

A Decomposition of US Net Exports Growth Rates 1966-1991

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August 2007

Preliminary and incomplete. Please do not quote

Abstract

This paper is based on the work of Dixit and Woodland (1982) on the determinants of growth rate of net exports (T). It incorporates the effect of changes in commodity prices, while allows for the presence of jointness in output quantities in order to decompose the determinants of a change in the volume of net exports for an open economy with non-balanced trade. A general equilibrium analysis is implemented where the revenue (GDP) function and the expenditure function are estimated for the US economy for the period 1963 to 1991. Then a decomposition of the growth rate of the net exports is implemented. It involves a terms of trade component, an endowment component, a technological change both in production and consumption and an income component.

Keywords: Net Exports, US Trade, non-balanced trade, 3SLS

JEL classification: F11, F14

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1 Introduction

One of the most characteristic phenomena of the last three decades in the world economy has been the rapid growth of international trade. In particular the value of world merchandise trade has increased from 578 billions in 1973 to 5.4 trillions in 1999 measured in current U.S. dollars (World Trade Organisation, Annual Report). This translates to an annual average growth rate of 6% for the world trade, while world output grew at an average of 3.7% per year over the same period¹. This clearly underlines the increasing significance of international trade in the world economy. One of the countries that has contributed significantly in this dramatic increase of international trade is the US. US exports and imports of merchandise products account for the 12% of world imports and exports and 19% of US GDP for the year 2004 (US Economic Accounts, Bureau of Economic Analysis). Hence, international trade is an important part of the US economy, it is interrelated to many production and consumption decisions and has been a frequent topic of investigation for many researchers.

There exists a vast theoretical literature, see for example Krugman and Baldwin (1987) and Feenstra (1998), that offers four main explanations for the enormous changes in the volume of international trade. The first core explanation is the gradual abolition of restrictive trade policies, mainly tariffs and quotas, that have been introduced by most of the countries through bilateral trade agreements within the World Trade Organisation (WTO). The second is the advancement of technology that has resulted in lower transportation costs. Due to more efficient and less costly means of transportation, it has become profitable to exchange products in international markets that before these changes were not. Thirdly, it is argued that the growth in real income, in the developed countries at least, is another reason of explaining the higher value and volume of international trade. While the last one (Feenstra, 1998) suggests that the rise of outsourcing has led to increased trade volumes between host and home countries.

Most of the empirical work in the existing literature, initiated with the work of Tinbergen (1962), has tried to assess empirically the factors that explain the growth of international trade using the gravity model, see Deardorff (1998) for a survey. In a recent paper using an augmented gravity model, Baier and Bergstrand (2001), found that income growth accounts

¹World Investment Report, United Nations, 1999.

for 66% of trade growth for sixteen OECD countries for the period 1958-1988. While tariff reductions can explain 26% and transport reductions 8% of trade growth respectively. On the other hand different approaches have been followed in an attempt to answer the same question like the work of Rose (1991) and Besedes (2005). Rose (1991) argues that there are three more potential reasons, the convergence of capital labour ratios of countries, the fall in the relative price of tradeables to non tradeables and the growth of international reserves, that could explain the growth of world trade in an analysis of sixteen OECD countries for the period 1951-1985. He finds that for small open economies rises in real output, rises in international reserves and declines in tariffs can explain the growth of their trade, while for large open economies none of the explanatory variables in his analysis has any statistical significance. Besedes (2005) uses a Ricardian model with a continuum of goods for five OECD countries for the period 1884-1992 in order to decompose the growth rate of import shares into two components. The first refers to changes in restrictive trade policies and the second to changes in the supply side of the economy. He finds that the former cannot explain solely the growth of international trade and that changes in the supply side of the economy, mainly technological change, should also be in action.

Another stream of the empirical literature, Laursen and Meltzer (1950), Persson and Svensson (1985) and Mendoza (1995), focuses on nominal factors, mainly exchange rate changes as possible determinants of the value of trade. But there remain some empirical questions that have attracted very little or none of the interest of researches. The first is to asses empirically with the use of a general equilibrium analysis what determines the changes in the volume of trade for a country. Economic theory tells that the answer lays on changes both in the production and consumption side of the economy. Hence, the factors that determine the production and consumption pattern of a country affect simultaneously the volume of its trade. That is changes in the world prices of commodities, changes in the endowments of the economy, technological changes both in the production and consumption and finally income changes.

A change in the world price for a commodity has two opposing effects on the volume of net exports of a country. A decrease in the world price of a commodity will increase the quantities exported for the country producing the commodity, but at the same time will increase its consumption and consequently its volume of imports. The final result is

an empirical question and depends on the price elasticities of supply and demand. On the other hand, changes on the endowments of the economy will change only the output produced and consequently will alter the volume of net exports at the same direction. Technological change in the production side of the economy, usually a positive one, will increase output and consequently will increase exports. But technological change on the demand side and in particular changes on the preferences of consumers towards commodities could either increase or decrease their consumption depending on the direction of the change on the preferences. While changes in income lead to higher consumption for all normal goods and consequently less net exports. All the above show that theoretical predictions are necessary, but not sufficient for determining what actually drives the changes in the volume of net exports in an economy. It is necessary to have estimates about the production and consumption structure of the economy in order to be able to offer definite answers on the question what determines changes in its volume of net exports.

In this paper, first I define an equilibrium where the economy is allowed to trade with the rest of the world within the neoclassical trade setup of a small country. This implies no impediments to trade, exogenous world prices for the commodities, no immigration of factors of production, all countries producing all goods, a linearly homogeneous technology in production and also homothetic preferences at the home country. A production equilibrium is then defined with the use of a revenue function and similarly a consumption equilibrium is represented using an expenditure function. This allows us to determine the trade equilibrium for the economy and consequently to disentangle the different parts that explain a country's volume of net exports.

The first contribution of the paper, is the fact that I include both sides of the economy, production and consumption, in the analysis and that I can identify the signs and also magnitudes of the different effects that theory predicts. The second contribution is that following a general equilibrium analysis I am able to decompose the changes of the volume of net exports into five different components. The first is a terms of trade effect that depends on the price elasticities of demand and supply. The second reflects the changes in the endowments of the economy. The third represents the effects of technological change in the production. The fourth refers to the effects on net exports arising from changes on preferences over time. The last one is the component that captures the effects of income changes on the volume of

net exports. Higher income levels imply higher consumption levels for all normal goods and consequently less net exports. Finally, I allow for a more general technology in the production side that permits the presence of jointness in output quantities (see Woodland 1977 and Kohli 1991). In addition, this broader definition of production's technology that is usually avoided in return of more tractable theoretical predictions seems to be supported by the data.

This paper draws its simple theoretic model from the work of Dixit and Woodalnd (1982), but neither focuses on the special case of an autarky equilibrium nor is investigating only the effect of a change of factor endowments on the volume of trade. I follow the empirical implementation of Harrigan (1997) and Kohli (1993). I first estimate a system of output equations (exportable, importable and non-tradable) derived from a Symmetric Normalised Quadratic Revenue function introduced by Kohli (1991, 1993) using a Three Stages Least Square (3SLS) estimation. Equivalently a system of consumption equations derived from an expenditure function of a Gorman-Polar type, (Diewert and Wales 1988) is estimated using again 3SLS. Then it is possible to calculate the fitted volume of net exports for the economy and to proceed to the decomposition discussed above. With such a decomposition and also with the estimates obtained from the revenue and expenditure function the signs and also the magnitude of all the five different components can be constructed. Hence, I can explain the reasons for which the net exports of a particular commodity has been observed to move towards a specific direction.

In particular, I find that the positive growth, 9.52% on average from 1966 to 1991, of net exports for the exportable good is mainly explained by better terms of trade and progressive technological change in the production, despite a very large income effect. In contrast, the negative growth, -17.11% on average over the whole period, of net exports for the importable good is due to a modest improvement in the terms of trade, small positive benefits through the endowments and preferences components, accompanied by a negative impact of technological change in the production side and a sizeable income effect. Finally, the net exports for the non-tradable good grew rapidly, an average of 106% for the period 1966-1991. This seems to be the result of a combination of very good terms of trade and benefits arising from the change in the economy's endowments regardless of lagre opposing effects in production from regressive technological change, in preferences and income changes.

The paper is organised in seven sections. Section 2 describes the theoretical model for the

economy, a trade equilibrium. The third discusses the econometric specification for both the revenue and the expenditure function. Section 4 briefly describes the data used, while the fifth discusses the estimation methods implemented and the results obtained. Section 6 involves the decomposition of the growth rate in the volume of net exports for the US economy for the period 1966-1991 and finally Section 7 concludes the paper.

2 The Model

Let $F(y, v, t) = 0$ be a transformation function for an economy with a linearly homogeneous technology, which produces $y = (y_1, \dots, y_n)$ goods with the use of m inputs, $v = (v_1, \dots, v_m)$, in a perfect competitive environment where t is a time index that captures technological change. Then, at given international prices $p = (p_1, \dots, p_n)$ and domestic inputs v , there exists a competitive production equilibrium. In such equilibrium we can think of the economy as one that maximizes the value of total output subject to the technological and endowment constraints. In other words there is a revenue or GDP function such that:

$$R(p, v, t) = \max_y \{py : F(y, v, t) = 0\} \quad (1)$$

The revenue function is increasing, linearly homogeneous and concave in v and non-decreasing, linearly homogeneous and convex in p . In addition if $R(p, v, t)$ is differentiable then from Hotelling's Lemma (Diewert 1974) the equilibrium output is:

$$y(p, v, t) = R_p(p, v, t) \quad (2)$$

On the consumption side the economy's preferences defined over the n goods are represented by an expenditure function, which is continuous and twice differentiable in prices:

$$E(p, u, t) = \min_c \{pc : u(c, t) \geq u\} \quad (3)$$

where u is the level of utility and $c = (c_1, \dots, c_n)$ is the consumption bundle and t is a time index that captures shifts on the expenditure function due to changes in preferences for

the consumers. The expenditure function is non-decreasing, linear homogenous and concave in prices and increasing in u . In addition, it is assumed that the expenditure function is homothetic:

$$E(p, u, t) = \bar{E}(p, t) u \quad (4)$$

From Shepherd's Lemma (Diewert 1974) the consumption vector of the economy is:

$$c(p, u, t) = E_p(p, u, t) \quad (5)$$

where E_p is the first partial derivative of the expenditure function with respect to product prices.

The trade equilibrium is defined as

$$TIMB = R(p, v, t) - E(p, u, t) \quad (6a)$$

$$T = R_p(p, v, t) - E_p(p, u, t) \quad (6b)$$

that is the difference between total value of production and total expenditure for the economy gives the trade imbalance ($TIMB$) for the economy and the difference between production and consumption gives the economy's vector of the volume of net exports, T .

In equilibrium the Hicksian demand function, $c^H(p, u, t) = E_p(p, u, t)$, has always the same value as the Marshallian demand function, $c^M(p, m, t) = H_p(p, m, t)$, where m indicates total nominal expenditure for the economy, assuming that there is an indirect utility function $H(p, m, t) = u$. Hence, I can substitute the Marshallian for the Hicksian demand function in Eq (6b)

$$T = R_p(p, v, t) - c^M(p, m, t) \quad (7)$$

Differentiating totally Eq (7) I get

$$\begin{aligned} dT &= R_{pp}dp + R_{pv}dv + R_{pt}dt - c_p^M dp - c_m^M dm - c_t^M dt \\ &= (R_{pp} - c_p^M) dp + R_{pv}dv + R_{pt}dt - c_t^M dt - c_m^M dm \end{aligned} \quad (8)$$

where dp , dv , dm and dt are respectively the change in product prices, factor endowments,

income and technology between two years. R_{pp} is the second partial derivative of the revenue function with respect to prices and R_{pv} is the second partial derivative of the revenue function with respect to prices and endowments respectively. While c_p^M , c_t^M and c_m^M are the first partial derivatives of the Marshallian demand function with respect to prices, technological change and income respectively.

Eq (8) is a decomposition of the changes in the volume of net exports into five components:

- the first, $(R_{pp} - c_p^M) dp$, is a component similar to changes in terms of trade² (*tot*) and depends on the substitutability and complementarity of the goods in production and consumption
- the second, $R_{pv}dv$, consists of the effect of changes in endowments on output and the entries of matrix R_{pv} can have all possible signs under the more general technology that allows jointness in output quantities
- the third, $R_{pt}dt$, captures technological change in production. The sign of R_{pt} , the effect of technological change on the supply of a good is positive, if technological change is progressive
- the fourth, $-c_t^M dt$, incorporates the effect of changes in preferences over time. But the sign of c_t^M cannot be determined a priori. Preferences towards a good can change in either direction over the passage of time
- the last one, $-c_m^M dm$, is an income effect component. For all normal goods c_m^M is positive and the total effects depends on the direction to which income is heading

Better terms of trade will increase the net exports for the exported good and decrease the net exports for the imported assuming that only the price of the exported good has increased. If both prices change in a fashion that results to better terms of trade, it is not clear what happens to the net exports of either good. The final outcome depends on the substitutability and complementary of the goods in production and consumption. The reason is that the matrix $R_{pp} - c_p^M$ is positive semidefinite, since the revenue function is convex in prices and the expenditure function concave respectively. The diagonal elements are all positive, while

²The ratio of prices between an exported and an imported good.

the signs on the off diagonal elements depend on the substitutability and complementarity of the commodities in both production and consumption. Hence, it is an open question and rests on the estimation of the parameters of the revenue and the expenditure function.

Increases on endowments lead to increases in net exports as long as the endowment increase enhances output. In the standard neoclassical trade model with two goods and two inputs the Rybczynski theorem identifies the signs of the elements of matrix R_{pv} . It states that an increase in the endowment that is used relatively more intensively in the production of a good will cause an increase in its production and hence its net exports. But if we depart from the 2×2 dimension to more goods and inputs and also allow for jointness in output quantities then no a priori prediction can be made. The signs of the elements in R_{pv} can have either sign³ and once again everything depends on the estimates obtained from the revenue function.

A progressive technological change of Hicks-neutral type on the production, implies a positive R_{pt} and equiproportionate changes for all goods, this leads to increases in trade, since it allows for a rise in commodity supplies. Hence, technological improvement in the production always increases net exports.

While technological change in the consumption side or changes in the preferences does not have a definite expected sign. It could be either positive or negative. It depends on the direction to which consumers change their preferences towards a specific good as time passes. For example, if consumers have changed their preferences and tend to prefer more (less) of a specific good now than before, then consumption will increase (decrease) and net exports will fall (rise).

Finally, the effect of a change in income on consumption, c_m^M , is positive for all normal goods. Hence the sign of the fifth component depends on whether income is increasing or not. More income will imply more consumption and hence less net exports for every normal good and vice versa.

The above discussion has made clear, the reason both sides of the economy should be included in the analysis. Furthermore, it has stressed the necessity to obtain estimates of the revenue function and Marshallian demand functions that will allow us to decompose the actual changes of a country's volume of net exports.

³see p 526 Woodland A.D., (1977), "Joint Outputs, Intermediate Inputs and International Trade Theory", International Economic Review, vol.18, no. 3, pp 517-533.

3 The Econometric Specification

3.1 The Revenue Function

The revenue function is assumed to have the symmetric normalized quadratic functional form as discussed in Kohli (1991, 1993):

$$\begin{aligned}
 R(p, v, t) = & \frac{1}{2} \left(\sum_{j=1}^M \psi_j v_j \right) \left(\sum_{i=1}^N \sum_{h=1}^N \alpha_{ih} p_i p_h \right) \left(\sum_{i=1}^N \theta_i p_i \right)^{-1} \\
 & + \sum_{i=1}^N \sum_{j=1}^M (c_{ij} p_i v_j) + \frac{1}{2} \left(\sum_{i=1}^N \theta_i p_i \right) \left(\sum_{j=1}^M \sum_{k=1}^M b_{jk} v_j v_k \right) \left(\sum_{j=1}^M \psi_j v_j \right)^{-1} \\
 & + \left(\sum_{j=1}^M \psi_j v_j \right) \left(\sum_{i=1}^N d_i p_i \right) t + \left(\sum_{i=1}^N \theta_i p_i \right) \left(\sum_{j=1}^M e_j v_j \right) t \\
 & + \left(\sum_{i=1}^N \theta_i p_i \right) \left(\sum_{j=1}^M \psi_j v_j \right) \left(\frac{1}{2} h_{tt} t^2 + h_t t \right) \tag{9}
 \end{aligned}$$

where p , and v , are the product prices and input endowment vectors respectively and t is an index of exogenous technological change. There are $N(N - 1) + M(M - 1) + (N \times M) + 2$ unknown parameters α_{ih} , b_{jk} , c_{ij} , d_i , e_j , h_t and h_{tt} , where $i, h = 1, \dots, N$ and $j, k = 1, \dots, M$. There are also $N + M$ predetermined parameters θ_i and ψ_j . In particular, θ_i and ψ_j are set equal to the share value of each product and input respectively at the base year. In order for the revenue function to be flexible, namely all its first and second derivatives to be defined, symmetry conditions are imposed $\alpha_{ih} = \alpha_{hi}$; $b_{jk} = b_{kj}$ that reduce the estimated parameters and consequently improve the efficiency of the estimates. In addition the assumption of linear homogeneity in p and v require some additional restrictions:

$$\sum_{i=1}^N \theta_i = \sum_{j=1}^M \psi_j = 1, \text{ and } \sum_{h=1}^N a_h = \sum_{k=1}^M b_{jk} = \sum_{i=1}^N d_i = \sum_{j=1}^M e_j = 0 \tag{10}$$

This functional form is attractive because it is flexible and retains its flexibility under the imposition of convexity and concavity in prices and endowments, respectively. The necessary and sufficient condition for global concavity in inputs is that the matrix $B = [b_{jk}]$ is negative

semi-definite and for global convexity that the matrix $A = [a_{ih}]$ is positive semi-definite. If these are not satisfied then they are imposed following Diewert and Wales (1987) without removing the flexibility properties of the revenue function. More specifically, as Diewert and Wales (1987) have shown global concavity on inputs can be imposed if matrix B is replaced by the negative product of a lower triangular matrix Φ and its transpose Φ' . That is $B = -\Phi\Phi'$, where $\Phi = [\phi_{jk}]$ and $\phi_{jk} = 0$ for every $j < k$; j indicates rows and k indicates columns of the matrix. In the same manner, global convexity on product prices can be imposed if matrix A is replaced by the product of a lower triangular matrix Ω and its transpose Ω' . Then $A = \Omega\Omega'$ with $\Omega = [\omega_{ih}]$ and $\omega_{ih} = 0$ for $i < h$ ⁴.

Based on (9) the reward of the j th factor becomes:

$$\begin{aligned}
w_j = & \frac{1}{2}\psi_j \left(\sum_{i=1}^N \sum_{h=1}^N \alpha_{ih} p_i p_h \right) \left(\sum_{i=1}^N \theta_i p_i \right)^{-1} + \left(\sum_{i=1}^N \theta_i p_i \right) \left(\sum_{k=1}^M b_{jk} v_k \right) \left(\sum_{j=1}^M \psi_j v_j \right)^{-1} \\
& - \frac{1}{2}\psi_j \left(\sum_{i=1}^N \theta_i p_i \right) \left(\sum_{j=1}^M \sum_{k=1}^M b_{jk} v_j v_k \right) \left(\sum_{j=1}^M \psi_j v_j \right)^{-2} + \sum_{i=1}^N c_{ij} p_i + \psi_j \left(\sum_{i=1}^N d_i p_i \right) t \\
& + e_j \left(\sum_{i=1}^N \theta_i p_i \right) t + \psi_j \left(\sum_{i=1}^N \theta_i p_i \right) h_t t + \frac{1}{2}\psi_j \left(\sum_{i=1}^N \theta_i p_i \right) h_{tt} t^2 \tag{11}
\end{aligned}$$

The output supply of good i th is:

$$\begin{aligned}
y_i = & \frac{1}{2}\theta_i \left(\sum_{j=1}^M \sum_{k=1}^M b_{jk} v_j v_k \right) \left(\sum_{j=1}^M \psi_j v_j \right)^{-1} + \left(\sum_{j=1}^M \psi_j v_j \right) \left(\sum_{h=1}^N \alpha_{ih} p_h \right) \left(\sum_{i=1}^N \theta_i p_i \right)^{-1} \\
& - \frac{1}{2}\theta_i \left(\sum_{j=1}^M \psi_j v_j \right) \left(\sum_{i=1}^N \sum_{h=1}^N \alpha_{ih} p_i p_h \right) \left(\sum_{i=1}^N \theta_i p_i \right)^{-2} + \sum_{j=1}^M c_{ij} v_j + d_i \left(\sum_{j=1}^M \psi_j v_j \right) t \\
& + \theta_i \left(\sum_{j=1}^M e_j v_j \right) t + \theta_i \left(\sum_{j=1}^M \psi_j v_j \right) h_t t + \frac{1}{2}\theta_i \left(\sum_{j=1}^M \psi_j v_j \right) h_{tt} t^2 \tag{12}
\end{aligned}$$

Equations (11) and (12) together with restrictions (10) form the first system of equations to be estimated.

⁴For more details about imposing global concavity or convexity see Wiley, Schmindt and Bramble (1973).

3.2 Expenditure Function

Assume the expenditure function $E(p, u, t)$ of the economy to be homothetic of the Gorman-polar form, Diewert and Wales (1988):

$$E(p, u, t) = \sum_i a_i p_i + \left[\sum_i \beta_i p_i + \frac{1}{2} \left(\sum_i \sum_j \gamma_{ij} p_i p_j \right) \left(\sum_i g_i p_i \right)^{-1} + \sum_i \delta_{it} p_i t \right] u \quad (13)$$

where $i = E, I, N$ indicates output, u is the utility level and t indicates changes on preferences. The parameters g_i are predetermined⁵ and $a_i, \beta_i, \gamma_{ij}$ and δ_{it} are the unknown ones. For well behaved preferences, we need to assume linear homogeneity and concavity in prices and also that expenditure function is non-decreasing with respect to utility. If concavity is not satisfied then it is imposed following the method of Diewert and Wales (1987) that was discussed before for the case of the revenue function. At the point of normalization, prices are set to one (p^* is a unitary column vector). These restrictions are necessary to guarantee standard preference choices for the consumers:

$$\sum_i a_i = \sum_j \gamma_{ij} = 0; \quad \sum_i g_i = 1 \quad (14)$$

Using Shephard's lemma, the Hicksian demand function (c_i^h) for the i th good is given by:

$$c_i^h = \frac{\partial E(p, u, t)}{p_i} = a_i + \left[\beta_i + \sum_j \gamma_{ij} p_j \left(\sum_i g_i p_i \right)^{-1} - \frac{1}{2} g_i \sum_i \sum_j \gamma_{ij} p_i p_j \left(\sum_i g_i p_i \right)^{-2} + \delta_{it} t \right] u \quad (15)$$

Setting (13) equal to the total nominal expenditure, $TNE = \sum_i p_i c_i$, and then solving for the utility (u) I get the indirect utility function

$$u = g(p, t, TNE) = \frac{TNE - \sum_i a_i p_i}{\sum_i \beta_i p_i + \frac{1}{2} \left(\sum_i \sum_j \gamma_{ij} p_i p_j \right) \left(\sum_i g_i p_i \right)^{-1} + \sum_i \delta_{it} p_i t} \quad (16)$$

⁵ g_i is set equal to the share of value for each good on total consumption.

Then substituting the indirect utility function (16) into the Hicksian demand (15) I get the Marshallian demand function (c_i^m) for the i th good

$$c_i^m = \frac{TNE - \sum_i a_i p_i}{\sum_i \beta_i p_i + \frac{1}{2} \left(\sum_i \sum_j \gamma_{ij} p_i p_j \right) \left(\sum_i g_i p_i \right)^{-1} + \sum_i \delta_{it} p_i t} \left[\sum_j \gamma_{ij} p_j \left(\sum_i g_i p_i \right)^{-1} - \frac{1}{2} g_i \sum_i \sum_j \gamma_{ij} p_i p_j \left(\sum_i g_i p_i \right)^{-2} + \delta_{it} t + \beta_i \right] + a_i \quad (17)$$

In order to identify all parameters, I impose further normalisations that imply more restrictions. I set technological change equal to one at the base year and I impose restrictions on the parameters such that the denominator of the ratio in (17) is equal to unity $\sum \beta_i p_i^* + \frac{1}{2} \sum \sum \gamma_{ij} p_i^* p_j^* (\sum g_i p_i^*)^{-1} + \sum \delta_{it} p_i^* t^* = 1$. Hence, I impose the following restrictions

$$\sum_i \beta_i = 1 \text{ and } \sum_i \delta_{it} = 0 \quad (18)$$

So the base year is considered as the reference point that any previous or future changes on preferences are compared with. The Marshallian demand equations (17) together with restrictions (14) and (18) form the second system of equations to be estimated.

The expenditure function in Eq (13) is a money metric utility function, $m(p, c) = e(p, u(c))$ (Samuleson, 1974). It provides information on how much money all consumers would need at given prices (p) in order to consume the observed bundle of goods (c). For fixed levels of product prices the money metric utility functions, $m(p, c)$, is equivalent to a utility function. The expenditure function is increasing in utility, hence for given product prices the only way to attain higher utility is to increase your spending. An important feature of the money metric utility function is that depends on observed variables, prices and consumption bundles. On the other hand the Gorman-polar form implies the assumption of the representative consumer model for aggregating preferences over all the consumers of the economy.

4 Data

There are three inputs in our model, capital, v_K , skilled labour, v_S , and unskilled labour, v_U . Data for the value (VAD_{ij}) and price of capital and aggregate labour (W_{ij}), at a 2-digit SIC87 analysis are obtained from Dale Jorgenson's database for the period 1963-1991⁶, where $j = K, L$ and i indicates the 2-digit industry. I construct the value added for capital and aggregate labour for the whole economy, $VAD_j = \sum_i VAD_{ij}$, by adding the value added for capital and labour for all the 2-digit industries, respectively. Then the aggregate price of capital and labour is calculated as a weighted average of their prices in each 2-digit industry with weights the share of each input in every 2-digit industry, $W_j = \sum_i \frac{VAD_{ij}}{VAD_j} W_{ij}$. I get the quantity of capital and aggregate labour for the whole economy by dividing their value added by their price, $Q_j = \frac{VAD_j}{W_j}$, respectively.

The division of aggregate labour into skilled and unskilled labour is implemented by using data from the NBER collection of Mare-Winship Data, 1963-1991. I get data on educational levels, weekly wages, status and weeks worked for full time workers in 2-digit SIC industries. I divide workers into skilled and unskilled following Katz and Murphy (1992), a worker is treated as skilled if he or she spent at least twelve years in education. Our sample contains only full time workers, aged 16-45, that have completed their educational grade and are working in the private sector. First, I calculate the total number of weeks worked per year and also the annual wages and salaries for skilled and unskilled workers⁷. Then I divide the annual value of wages and salaries by the corresponding total weeks worked in order to calculate the full time weekly wage for each group respectively. After that I calculate the share of weeks worked for skilled and unskilled workers relative to the total hours worked of all workers. Similarly, I find the shares of wages for each occupational group in the sample. Finally, these shares are multiplied with the total quantity and total wages of aggregate labour, respectively, obtained from Jorgenson's data set in order to get the quantity and wages for skilled and unskilled workers in US.

In our model there are three aggregate products, exportable, y_E , importable, y_I , and non tradable, y_N . Initially the products are divided into tradeable and non-tradeables. A 2-digit

⁶<http://post.economics.harvard.edu/faculty/jorgenson/data/35klem.html>

⁷Following Katz, L. and Murphy, K. (1992) we include only full time workers that have worked more than 39 weeks in that year. Also, top code wage and salaries were multiplied by 1.45

industry is termed tradable if the ratio of its exports plus imports divided by its revenue is above 10%, otherwise it is termed as non-tradable⁸. Then tradable industries are grouped to exportables and importables depending on whether their net exports are positive or negative, respectively.

For the calculation of value added of the three aggregate products I again use Jorgenson's data set. While data for output deflators are obtained from the Bureau of Economic Analysis at a 2-digit SIC level. Since these are available from 1977 onwards, the values of output deflators for years before 1977 are obtained by interpolation assuming a constant growth rate equal to the growth rate between 1977 and 1978. The aggregation of the three goods is achieved in three stages⁹. First, I calculate each industry's value added (VAD_i) by summing the value added of capital and labour of each 2-digit industry, $VAD_i = \sum_j VAD_{ij}$. Then the value added of each aggregate good, VAD_A ; A indicates the three aggregate outputs, is constructed by adding the value added of each 2-digit industry that belongs to an aggregate product. For example, in order to calculate the value added of the exportable good, I add the value added of the following industries SIC 20, SIC 28, SIC 35, SIC 36, SIC 37 and SIC 38¹⁰ that have been termed as exportable following the above rule. The aggregate price of each aggregate good, P_A ; A indicates the three aggregate outputs E, I, N , is a weighted average of the prices of all 2-digit industries, P_i ; i indicates a 2-digit industry, that belong to an aggregate good, with weights the share of each 2-digit industry, $\frac{VAD_i}{VAD_A}$. The aggregate quantity of output is calculated by dividing the value of each aggregate good by its aggregate price, $Q_A = \frac{VAD_A}{P_A}$. Similarly, the volume of net exports is calculated by dividing the value of net exports for each aggregate good by its corresponding aggregate price.

Data for consumption are generally not available and when available, they are usually not reliable. For these reasons, the volume of consumption for each of the goods is calculated as the difference between the volume of output and net exports:

$$c = y - T \tag{19}$$

⁸Trade data at a 2-digit SIC87 level were obtained online from the Centre for International Data at the University of California Davis. <http://data.econ.ucdavis.edu/international/index.html>

⁹Table 1 shows the SIC categories that are included in each aggregate good.

¹⁰Look at Table 1, for an explanation of the SIC codes of 2 -digit industries.

where y and c is the vector of production and consumption respectively.

5 Estimation

I estimate the equation sets (11) and (12) together with the parameter restrictions (10) in order to get the parameters of the revenue function. Although only estimates of (12) are necessary for the decomposition. I am estimating both (11) and (12), because it improves the efficiency of the estimated parameters. The reason lays on the fact that the number of estimated parameters does not alter when (12) is jointly estimated with (11) and as a result the degrees of freedom¹¹ increase. The errors related to equations (11) and (12) are assumed to be identically and independently distributed with zero expected value and a positive definite covariance matrix. These equations are jointly estimated by the iterative Three Stages Least Square (3SLS) estimator¹² applied to data for the US manufacturing sector over the period from 1965 to 1991. There are six equations, three relating to outputs and three relating to factor rewards. The goods are exportables, importables and non-tradeable and the three factors of production are capital, skilled and unskilled labor.

Table 2 shows the estimated parameters of the revenue function and the R^2 for the system of the six equations. Most of the parameters are significant and the system R^2 is 0.98, indicating that the overall estimation seems to appear robust. Linear homogeneity in prices (p) and inputs (v) is satisfied, but initially convexity for prices was not satisfied and was imposed following Diewert and Wales (1987). Three hypotheses have been tested using the Wald test that follows a chi-squared distribution with n degrees of freedom $X^2(n)$, where n is the number of restrictions imposed. The first is the hypothesis of no convexity, in order to check whether the imposed convexity is accepted by the data. At 5% significance level and 2 degrees of freedom I reject the null of no convexity, since the Wald Statistic, 24.7, is greater than the critical value of 5.991. The second test is implicitly testing the assumption of the more general technology on the production side of the economy that allows for the presence of jointness in output quantities. The null hypothesis of a production technology without jointness in output quantities is rejected at a 5% level and 2 degrees of freedom, because the

¹¹The degrees of freedom, under the 3SLS estimation, are defined as the product of the number of years observed times the number of equations estimated minus the number of the estimated parameters.

¹²I use one year lagged values of product prices and endowments as instruments.

Wald Statistic, 30.2, is greater than the critical value of 5.991. The last hypothesis that is tested is that of a specification for the revenue function that would not involve technological change as one of the explanatory variables. Once again the null hypothesis of no-technological change is rejected at the 5% level of significance, since the chi-square critical value with two degrees of freedom is smaller, 5.991, than the Wald Statistic of 74.1, implying that specification that includes technological change is consistent with the actual data.

Table 4 and Table 5 show the mean price elasticities of output (ϵ_{ih}) and the input (ω_{ih}) and technology (ω_{it}) elasticities of output, respectively. All own price elasticities are positive, which is a necessary but not sufficient condition for convexity in prices. They range from 0.222 for the importable good to 0.022 for the exportable, which implies that the supply for all goods is inelastic. A rise in the price of the importable good decreases the supply of both the exportable and the non-tradable good, suggesting that the importable good is a substitute in the production with both the exportable and non-tradable good. While an increase in the price of the exportable leads to an increase in the supply of the non-tradable, which implies that the two goods are complements in the production.

All input elasticities of output are positive, with the exception of the elasticity of the non-tradable with respect to unskilled labour indicating that a 1% increase in the endowments of unskilled labour for the economy reduces the supply of non-tradable good by almost 16%. From the elasticities of output with respect to technological change it is evident that on average only the exportable good has gained from technological improvement, while the other two goods have been affected adversely. More specifically, a 1% increase in technological change increases on average the supply of the exportable by 2.8%, while at the same time reduces the supply of the importable and non-tradable by 1.3% and 0.7%, respectively.

The system of equations (17) is estimated together with restrictions (14) and (18) in order to obtain the estimates of the parameters for the Marshallian demand functions using the Three Stages Least Square (3SLS) estimator¹³ for the same period as above. Three equations of exportable, importable and non-tradable Marshallian demand functions are estimated. The assumption of linear homogeneity in product prices is satisfied. But concavity for product prices (p) failed initially and was imposed following the method proposed by Diewert and Wales (1987). The null hypothesis of no concavity is rejected at a 5% level, since the Wald

¹³I use one year lagged values of product prices and income as instruments.

Statistic, 42.4, is greater than the critical value of the chi-square with two degrees of freedom, 5.991. This implies that the imposed concavity of the Marshallian demand function with respect to the product prices is satisfied by the data. In addition the null hypothesis of no shifts in preferences over time is also rejected, supporting the initial specification for the Marshallian demand functions that involved such changes in preferences.

Table 3 shows the estimates of the parameters of the Marshallian demand functions and the R^2 for the system of equations. Most of the estimates are significant and the system R^2 is 0.97. Table 6 presents the Marshallian demand elasticities with respect to prices, technology¹⁴ and income. All own prices elasticities are negative and for the case of the exportable and non-tradable goods their demand is elastic. That is changes on the prices of tradable and non-tradable goods cause amplified changes on their demands, respectively. Exportable and non-tradable goods are substitutes, while each other pair of goods is characterised by complementarity. From the technology elasticities of Marshallian demand is evident that on average consumers have shifted their preferences away from importables goods and towards either exportable or non-tradable ones, but the magnitude of these effects is quite small. Finally, the income elasticities of all three goods are positive, suggesting that all of them appear to be normal goods as expected. The highest average income elasticity is observed for the importable good, 1.126. While the income elasticities of exportable and non-tradable are quite similar, 0.989 for the exportable and 0.863 for the non-tradable.

6 Decomposition of the Growth Rate in US Commodity Net Exports

In this section I decompose the growth rate of the volume of net exports for the three aggregate goods of US manufacturing, exportable, importable and non tradable, into their five components using Eq (A1) from the Appendix. Tables 7, 8 and 9 present on the first two columns the growth rate of the fitted volume of net exports (*Fitted*) and its approximation (*Approximated*) using Eq (A1), while the last five columns present the five components of the decomposition of Eq (8) in growth format: a) the terms of trade component (*TOT*),

¹⁴More precisely, changes in preferences over time.

b) the endowments component (*Endowments*), c) the technology component in production (*Production Technology*), d) the change in preferences over time (*Preferences*) and e) the income component (*Income*) for the exportable (E), importable (I) and non-tradable (N) good respectively ($i = E, I, N$).

From Table 7, we see that the average growth rate of the fitted volume of net exports and the average growth rate of the approximation by Eq (A1) have the same sign for each sub-period and are also very close in terms of magnitude. This suggests that the approximation used in Eq (A1) is a good representation of the estimated model. The volume of net export for the exportable good increased by an average of 48% for the period 1966-1978. If only product prices had changed then the net exports of the exportables would have increased by 258 %, as it is seen from the terms of trade (*TOT*) component. The endowments component has increased the growth rate of net exports of the exportable by 42%, ceteris paribus. The effect of technological change in the production raised the growth of net exports by 128% while the effect of changes in preferences is also positive, but smaller in magnitude 22%. The only negative effect was observed for the income component that resulted to a decrease of net exports of exportables by 403%. Hence, the strong positive effect of the first four components was weakened by the very strong negative income effect. For the period 1979-1991 the volume of net exports decreased on average by 29%. This is the result of a relative worsening of the terms of trade component, despite the much smaller magnitude of the income component compared with the previous period, while all the other four components remained relatively stable. The terms of trade component led to an increase of net exports by 21%, ceteris paribus, for the years between 1979 and 1991, while for the previous period its contribution was almost twelve times greater. It worth noticing that the terms of trade and income component were the highest among all products for the period 1966-1978.

The average growth rate of the volume of net exports for the importable good and its component are presented in Table 8. The values of the first two columns, indicating the fitted growth rate and the approximated growth rate of the net exports of the importable from Eq (8) are very close. This is similar to the case of the exportable good and suggests that the approximation implemented in Eq (A1) is very close to the estimated model. The net exports of the importable good were decreasing in a stable rate over the two sub-periods. An approximately 20% and 14% decrease in the net exports of the importable good for the first

and second sub-period, respectively. The terms of trade component experienced a relative worsening for the importable good, since it fell from a 48% increase for the years 1966-1978 to a 34% increase for the second sub-period. Similarly, the Endowments and Preferences components were positive but decreased in magnitude over the two sub-periods. From 26% to 10% for the first and from 4% to 3% for the second. In the case of the importable good the Production Technology component was negative in both sub-periods, suggesting that technical change is regressive for its production. Hence, if only technical change had occurred then the net exports of the importable would have fallen by 9% on average for the whole period. The income component was negative as in the case of the exportable, but much smaller in magnitude, an average of 70% for the period 1966-1991.

Table 9 reports the average growth rate of the net exports for the non-tradable good. They are positive and much higher in magnitude relative to the growth rate of the two other goods. A possible explanation could be along the lines of a "catching-up" argument. Since the level of the net exports of the non-tradable were much smaller than the other goods, then it could be expected that their net exports grow faster. In particular, they grew by 106% on average over the period 1966-1991. The terms of trade component was positive and high in magnitude, 153%, but smaller than the one of the exportable. A similar story for the income effect that it was negative, -193%, but smaller in magnitude than in the case of the first good. The effect of technical change in production was negative and very big in magnitude, -180%, suggesting that technical change has worsened the productive capabilities of the non-tradable good. Also the preferences component was negative, -120%, implying that the consumers changed positively their preferences towards the non-tradable good that resulted in higher consumption and lower net exports, *ceteris paribus*. Finally, the Endowments component was positive and very large in magnitude. In a hypothetical scenario that only endowments had been altered in US manufacturing for the period 1966-1991, then the net exports of the non-tradable good would have increased by 447%.

7 Conclusions

In this paper, I extend the work of Dixit and Woodland (1982), on the factors that determine changes of net exports (T). First, the model focuses on a trade equilibrium that allows trade

imbalances. Second, it incorporates the effect of changes in commodity prices, while it does not rule out the jointness in output quantities. A general equilibrium analysis is implemented where the revenue (*GDP*) function and the expenditure function are estimated for the US economy for the period 1963 to 1991. Then a decomposition of the changes of the net exports is implemented. It involves a terms of trade component, an endowment component, a technological change both in production and consumption and an income component. I also allow for a more general technology in the production side that permits the presence of jointness in output quantities (see Woodland 1977 and Kohli 1991). This broader definition of production's technology that is usually avoided in return of more tractable theoretical predictions is supported by the data.

I follow the empirical implementation of Harrigan (1997) and Kohli (1992). I first estimate a system of output equations derived from a Symmetric Normalised Quadratic Revenue function introduced by Kohli (1991, 1993) using a Three Stages Least Square (3SLS) estimation. In addition a system of Marshallian demand functions derived from an expenditure function of a Gorman-Polar type, (Diewert and Wales 1988) is estimated using again 3SLS. Then, it is possible to calculate the fitted volume of net exports for the economy and to proceed to its empirical decomposition into a terms of trade component, an endowment component, a technology component in production, a change in preferences component and an income component as shown in Eq (8).

It is evident that the mainly positive growth rate of the net exports of the exportable good for the first thirteen years is explained by better terms of trade combined with a strong positive production technology effect, despite the highest income effect observed for all the three goods and periods. The following time period the volume of net exports for the exportable decreased by 28% mainly due to a relative worsening in the terms of trade of the exportable good, despite a weaker negative income effect.

On the other hand, the negative growth rate of the net exports of the importable good are attributed to a sizeable negative income effect, a slower improvement in the terms of trade for the importable and a negative production technology effect. The negative sign of the production technology component that implies a regressive technical change for the production of the importable is consistent with the argument that the import-competing sector in the US has lost in terms of competitiveness the last years due to adverse technological change.

This results into diversion of resources from the import-competing sector to the rest of the economy and consequently to a decrease in the volume of its net exports.

The net export of the non-tradable grew with a high rate of 106% over the whole period. This is explained by a very strong positive terms of trade component of 153% combined with a positive and huge Endowments component of a 356% increase, despite the negative and high in magnitude growth rate of the rest three components. In particular, the negative sign for the Preferences component implies that domestic consumers have continuously altered their preferences in favour of the non-tradable good.

From Tables 7, 8 and 9 we see that the growth rate of the volume of net exports was positive for the exportable and negative for the importable good on average for the whole period. But the importable experienced a higher growth in absolute terms, which implies that the net imports of the importable grew faster than the net exports of the exportable. For the same period, the growth rate of the volume of trade for the no-tradable was very high. This suggests that the composition of net exports between the three goods has changed over time, with the non-tradable to have gained a bigger share. Finally, the probably paradoxical result of the decreasing volume of trade for the exportable good for over the period 1979-1991 can possibly be explained by the big and increasing in absolute terms trade deficit of the US economy.

Appendix

Let $diag(T)$, Y , P , C^M , V , X and M indicate the diagonal matrix of net exports, production of goods, product prices, Marshallian demands, endowments, time and income respectively. Rearranging equation. (8) I get

$$\begin{aligned}
dT &= \left(\frac{\partial y}{\partial p} - \frac{\partial c^M}{\partial p} \right) dp + \frac{\partial y}{\partial v} dv + \frac{\partial y}{\partial t} dt - \frac{\partial c^M}{\partial m} dm - \frac{\partial c^M}{\partial t} dt \\
[diag(T)]^{-1} dT &= [diag(T)]^{-1} \left[YY^{-1} \frac{\partial y}{\partial p} PP^{-1} - C^M [C^M]^{-1} \frac{\partial c^M}{\partial p} PP^{-1} \right] dp \\
&\quad + [diag(T)]^{-1} YY^{-1} \frac{\partial y}{\partial v} VV^{-1} dv \\
&\quad + [diag(T)]^{-1} YY^{-1} XX^{-1} \frac{\partial y}{\partial t} dt \\
&\quad - [diag(T)]^{-1} C^M C^M MM^{-1} \frac{\partial c^M}{\partial m} dm \\
&\quad - [diag(T)]^{-1} C^M [C^M]^{-1} XX^{-1} \frac{\partial c^M}{\partial t} dt \\
\hat{T} &= \left[Y [diag(T)]^{-1} \varepsilon_{yp} - C^M [diag(T)]^{-1} \varepsilon_{cp}^M \right] \hat{p} \\
&\quad + Y [diag(T)]^{-1} \varepsilon_{yv} \hat{v} + Y [diag(T)]^{-1} \varepsilon_{yt} \hat{t} \\
&\quad - C^M [diag(T)]^{-1} \varepsilon_{cm}^M \hat{m} - C^M [diag(T)]^{-1} \varepsilon_{ct}^M \hat{t} \tag{A1}
\end{aligned}$$

where \hat{T} , \hat{p} , \hat{v} , \hat{t} and \hat{m} indicate the growth rate of net exports, product prices, endowments, technological change and income respectively. While ε_{yp} , ε_{cp}^M , ε_{yv} , ε_{yt} , ε_{cm}^M and ε_{ct}^M are the elasticity of output with respect to product prices, the elasticity of consumption with respect to product prices, the elasticity of output with respect to inputs, the elasticity of output with respect to technical change, the Marshallian elasticity of consumption with respect to income and the Marshallian elasticity of consumption with respect to technological change. Equation (A1) is the equivalent of equation (8) in a growth format. The five components are:

- the terms of trade component (TET) is $\left[Y [diag(T)]^{-1} \varepsilon_{yp} - C^M [diag(T)]^{-1} \varepsilon_{cp}^M \right] \hat{p}$.
- the *Endowments* component is $Y [diag(T)]^{-1} \varepsilon_{yv} \hat{v}$.
- the *Production Technology* component is $Y [diag(T)]^{-1} \varepsilon_{yt} \hat{t}$.
- the *Preferences* component is $-C^M [diag(T)]^{-1} \varepsilon_{cm}^M \hat{m}$ and

- the *Income* component is $-C^M [\text{diag}(T)]^{-1} \varepsilon_{ct}^M \hat{t}$.

References

- Baier S. L. and Bergstrand J. H., "The Growth of World Trade: Tariffs, Transport Cost and Income Similarity", *Journal of International Economics*, vol 53, pp 1-27, 2001.
- Besedes T., "Decomposing the Growth of Trade 1884-1992", working paper, 2005.
- Centre for International Data at UC Davis.
- Diewert W. E. and Wales T.J., "Flexible Functional Forms and Global Curvature Conditions", *Econometrica*, vol. 55, pp 43-68, 1987.
- Diewert W. E. and Wales T.J., "Normalized Quadratic Systems of Consumer Demand Functions", *Journal of Business & Economic Statistics*, Vol. 6, No. 3, pp. 303-312, 1988.
- Dixit A. and Woodland A. "The Relationship between Factor Endowments and Commodity Trade", *Journal of International Economics*, vol.13:3-4, pp. 201-14, 1982.
- Feenstra R. C., "Integration of Trade and Disintegration of Production in the Global Economy", *Journal of Economic Perspectives*, vol 12, issue 4, pp 31-50, 1998.
- Harrigan J., "Technology, Factor Supplies and International Specialization: Estimating the Neoclassical Model", *The American Economic Review*, v. 87 no. 4, pp. 475-494, 1997.
- Katz L. and Murphy K., "Changes in relative wages, 1963-1987: supply and demand factors", *Quarterly Journal of Economics*, CVII, 36-78, 1992.
- Kohli U., "Technology, Duality, and Foreign Trade: The GNP Function Approach to Modelling Imports and Exports", London: Harvester Wheatsheaf and Ann Arbor, MI: University of Michigan Press, 1991.
- Kohli U., "A Symmetric Normalised Quadratic GNP function and the US Demand for Imports and Supply of Exports", *International Economic Review*, vol. 34, 243-255, 1993.
- Krugman P. and Baldwin R., "The Persistence of the US Trade Deficit", *Brookings Papers on Economic Activity*, vol 1, pp. 1-43, 1987
- Laursen, Svend, and Lloyd A. Metzler, "Flexible Exchange Rates and the Theory of Employment," *Review of Economics and Statistics*, vol. 32, pp. 281-299, 1950.

- Mendoza E. G., "The Terms of Trade, The Real Exchange Rate, and Economic Fluctuations", *International Economic Review*, Vol. 36, No. 1, 101-137. Feb., 1995.
- NBER's Mare-Winship Data, 1964-1992.
- Persson, Torsten & Svensson, Lars E O, "Current Account Dynamics and the Terms of Trade: Harberger-Laursen-Metzler Two Generations Later," *Journal of Political Economy*, vol. 93(1), pp. 43-65, 1985 .
- Rose A., "Why Has Trade Grown Faster Than Income?", *Canadian Journal of Economics*, May 1991, no 2, pp 417-427.
- Samuelson P. A., "Complementarity: An essay on the 40th Anniversary of the Hicks-Allen Revolution in Demand Theory", *The Journal of Economic Literature*, vol. 12, pp. 1255-1289, 1974.
- Tinbergen J., "Shaping the World Economy", Twentieth Century Fund, New York, 1962.
- Woodland AD, "Joint Outputs, Intermediate Inputs and International Trade Theory", *International Economic Review*, vol.18:3, pp. 517-33, 1977.

Table 1: SIC CODES FOR AGGREGATE GOODS

Aggregate Good	SIC Code Category
<i>Exportable</i>	Food & Kindred Products (SIC 20)
	Chemicals & Allied Products (SIC 28)
	Industrial & Commerce Machinery & Computer Equipment (SIC 35)
	Electronic & Other Electric Equipment (SIC 36)
	Transportation Equipment (SIC 37)
<i>Importable</i>	Instruments, Photographic, Medical & Optical Goods (SIC 38)
	Textile Mill Products (SIC 22)
	Apparel & Other Finished Products (SIC 23)
	Lumber & Wood Products (SIC 24)
	Paper & Allied Products (SIC 26)
	Petroleum Refining & Related Industries (SIC 29)
	Leather & Leather Products (SIC 31)
	Primary Metal Industries (SIC 33)
Miscellaneous Manufacturing Industries (SIC 39)	
<i>Non-tradable</i>	Tobacco Products (SIC 21)
	Furniture & Fixtures (SIC 25)
	Printing, Publishing & Allied Industries (SIC 27)
	Rubber & Miscellaneous Plastic Products (SIC 30)
	Stone, Clay, Glass & Concrete Products (SIC 32)
	Fabricated Metal Products, Except Machinery (SIC 34)

Table 2: PARAMETER ESTIMATES OF REVENUE FUNCTION

Parameter	Estimate	t-stat	Parameter	Estimate	t-stat
a_{EE}	28326	0.392	c_{IK}	20818	2.264
a_{EI}	-21271	-0.598	c_{IS}	46727	5.079
a_{EN}	-7055	-0.184	c_{IU}	1934	0.259
a_{II}	15973	0.966	c_{NK}	75220	6.574
a_{IN}	5298	0.224	c_{NS}	14737	1.095
a_{NN}	1757	0.119	c_{NU}	-14350	-1.696
e_K	-1342	-3.836	b_{KK}	-3762	-0.882
e_S	2080	9.705	b_{KS}	-6068	-3.305
e_U	-737	-2.349	b_{KU}	9830	1.641
d_E	4470	4.449	b_{SS}	-9785	-1.589
d_I	-1704	-2.735	b_{SU}	15854	3.125
d_N	-2766	-4.943	b_{UU}	-25685	-5.926
c_{EK}	-20389	-1.712	h_t	808	1.006
c_{ES}	30910	1.627	h_{tt}	134	2.584
c_{EU}	72065	6.156	System R^2	0.98	
Hypothesis Testing			Wald Statistic	$X_{0.5}^2$	
No convexity			Wald(2) = 24.7	5.991	
Non-jointness			Wald(2) = 30.2	5.991	
No technological change			Wald(2) = 74.1	5.991	

Table 3: PARAMETER ESTIMATES OF EXPENDITURE FUNCTION

Parameter	Estimate	t-stat	Parameter	Estimate	t-stat
a_E	-4624	-0.226	γ_{EN}	0.698	2.154
a_I	-14683	-1.132	γ_{II}	-0.220	-1.066
a_N	19307	1.828	γ_{IN}	-0.297	-1.609
β_E	0.530	4.453	γ_{NN}	-0.401	-2.653
β_I	0.369	5.050	δ_{Et}	-0.41E-02	-0.736
β_N	0.099	1.671	δ_{It}	-0.14E-02	-0.433
γ_{EE}	-1.216	-1.730	δ_{Nt}	0.52E-02	2.121
γ_{EI}	0.517	1.330	System R^2	0.97	
Hypothesis Testing		Test Statistic		$X^2_{0.5}$	
No concavity		Wald(2) = 42.4		5.991	
No shifts in preferences		Wald(2) = 19.3		5.991	

Table 4: PRICE ELASTICITIES OF OUTPUT(ϵ_{ih})
(Mean values, Std. Error in parenthesis)

	Price		
	<i>Exportable</i>	<i>Importable</i>	<i>Non-tradable</i>
Output	ϵ_{iE}	ϵ_{iI}	ϵ_{iN}
<i>Exportable</i>	0.022 (0.003)	-0.046 (0.005)	0.023 (0.002)
<i>Importable</i>	-0.109 (0.006)	0.222 (0.015)	-0.113 (0.011)
<i>Non-tradable</i>	0.057 (0.005)	-0.115 (0.007)	0.058 (0.002)

Table 5: INPUT & TIME ELASTICITIES OF OUTPUT(ω_{ih})
(Mean values, Std. Error in parenthesis)

	Input			<i>Technology</i>
	<i>Capital</i>	<i>Skilled Labour</i>	<i>Unskilled Labour</i>	
Output	ω_{iK}	ω_{iS}	ω_{iU}	ω_{it}
<i>Exportable</i>	0.122 (0.027)	0.581 (0.088)	0.296 (0.114)	0.028 (0.001)
<i>Importable</i>	0.685 (0.092)	0.093 (0.007)	0.222 (0.088)	-0.013 (0.003)
<i>Non-tradable</i>	0.210 (0.035)	0.948 (0.040)	-0.159 (0.073)	-0.007 (0.004)

Table 6: MARSHALLIAN ELASTICITIES (η_{ih})
(Mean values, Std. Error in parenthesis)

Quantity	Price			<i>Technology</i>	<i>Income</i>
	<i>Exportable</i>	<i>Importable</i>	<i>Non-tradable</i>		
	η_{iE}	η_{iI}	η_{iN}	η_{it}	η_{im}
<i>Exportable</i>	-1.155 (0.023)	-0.137 (0.014)	0.303 (0.017)	0.003 (4.80E-04)	0.989 (0.013)
<i>Importable</i>	-0.322 (0.028)	-0.496 (0.014)	-0.308 (0.016)	-0.012 (0.003)	1.126 (0.020)
<i>Non-tradable</i>	0.779 (1.449)	-0.323 (0.796)	-1.320 (0.659)	0.009 (0.002)	0.863 (0.054)

Table 7: DECOMPOSITION FOR THE GROWTH IN NET EXPORTS FOR THE EXPORTABLE
average growth rate

Year	Growth Rate		Components					
	Fitted	Approximated	TOT	Endowments	Production	Technology	Preferences	Income
1966-1978	55.91	47.58	258.28	42.19	128.02		22.09	-403.00
1979-1991	-25.34	-28.53	21.44	6.78	90.05		19.12	-165.92
1966-1991	15.28	9.52	139.86	24.49	109.04		20.61	-284.46

Table 8: DECOMPOSITION FOR THE GROWTH IN NET EXPORTS FOR THE IMPORTABLE
average growth rate

Year	Growth Rate		Components					
	Fitted	Approximated	TOT	Endowments	Production	Technology	Preferences	Income
1966-1978	-20.63	-20.02	47.50	25.81	-12.23		3.97	-85.07
1979-1991	-15.71	-14.19	34.20	9.83	-6.54		2.97	-54.65
1966-1991	-18.17	-17.11	40.85	17.82	-9.39		3.47	-69.86

Table 9: DECOMPOSITION FOR THE GROWTH IN NET EXPORTS FOR THE NON TRADABLE
average growth rate

Year	Growth Rate		Components					
	Fitted	Approximated	TOT	Endowments	Production	Technology	Preferences	Income
1966-1978	28.46	56.34	121.21	537.65	-232.80		-131.21	-238.50
1979-1991	152.23	155.23	185.60	356.96	-128.76		-108.81	-149.23
1966-1991	90.35	106.05	153.40	447.30	-180.78		-120.01	-193.87