Plastic Products	-8,1	-7,2	1,3
21 Other Manufactures	-3,3	-2,8	0,3

Table 3: Output effects of an import price/export demand (- 10% /+ 10%) shock in 1990: Changes of output (δX) in the static open Leontief model vs. endogenized i – o model

	Leontief δ X	Endogenized δ X	Difference in %
1 Agriculture,etc.	1056	1057	0,1
2 Coal & Coke	38	38	0,5
3 Oil & Gas Extraction	46	46	0,5
4 Gas Distribution	339	340	0,5
5 Refined Oil	537	539	0,4
6 Electricity, etc.	1305	1312	0,5
7 Water Supply	32	32	0,5
8 Ferrous & Non Ferrous Metals	5993	6000	0,1
9 Non-metallic Mineral Products	1857	1859	0,1
10 Chemicals	4400	4406	0,1
11 Metal Products	3135	3138	0,1
12 Agricultural & Industrial Machines	5561	5563	0,0
13 Office Machines	48	48	0,0
14 Electrical Goods	4606	4608	0,0

15 Transport Equipment	3621	3621	0,0
16 Food, Drink & Tobacco	1848	1850	0,1
17 Textiles, Clothing & Footwear	3824	3829	0,1
18 Paper & Printing Products	4202	4209	0,2
19 Rubber & Plastic Products	2527	2531	0,1
20 Recycling, Emission Abatement	65	65	0,1
21 Other Manufactures	4166	4167	0,0
22 Construction	461	463	0,5
23 Distribution	2833	2848	0,5
24 Lodging & Catering	195	196	0,6
25 Inland Transport	516	518	0,5
26 Sea & Air Transport	75	76	0,5
27 Other Transport	116	116	0,5
28 Communications	363	364	0,5
29 Bank. Finance & Insurance	2337	2350	0,5
30 Other Market Services	1928	1938	0,5
31 Non – Market Services	310	311	0,5
32 Unallocated	1808	1814	0,3
All industries	60148	60253	0,2

4. Concluding Remarks

A consistent link between the i – o price model and econometric factor demand (for intermediate demand and labour) and price equations is set up in this study. The i – o price model takes into account the link between input and output prices with given technology. If changes in the technology by factor demand equations are allowed and additionally price equations are introduced, this must be built in the structure of the i – o price model. That means integrating the feedback of output prices on input prices as well as the feedback of factor demand changes on the technical coefficients matrix. In this paper these feedbacks are demonstrated both in a theoretical way as well as in an empirical application. The importance of these changes in technical coefficients for the solution of the quantity model are also shown. It seems that this impact is rather low, given the low own price elasticities of intermediate inputs, but makes sense in an i – o framework, as there are important spill over effects.

The presented model is still a partial model with important shortcomings. Especially for the import price/export demand shock shown in this study it is worth noting, that the impact of import prices on imported and domestic demand as well as the impact of prices on the level and structure of final demand are not taken into account. This can only be done in a fully closed i – o model.

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