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# **Attributing GDP growth of the Euro Area to final demand categories**

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Paper prepared for the 18<sup>th</sup> International Input-Output Conference,  
June 20-25<sup>th</sup>, Sydney, Australia

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Remarks:

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*Project number:*

*CBO-*

*BPA number:*

*-CBO*

*Date:*

*5 April 2010*

## **ATTRIBUTING GDP GROWTH OF THE EURO AREA TO FINAL DEMAND CATEGORIES**

Summary: To analyse economic growth it is important to understand the underlying driving forces. Particularly after the financial crises it is of utmost importance for economists to analyse which areas of the economy are weak and which areas are contributing to the recovery. One of the analyses which are used is the attribution of GDP growth rates to final demand components such as household consumption, gross fixed capital formation and exports. Two methods are available: Firstly, there is the “net-exports method” in which the growth rate is decomposed using a net measure for exports i.e. imports are subtracted from exports. Secondly, there is the “attribution method” which adopts input-output modelling techniques to decompose the effects of changes in final demand components.

In this paper we will show that the attribution method leads to more fruitful economic analysis but that the data requirements are larger because the method requires an input-output table (IOT). We have applied the net-exports and attribution method to the Euro Area (EA) by building EA-IOTs for 2003, 2004 and 2005. These are used to attribute annual (2003-2006) and quarterly (2006Q1-2007Q3) growth rates to final demand components.

Keywords: GDP growth rate, attribution method, attribution to final demand components, input-output modelling, asymmetries, European input-output tables

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## **Abbreviations**

BEC	Broad Economic Categories
CBS	Statistics Netherlands
CPS	Cumulated Production Structure
COMEXT	Database containing EU trade data
CPA	Classification of Products by Activities
CPB	Netherlands Bureau for Economic Policy Analysis
CN	Combined Nomenclature
DNB	Dutch National Bank
EA	Euro Area
ECB	European Central Bank
BP	Basic Prices
HS	Harmonized System
IOT	Input-output table
ITS	International trade in services data
MED	Macro-economic aggregates
NPISH	Non-profit organisations serving households
PP	Purchaser prices
TLS	Taxes less subsidies on products
SUT	Supply and use tables
TTM	Trade and transport margins
WINADJUST	CBS Lagrangian balancing program (van Dalen and Sluis, 2002)

## **Country labels**

AT	Austria
BE	Belgium
DE	Germany
ES	Spain
FI	Finland
FR	France
GR	Greece
IE	Ireland
IT	Italy
LU	Luxemburg
NL	The Netherlands
PT	Portugal
SI	Slovenia

## 1. Introduction

To analyse economic growth it is important to understand the driving forces. Particularly after the financial crises it is of utmost importance for economists to analyse which areas of the economy are weak and which areas are contributing to the recovery. One of the analyses which are used is the attribution of GDP growth rates to final demand components such as household consumption, gross fixed capital formation and exports. Two methods are available: Firstly, there is the “net-exports method” (see for example in *Monthly Bulletin* of the ECB (ECB, 2008, p65). In this method, the growth rate is decomposed using a net measure for exports i.e. imports are subtracted from exports. Secondly, there is the “attribution method” which adopts input-output modelling techniques to decompose the effects of changes in final demand components.

In this paper we will show that the attribution method leads to more fruitful economic analysis but that the data requirements are larger because the method requires an input-output table (IOT). Because of the lower data requirements the net-exports method is far more prevalent but the use of the attribution method has increased significantly recently in policy circles (Alders, 1988; Kranendonk, 1998; Cameron and Cross, 1999; Cross, 2002; Kranendonk and Verbruggen, 2005 and 2008; Danish Ministry of Finance, 2006; Heitz and Rini, 2006; Statistics Netherlands, 2006; and CPB, 2006).

To illustrate the usefulness of the attribution method we have applied the net-exports and attribution method to the Euro Area (EA) by building EA-IOTs for 2003, 2004 and 2005. These are used to attribute annual (2003-2006) and quarterly (2006Q1-2007Q3) growth rates to final demand components. This summarizes the methodological and empirical work which was done by Statistics Netherlands during two consultancy projects for the ECB (Hoekstra *et al.*, 2006; and van der Helm and Hoekstra, 2008).

The paper is structured as follows. In section 2 the theoretical aspects of the net-exports and attribution methods are explained. Section 3 described the production of the data, including IOT for the EA for 2003, 2004 and 2005. Finally, Section 4 provides the results while in section 5 a number of conclusions are drawn.

## 2. Theory

The theoretical underpinnings of the net-exports and attribution methods are provided in this section. The derivations are based on the variables provided by the input-output table (IOT) shown in table 1. This type of table is known as an IOT excluding imports in basic prices. Note that the data on the imports as well as taxes less subsidies on products (TLS) are provided in the row of the IOT.

Table 1. Input-output table of year  $t$  excluding imports in basic prices

	Commodity 1	...	Commodity $n$	Domestic final demand	Export	Total
Commodity 1						
...		$Z_{dom}^t$		$c_{dom}^t$	$e_{dom}^t$	$q^t$
Commodity $n$						
Value added +TLS		$w_Z^t$		$w_c^t$	$w_e^t$	$y^t$
Imports		$m_Z^t$		$m_c^t$	$m_e^t$	$m^t$
Total		$q^t$		$c^t$	$e^t$	

The superscript  $t$  indicates the time period for all variables. Matrices are shown in capital letters. Vectors and scalars are shown in lower case.

- $Z_{dom}^t$  Intermediate demand satisfied by domestic products ( $n$  by  $n$  matrix)
- $c_{dom}^t$  Domestic final demand satisfied by domestic products ( $n$  by 1 vector)
- $e_{dom}^t$  Exports satisfied by domestic products ( $n$  by 1 vector)
- $q^t$  Total output of domestic products ( $n$  by 1 vector)
- $w_Z^t$  GDP (value added and TLS) per commodity (1 by  $n$  vector)
- $w_c^t$  GDP (TLS) of domestic final demand (scalar)
- $w_e^t$  GDP (TLS) of exports (scalar)
- $y^t$  Total GDP (scalar)
- $m_Z^t$  Imports per commodity (1 by  $n$  vector)
- $m_c^t$  Import requirements of domestic final demand (scalar)
- $m_e^t$  Import requirements for exports (scalar)
- $m^t$  Total imports (scalar)
- $c^t$  Total domestic final consumption (scalar)
- $e^t$  Total exports (scalar)

## 2.1. Net-exports method

GDP can be defined by the final demand components (domestic and exports) less imports:

$$y^t = c^t + e^t - m^t \quad (1)$$

The GDP growth from period 0 to period 1 can be attributed to these categories as shown in equation 2. Note that variables  $y^t$ ,  $c^t$ ,  $e^t$  and  $m^t$  are expressed in prices of year 0 so that the real growth in GDP is analysed.

$$\dot{y} = \left( \frac{c^1 - c^0}{y^0} \right) + \left( \frac{e^1 - e^0}{y^0} \right) - \left( \frac{m^1 - m^0}{y^0} \right) \quad (2)$$

$$\text{Where } \dot{y} = \left( \frac{y^1 - y^0}{y^0} \right)$$

The growth rate of variable  $y$  can therefore be related to the growth rate of variables  $c$ ,  $e$ , and  $m$  weighted by the base year. The last two terms of equation 2 are defined as the contribution of net-exports as shown in equation 3.

$$\dot{y} = D_c^{net} + D_e^{net}$$

$$D_c^{net} = \left( \frac{c^1 - c^0}{y^0} \right) \quad (3)$$

$$D_e^{net} = \left( \frac{e^1 - e^0}{y^0} \right) - \left( \frac{m^1 - m^0}{y^0} \right)$$

$D_c^{net}$  Contribution of domestic final demand using the net-exports method

$D_e^{net}$  Contribution of exports using the net-exports method

## 2.2. Attribution method 1

In the net-exports method the imports are subtracted from exports. However, imports are used for domestic demand as well, through final and intermediate demand (Kranendonk and Verbruggen, 2005 p3; ECB, 2005 p54-56). In the attribution method the GDP and imported inputs per final demand component is calculated using an input-output modelling technique. Using the IOT in table 1 it is possible to define GDP from the income perspective, as is shown in equation 4.

$$y^t = w_Z^t \cdot i + w_c^t + w_e^t \quad (4)$$

Where  $i$  is a summation vector ( $n$  by 1) of 1's. Using input-output analysis it is possible to impute GDP to final demand components. This imputation is represented by the following equations. A hat on a variable indicates that it is diagonalized.  $t$  is used throughout the report to identify the time period.

$$y^t = \lambda^t \cdot L^t \cdot (c_{dom}^t + e_{dom}^t) + w_c^t + w_e^t$$

$$\lambda^t = (w_Z^t \cdot \hat{q}^{t-1})$$

$$L^t = (I - A^t)^{-1}$$

$$A^t = (Z_{dom}^t \cdot \hat{q}^{t-1})$$
(5)

$\lambda^t$  GDP (Value added plus TLS) coefficients per commodity ( $n$  by 1 vector)  
 $L^t$  Leontief inverse matrix ( $n$  by  $n$  matrix)  
 $A^t$  Technical coefficients matrix ( $n$  by  $n$  matrix)

If the GDP growth rate is decomposed using this relationship for a year 0 and 1 then the following equation is obtained (the variables for year 1 are in prices of year 0).

$$\dot{y} = \frac{(w_c^1 + \lambda^1 \cdot L^1 \cdot c_{dom}^1) - (w_c^0 + \lambda^0 \cdot L^0 \cdot c_{dom}^0)}{y^0} + \frac{(w_e^1 + \lambda^1 \cdot L^1 \cdot e_{dom}^1) - (w_e^0 + \lambda^0 \cdot L^0 \cdot e_{dom}^0)}{y^0} \quad (6)$$

Now define the attributed GDP share of domestic final demand and exports as follows ( $\alpha_c^t$  and  $\alpha_e^t$  respectively).<sup>1</sup>

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<sup>1</sup> This definition of the alpha's differ from Kranendonk and Verbruggen (2005). In that paper the domestically produced output are used as the denominator i.e.

$$\alpha_c^t = \frac{(w_c^t + \lambda^t \cdot L^t \cdot c_{dom}^t)}{(c^t - m_c^t)} \quad \alpha_e^t = \frac{(w_e^t + \lambda^t \cdot L^t \cdot e_{dom}^t)}{(e^t - m_e^t)}$$

This is done because the models of the CPB distinguish between the growth in imported and domestic shares of final demand components. Since there are only growth figures for total



$$\alpha_c^t = \frac{(w_c^t + \lambda^t \cdot L^t \cdot c_{dom}^t)}{c^t} \quad (7)$$

$$\alpha_e^t = \frac{(w_e^t + \lambda^t \cdot L^t \cdot e_{dom}^t)}{e^t}$$

$\alpha_c^t$  Attributed GDP share of domestic final demand (scalar)

$\alpha_e^t$  Attributed GDP share of exports (scalar)

The equation for the GDP growth rate can be rewritten as shown in equation 8.

$$\dot{y} = \frac{(\alpha_c^1 \cdot c^1) - (\alpha_c^0 \cdot c^0)}{y^0} + \frac{(\alpha_e^1 \cdot e^1) - (\alpha_e^0 \cdot e^0)}{y^0} \quad (8)$$

The contributions of domestic final demand and exports can therefore be defined by the following equations.

$$\dot{y} = D_c^{att1} + D_e^{att1}$$

$$D_c^{att1} = \frac{(\alpha_c^1 \cdot c^1) - (\alpha_c^0 \cdot c^0)}{y^0} \quad (9)$$

$$D_e^{att1} = \frac{(\alpha_e^1 \cdot e^1) - (\alpha_e^0 \cdot e^0)}{y^0}$$

$D_c^{att1}$  Contribution of domestic final demand using the attribution method 1

$D_e^{att1}$  Contribution of exports using the attribution method 1

If an IOT is available for both years (in current prices for year 0 and in prices of the previous year for year 1) the contribution to GDP growth of the domestic final demand and exports can be calculated using this equation. This method is currently used at Statistics Netherlands.

In cases where there is only one IOT available, as is the case in this project, a number of alternatives exist which is described in subsequent sections.

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demand components for the EA, this report adopts coefficients which are related to the growth in total domestic final demand and total exports.

### 2.3. Attribution method 2

Kranendonk and Verbruggen (2005, 2008) describe the method used by the CPB. In this approach the attributed GDP share that is derived from the IOT is assumed to remain constant for all years for which the analysis is done. Kranendonk and Verbruggen (2005, p 7) argue that “Earlier research suggested that in general these ratios are fairly stable over time. For most years, the error caused being committed by using fixed ratios is accordingly limited.” They refer to Kranendonk (1998) for corroboration. It is important to stress that the CPB work is done at a very detailed level. It distinguishes over 10 different demand components and also has information about the final imports of each. At this level of detail the shares are more likely to remain constant than more aggregated data, such as this project. Replacing  $\alpha^l$  by  $\alpha^0$  in equation 9, the following equation is obtained:

$$\begin{aligned} \dot{y} &= D_c^{att2} + D_e^{att2} \\ D_c^{att2} &= \frac{(\alpha_c^0 \cdot c^1) - (\alpha_c^0 \cdot c^0) + r_c}{y^0} \\ D_e^{att2} &= \frac{(\alpha_e^0 \cdot e^1) - (\alpha_e^0 \cdot e^0) + r_e}{y^0} \end{aligned} \quad (10)$$

$D_c^{att2}$  Contribution of domestic final demand using attribution method 2

$D_e^{att2}$  Contribution of exports using attribution method 2

$r_c$  Residual attributed to domestic final demand

$r_e$  Residual attributed to exports

The contributions are therefore calculated using a pure effect and a residual. The residual emerges because of changes in attributed GDP shares. The following equation shows that if the attributed GDP shares remain constant, the residual equals zero.

$$\begin{aligned} r &= (\alpha_c^1 - \alpha_c^0) \cdot c^1 + (\alpha_e^1 - \alpha_e^0) \cdot e^1 \\ r &= r_c + r_e \end{aligned} \quad (11)$$

Total residual

Kranendonk and Verbruggen (2005) split the residual according to the share of the final demand components in the attributed GDP. These weights can only be adopted for a year in which an IOT is present (year 0 in this case). Note that this approach

has the drawback that the residual may actually exceed the pure effect and lead to a change in sign. Kranendonk and Verbruggen (2005, footnote 10, p8) however state that for the Netherlands, “in the period 1990-2004, the residual left to be divided has been approximately nil on average, and in absolute terms, except for one year, it had been 0.5 percentage point or less”. Their procedure is shown in the following equation:

$$r_c = \beta_c \cdot r$$

$$r_e = \beta_e \cdot r$$

$$\beta_c = \frac{w_c^0 + \lambda^0 \cdot L^0 \cdot c_{dom}^0}{y^0} = \frac{\alpha_c^0 \cdot c^0}{y^0} \quad (12)$$

$$\beta_e = \frac{w_e^0 + \lambda^0 \cdot L^0 \cdot e_{dom}^0}{y^0} = \frac{\alpha_e^0 \cdot e^0}{y^0}$$

$\beta_c$  Share of residual assigned to domestic final demand

$\beta_e$  Share of residual assigned to exports

#### 2.4. Attribution method 3

Statistics Netherlands currently adopts attribution method 1, but has also used an alternative approach in 1990's. Assume that table 1 shows the results for the year for which the IOT exists (year 0). This table is a simple Cumulated Production Structure (CPS) discussed in Kranendonk and Verbruggen (2005)

If there is no IOT available for year 1, then only the macro-economic aggregates  $y^1$ ,  $m^1$ ,  $c^1$  and  $e^1$  (in prices of year 0) are known. The CBS estimates the attributed GDP and attributed imports for year 1 in two steps. First, the attributed GDP and imports are assumed to have the same shares as in year 0. Secondly, these initial estimates are fitted to the table totals using WINADJUST, which is a Lagrangian balancing technique used by Statistics Netherlands (van Dalen and Sluis, 2002). The CPS estimates, denoted by the  $\Pi$  symbols, are shown in table 3.

Table 2. Cumulated Production Structure for year 0

	Domestic final demand	Exports	Total
Attributed GDP	$\alpha_c^0 \cdot c^0$	$\alpha_e^0 \cdot e^0$	$y^0$
Attributed imports	$\tau_c^0 \cdot c^0$	$\tau_e^0 \cdot e^0$	$m^0$
Total	$c^0$	$e^0$	

$$\tau_c^t \quad \text{Import share of domestic final demand } (= (1 - \alpha_c^t))$$

$$\tau_e^t \quad \text{Import share of exports } (= (1 - \alpha_e^t))$$

Table 3. Cumulated Production Structure for year 1

	Domestic final demand	Exports	Total
Attributed GDP	$\Pi_{yc}^1$	$\Pi_{ye}^1$	$y^1$
Attributed imports	$\Pi_{mc}^1$	$\Pi_{me}^1$	$m^1$
Total	$c^1$	$e^1$	

$$\Pi_{yc}^t \quad \text{Estimated attributed GDP of domestic final demand (scalar)}$$

$$\Pi_{ye}^t \quad \text{Estimated attributed GDP of exports (scalar)}$$

$$\Pi_{mc}^t \quad \text{Estimated attributed imports of domestic final demand (scalar)}$$

$$\Pi_{me}^t \quad \text{Estimated attributed imports of exports (scalar)}$$

The equation for the share in the growth rate is therefore given by:

$$\dot{y} = D_c^{att3} + D_e^{att3}$$

$$D_c^{att3} = \frac{\Pi_{yc}^1 - (\alpha_c^0 \cdot c^0)}{y^0} \tag{13}$$

$$D_e^{att3} = \frac{\Pi_{ye}^1 - (\alpha_e^0 \cdot e^0)}{y^0}$$

$$D_c^{att3} \quad \text{Contribution of domestic final demand using attribution method 3}$$

$$D_e^{att3} \quad \text{Contribution of exports using attribution method 3}$$

Note that this method provides an estimate of the attributed GDP shares in year 1. The shares are defined by the following equations.

$$\alpha_c^1 = \frac{\Pi_{yc}^1}{c^0}$$

$$\alpha_e^1 = \frac{\Pi_{ye}^1}{e^0} \tag{14}$$

## 2.5. Summary of methods

Table 4 summarizes the formulas which are derived in the previous sections. The equations clearly illustrate the difference between the net-exports and attribution methods. In the net-exports method the imports are deducted fully from the exports to assess the contribution of (net) exports, while in the attribution method the imports are divided amongst the final demand components by multiplication of the attributed GDP share coefficients.

Table 4. Summary of the methods

	Contribution of domestic final demand	Contribution of exports
Net-exports method	$\left(\frac{c^1 - c^0}{y^0}\right)$	$\left(\frac{e^1 - e^0}{y^0}\right) - \left(\frac{m^1 - m^0}{y^0}\right)$
Attribution method 1	$\frac{(\alpha_c^1 \cdot c^1) - (\alpha_c^0 \cdot c^0)}{y^0}$	$\frac{(\alpha_e^1 \cdot e^1) - (\alpha_e^0 \cdot e^0)}{y^0}$
Attribution method 2	$\frac{(\alpha_c^0 \cdot c^1) - (\alpha_c^0 \cdot c^0) + r_c}{y^0}$	$\frac{(\alpha_e^0 \cdot e^1) - (\alpha_e^0 \cdot e^0) + r_e}{y^0}$
Attribution method 3	$\frac{\Pi_{yc}^1 - \alpha_c^0 \cdot c^0}{y^0}$	$\frac{\Pi_{ye}^1 - \alpha_e^0 \cdot e^0}{y^0}$

Many authors have noted that the main problem with the net-exports is that it leads to an underestimation of the importance of exports for GDP growth and overestimates the importance of domestic expenditure categories (ECB, 2005; Kranendonk and Verbruggen 2005, 2008; Hoekstra *et al.* (2006)). It is easy to show that the impact of the domestic final demand component of the net-exports method is larger than the impact calculated through attribution method 1 if the following condition is met:

$$(1 + \dot{c}) \cdot (1 + \dot{\tau}_c) > 1 \quad (15)$$

$\dot{c}$  Growth rate of domestic final demand

$\dot{\tau}_c$  Growth rate of import share of domestic final demand

This condition in equation 15 will only be violated if the growth in the domestic consumption  $c$  is off-set by a decrease in the import share  $\tau$ . Kranendonk and Verbruggen (2005) show, for the Netherlands, that this situation occurs regularly in

practice.<sup>2</sup> When applying these methods it is therefore likely that one will find that the net-exports method leads to a higher estimation of the contribution of domestic final demand to GDP growth.

As the previous section has argued, the attribution methods 2 and 3 are second-best alternatives that may be used if IOT data is not available for all time periods of the decomposition. Both are based on the attribution method and are therefore theoretically preferable to the net-exports method. Nevertheless, both methods have their drawbacks. Attribution method 2 leads to a residual which has to be split amongst the “pure” effects. Potentially, the sign of the pure effect and the total effect may be different because of these adjustments. Method 3 has the disadvantage that the updating method is based on the shares of the previous years. Although this has the advantage that information from recent time periods is being used, the estimates found are path-dependent and may vary from the actual attributed GDP and attributed imports. Note that if attributed shares remain constant over time, all three attribution methods are equal.

Table 5 summarizes the theoretical and practical advantages and disadvantages of the 4 methods which have been introduced in this section.

*Table 5. Summary of advantages and disadvantages of the four methods*

	Advantages	Disadvantages
Net-exports method	Ease of application due to readily available data.	Theoretically problematic because imports are attributed entirely to exports. Likely to overestimate contribution of domestic final demand.
Attribution method 1	Theoretically preferable to the net-exports method	Requires IOT for all time periods being analysed
Attribution method 2	Theoretically preferable to net-exports method, but less so than attribution method 1.	The assumption of a constant attributed GDP share leads to a residual. The “pure effect” may therefore change sign after correction for the residual.
Attribution method 3	Theoretically preferable to net-exports method, but less so than attribution method 1. Uses information from recent year for updating.	Estimates of the attributed GDP and imports are path dependent and may therefore vary from the real values.

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<sup>2</sup> Similarly the ECB’s Monthly Bulletin of June 2005 (Box 7, p 54-56) concludes that “Overall, while net trade and exports are useful measures of activity, it should be borne in mind that the former may in some circumstances give an understated picture of the impulse of the external sector.”

### 3. Data construction

To perform the attribution method calculations, three IOT (for 2003, 2004 and 2005) for the euro area were produced in this project. Before we discuss the data construction methodology, it is important to understand the conceptual challenges related to EA-aggregates.

There are a number of conceptual reasons why the EA aggregates are not simply the summation of national accounts data supplied by the member states. First of all European institutions have to be added because these are not considered “residents” of any of the member states. Secondly, the aggregation of ROW accounts of the member states includes intra-EA trade, which should be excluded if one wants to correctly depict the external trade of the EA. To correct for intra-EA trade, the problem of asymmetries (the fact that intra-EA imports and exports are not equal) has to be resolved. In the process of reconciling these asymmetries it unavoidable that aggregates for the industry and goods levels as well as the total economy will differ from the summation of all countries.

For some years now, the ECB has produced a time series of EA aggregates in which the above conceptual issues are tackled. However, this data set only provides macro-economic aggregates such as GDP and the totals for the final demand categories which are not broken down for the commodity and industry classifications. In this project SUT/IOT for 2003, 2004 and 2005 have been produced which are consistent to these aggregates. This means that, for these years, there is a complete set of consistent production accounts (in current prices) available for the EA.

Now we are ready to discuss briefly the method by which this time series of IOT was produced (a full description is provided in van der Helm and Hoekstra, 2008). There are five types of data which have been used in this project: Supply and use tables (SUT), Input-output tables (IOT), Macro-economic data (MED), International trade in goods (COMEXT) and International trade in services (ITS). The advantage of the approach used in this report is that it is almost entirely based on data available from the ESA95 transmission program, other data freely available from Eurostat and the EA series produced by the ECB. Only in a couple of instances was the data supplemented with information from individual countries.

The IOT required is an “IOT excluding imports in basic prices” as shown in the table below. In this type of IOT the imports and taxes less subsidies on products (TLS) are presented in the rows of the table. The final column is equal to domestic production of goods and services.

The production of the data can be split into six steps. In the first five steps an EA-IOT for 2003 is produced using country level data. The most recent SUT and IOT data is used as well as MED/COMEXT/ITS data for 2003. After the EA-IOT for 2003 is completed it is extrapolated to 2004 and 2005 using data at the EA level.

In step 1, the SUT are constructed for the 13 countries of the EA for the year 2003.<sup>3</sup> For this project, the Eurostat transmission program provided harmonized SUT for 10 of the 13 countries for 2003. The other SUT had to be produced by extrapolating older SUT with MED, COMEXT and ITS data<sup>4</sup>. (ES:2001; GR:1999; IE:2000).

Step 2 involved the conversion of the use table in purchaser prices to basic prices. The trade and transport margins (TTM) and taxes less subsidies related to products (TLS) are calculated for the 13 use tables. IOT or special use tables from the transmission program are used as well as country specific information.

In step 3, the 13 use tables in basic prices are split into the domestic and imported components. This is done using the IOT or special use tables from the Eurostat transmission program or specific information for individual countries.

Step 4 leads to the production of the SUT for 2003 for the EA. This is done by aggregating the SUT (supply tables from step 1 and use tables in basic prices from step 3) for the 13 euro countries and subtracting the intra-EA trade from the imports and exports. The intra-EA trade asymmetries are resolved in this step. The import matrix of the EA is based on the results of the asymmetry calculations as well as the Broad Economic Categories (BEC) classification scheme. A novel aspect of this project was the inclusion of the re-exports data which was produced by the trade statistics department of the CBS. These data for the Netherlands were combined with the other available data of the EA countries to produce an EA re-export series.

In step 5 the IOT for the EA for the year 2003 is calculated by applying the industry technology assumption to the SUT from step 4.<sup>5</sup> The resulting IOT distinguishes 30 commodities as well as 6 final demand components (household consumption, NPISH, government consumption, gross capital formation and exports).

In step 6 the IOT for 2003 is extrapolated to 2004 and 2005 using MED, COMEXT and ITS data at the EA-level. Note that the MED that are referred to here are the macro-economic series produced by the ECB.

#### **4. Results**

The IOT for 2003, 2004 and 2005, which were described in the previous section, were used to apply the attribution method to annual and quarterly GDP growth rates. The GDP growth rate is attributed to the final consumption expenditures by households

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<sup>3</sup> At the start of this project the Euro area consisted of 13 countries.

<sup>4</sup> This method is fairly similar to the “euro method” in Eurostat (2008).

<sup>5</sup> For other methods of constructing input-output tables see Almon (2000) and Konijn (1994).



and NPISH<sup>6</sup>, the final consumption by government, gross capital formation and exports.<sup>7</sup>

The results of these calculations are provided in Tables 6-8 and Figures 1-3. The annual results are provided for the years 2001 to 2006 (Table 6 and Figure 1). Table 7 and Figure 2 provide the quarterly results (seasonally adjusted, compared to previous quarter) for quarters 2006Q1 to 2007Q3. Table 8 and Figure 3 shows the results for the growth rates compared to the same quarter in the previous.

The annual results shows that the contribution of government expenditures is remains fairly stable at around 0.2 to 0.5%. The most volatile determinant of growth is the changes in gross capital formation which contributed negatively in 2001 and 2002 while it was the most important factor for positive growth in 2005. The slow-down of 2002 and 2003 was caused primarily by a decrease in the gross capital formation (2002) and a slow down in consumption (2002 and 2003) and exports (2003). After 2003 the economy recovers to a high of nearly 3% growth in 2006. The recovery is caused mainly by the growth in exports and gross capital formation. Consumption growth does not show as strong a recovery.

The quarterly growth rates are provided on a quarter-by-quarter basis (Table 7 /Figure 2) and on a year-on-year basis (Table 8/Figure 3). The quarter-on-quarter growth rates, which when added together should approximate but not exactly equal the annual growth rate, shows that the influence of the final demand categories is very variable over the quarters. Particularly exports and GCF show large variations per quarter. The conclusions from the year-on-year quarterly growth analysis are similar to those of the annual results: growth is primarily caused by exports and GCF, with rather stable contribution from household consumption and GCF.

*Table 6. Annual growth rate decomposition results*

Year	GDP growth rate	Domestic demand			Total	Exports
		Consumption by Households and NPISH	Consumption by Government	Gross capital formation		
2001	2.23	1.14	0.37	-0.16	1.36	0.87
2002	0.82	0.27	0.45	-0.54	0.18	0.64
2003	0.91	0.20	0.34	0.29	0.83	0.08
2004	1.74	0.58	0.23	0.28	1.10	0.64
2005	1.68	0.50	0.19	0.54	1.23	0.45
2006	2.91	0.59	0.34	0.92	1.85	1.07

<sup>6</sup> The IOT distinguish between consumption by households and NPISH but the EA data series do not. The attribution calculations are therefore done for the aggregate of both.

<sup>7</sup> For this purpose of the calculations, attribution method 3 has been adopted.

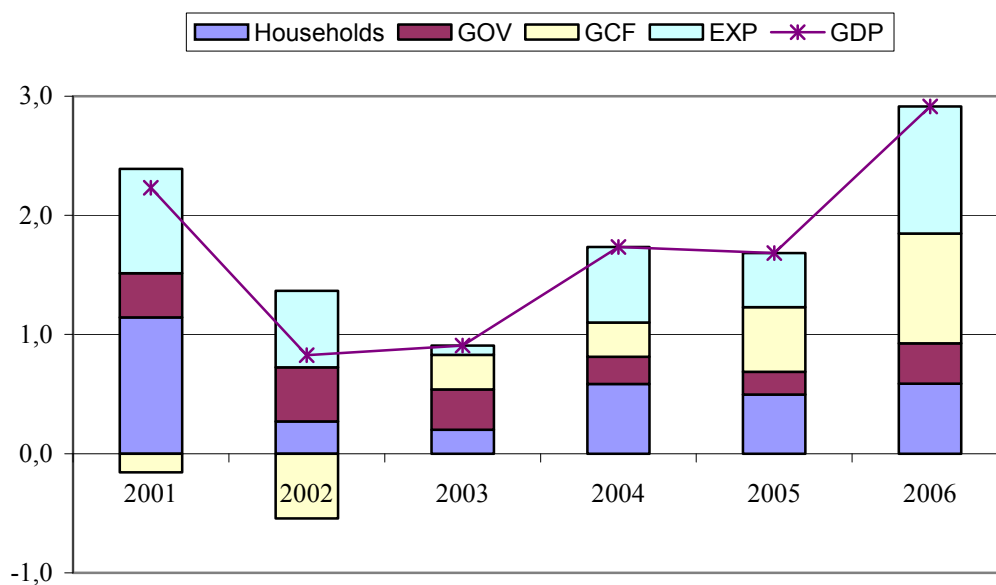


Figure 1. Annual growth rate decomposition results

Table 7. Quarter-on-quarter quarterly growth rate decomposition results

Quarter	GDP growth rate	Domestic demand			Total	Exports
		Consumption by Households and NPISH	Consumption by Government	Gross capital formation		
2005Q1	0.27	0.32	0.04	-0.10	0.26	0.01
2005Q2	0.65	-0.07	0.17	0.29	0.38	0.26
2005Q3	0.57	0.18	-0.04	0.00	0.13	0.43
2005Q4	0.58	-0.13	0.04	0.69	0.60	-0.02
2006Q1	0.76	0.39	0.10	-0.10	0.39	0.37
2006Q2	1.04	0.25	0.11	0.45	0.81	0.23
2006Q3	0.53	0.05	0.09	0.21	0.34	0.19
2006Q4	0.80	0.04	0.21	-0.06	0.20	0.60
2007Q1	0.64	0.07	0.02	0.48	0.57	0.05
2007Q2	0.39	0.24	0.03	-0.06	0.22	0.17
2007Q3	0.61	-0.02	0.12	0.09	0.19	0.43

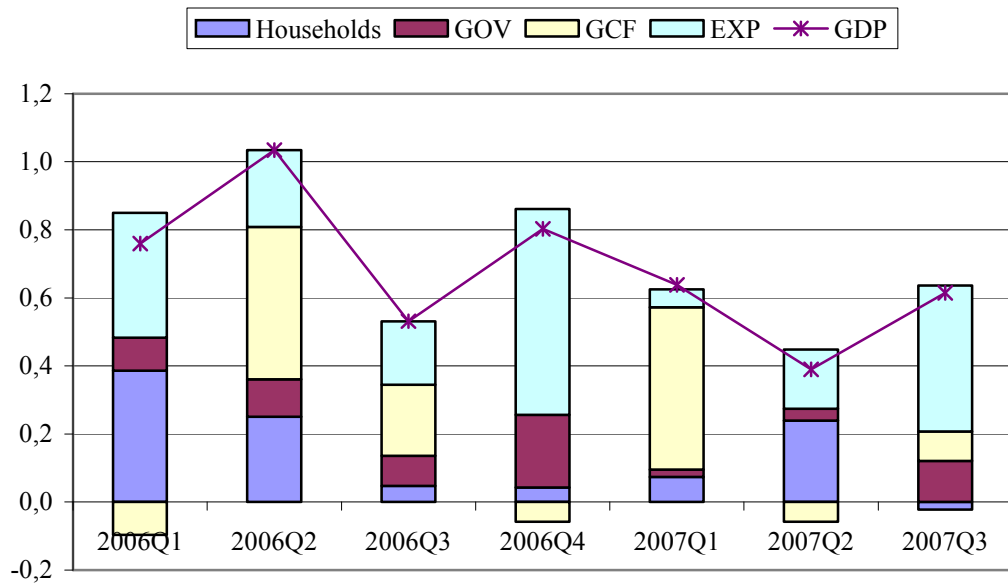


Figure 2. Quarter-on-quarter quarterly growth rate decomposition results

Table 8. Year-on-year quarterly growth rate decomposition results

Quarter	GDP growth rate	Domestic demand			Exports	
		Consumption by Households and NPISH	Consumption by Government	Gross capital formation		
2005Q1	0.77	0.56	0.11	0.08	0.75	0.03
2005Q2	2.01	0.56	0.27	0.86	1.69	0.32
2005Q3	1.68	0.67	0.16	0.16	0.98	0.70
2005Q4	1.73	0.21	0.22	0.73	1.16	0.57
2006Q1	3.29	0.36	0.28	1.33	1.97	1.34
2006Q2	2.27	0.73	0.21	0.57	1.51	0.76
2006Q3	2.63	0.59	0.34	1.05	1.97	0.66
2006Q4	2.96	0.67	0.53	0.41	1.61	1.33
2007Q1	2.89	0.39	0.44	1.03	1.86	1.05
2007Q2	2.42	0.45	0.36	0.56	1.37	1.05
2007Q3	2.53	0.37	0.39	0.47	1.22	1.32

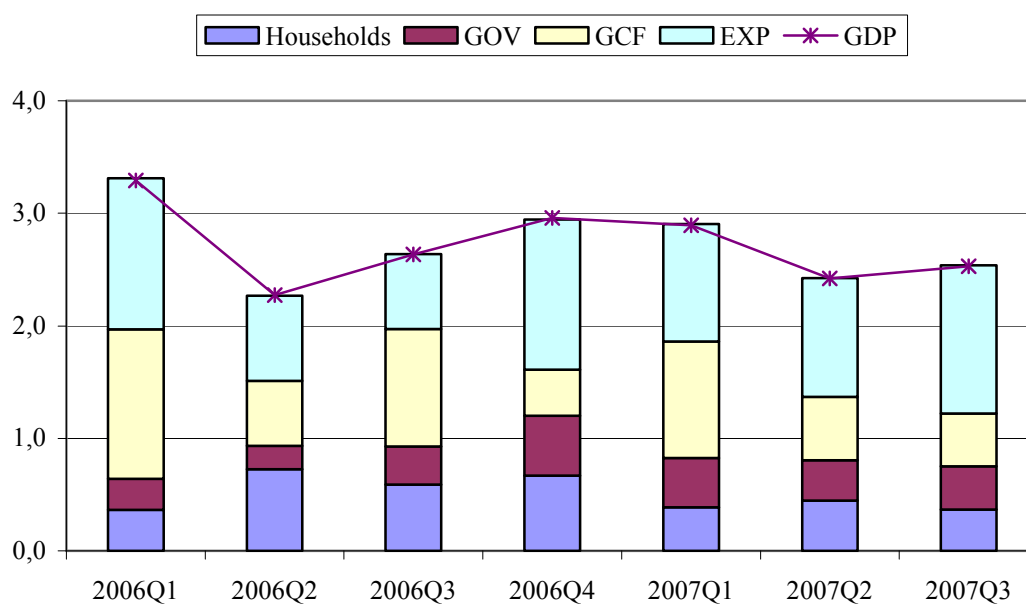


Figure 3. Year-on-year quarterly growth rate decomposition results

#### 4.1. Summary statistics of the IOT

Table 9 shows the “Cumulated Production Structure” (CPS) of the IOT for 2005. The CPS breaks down the total final demand into attributed GDP and attributed imports. The attributed GDP and imports are composed of a direct portion (“final”)

and an intermediary portion, of which the latter is calculated using the input-output model.

The table shows total GDP of the EA is 8073 thousand million in 2005. Total imports of the EA from the rest of the world are 1557 thousand million euros while the exports are 1624 thousand million. Note that all these totals are consistent to the EA series published by the ECB.

Note that the IOT which are produced for 2003, 2004 and 2005 can be used in the attribution of growth rates, but may also be used for the other modelling applications.

*Table 9. Cumulated Production Structure (CPS) matrix for the EA, 2005 (thousand million euro and ratio's)*

	Households	NPISH	Government	Gross capital formation	Exports	Total
<b>Attributed GDP</b>	3792	91	1549	1398	1242	8073
-Final GDP	509	0	7	127	1	644
-Intermediary GDP	3283	91	1543	1271	1241	7430
<b>Attributed imports</b>	764	6	106	300	382	1557
-Final imports	302	0	11	103	93	509
-Intermediary imports	461	6	94	197	289	1048
<b>Total demand</b>	4556	98	1655	1699	1624	9630
-Attributed GDP share	0.83	0.93	0.94	0.82	0.76	0.84
-Attributed imports share	0.17	0.07	0.06	0.18	0.24	0.16
-GDP contribution	0.47	0.01	0.19	0.17	0.15	1.00

#### **4.2. Attributed GDP shares**

For the attribution method, the attributed GDP shares of the annual IOT for 2003 and 2004 and 2005 are used as a first estimate for the quarterly data. However, the balancing routine adopted in attribution method 3 leads to an estimate of the implicit attribution shares per quarter. Figure 4 shows how these attribution shares of the different final demand categories develop from 2001Q1 to 2007Q3. The shaded area shows the period for which an IOT was produced. Generally, the shares remain within a fairly narrow range. All the shares, except the government shares, appear to increase slightly at first and then decrease. Particularly exports show a significant decrease in the attributed GDP share which is caused by both the increase in re-exports and an increase of imports used intermediately.

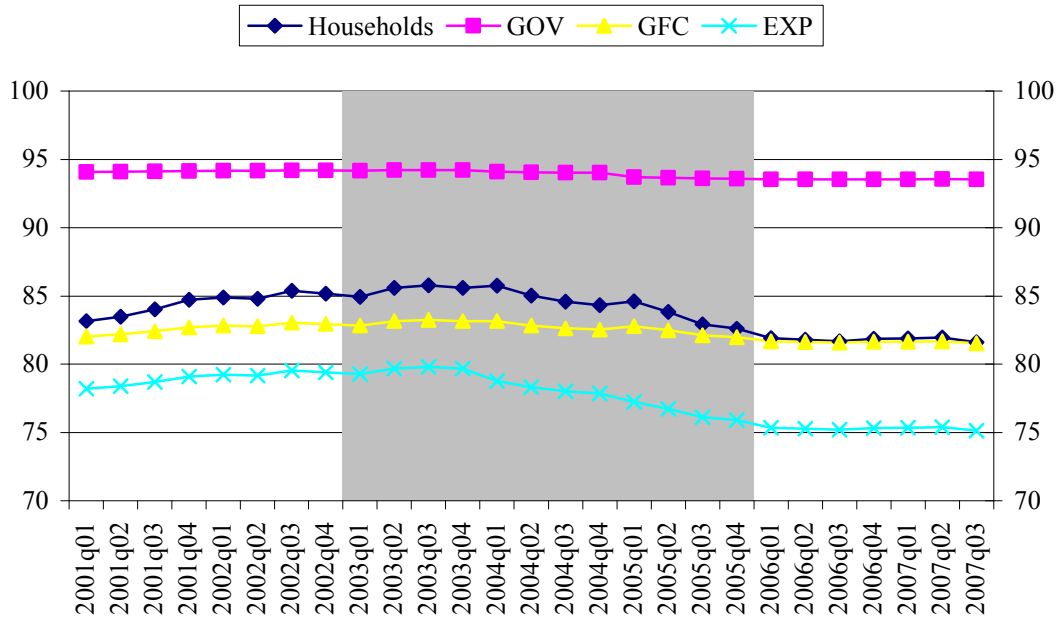


Figure 4. Quarterly attribution GDP shares of final demand categories

Note that the values in Figure 4 are not observations, but rather modelling outcomes of the attribution method 3. The results therefore also provide some hints about possible improvements to the attribution method. It is for example interesting to note that the change in the attributed GDP share is often quite large from the fourth to the first quarter (see for example the changes for 2003Q4-2004Q1). There is no way of checking whether this is a real phenomenon or a modelling artefact although the latter does seem fairly plausible. There are two ways of resolving this issue. Firstly one might smooth the developments in the attributed shares using procedures such as the Denton method (Bikker and Buijtenhek, 2006; TF-QSA, March 2004). Secondly, one could try to add more specific quarterly data to the calculations. For example, if quarterly estimates of re-exports were available or a breakdown of the products which are consumed by households per quarter, it would help to produce more accurate estimates of the quarterly GDP shares.

### 4.3. Re-exports of the EA

A major improvement in the data of this project has been the construction of time series of re-exports for the EA. The data is based on aggregate data which we were able to find for re-exports for individual countries, in particular the 4 major re-

exporters Germany, the Netherlands, Belgium and France<sup>8</sup> (which constitute about 95% of the re-exports from a national perspective).

However, not all these national data are re-exports from the EA-community perspective. The trade statistics department of the Statistics Netherlands were therefore asked to distinguish the source and destination of the re-exports so that the re-exports can be recalculated using the community concept.

Table 10 shows the percentages of the re-exports per source-destination combination (EA-Euro area, NEA-Non-euro area) for the Netherlands. The results show that 25% of the re-exports of the Netherlands in 2006 are re-exports from the EA-community perspective. It is interesting to note that the importance of EA re-exports is increasing for this period.

*Table 10. Source and destination of re-exports for the Netherlands, 2003-2006 (%)*

	Source-destination			
	EA-EA	NEA-EA	EA-NEA	NEA-NEA
2003	26%	39%	14%	21%
2004	25%	39%	14%	23%
2005	24%	37%	14%	25%
2006	24%	37%	14%	25%

Table 11 shows the resulting estimates of the re-exports of the EA in thousand million euros. The figures show that the Dutch figures constitute about a third of the total estimate. Furthermore, the data shows that although re-exports are fairly modest as a percentage of the total exports, they are growing faster than total exports.

*Table 11. Re-exports estimates for the EA, 2003-2006 (1000 million euro and %)*

	2003	2004	2005	2006
Re-exports NL (EA community principle)	20778	25867	30905	34688
Re-exports EA	63168	80033	92523	105885
Exports EA	1371931	1493098	1623543	1828136
Ratio re-exports/exports EA	4.6%	5.4%	5.7%	5.8%

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<sup>8</sup> Note that France has revised its re-exports significantly in the latest transmission of its IOT. In previous versions, France showed re-exports of around 100.000 million while the values are now lower than 20.000 million.

## 5. Future research

The production process is currently split into 6 steps which have been made in linked Excel workbooks. These can be quickly updated as new SUT and other macro-economic data become available.<sup>9</sup> If one would want to further automate the statistical process (using MATLAB for example) it would be wise to work backwards through the steps.

The quality of the IOT would benefit from the following improvements in the underlying data:

1. Further harmonization of data. More consistent data would benefit the automation and quality of the data.
  - SUT/IOT. The availability and consistency of SUT and IOT differs for each country. The data process would be easier to automate if all data (including all IOT sub tables) became available at a specified time.
  - MED/SUT. Although the consistency between the MED and SUT has improved there are still differences.
  - COMEXT/ITS. Further improvement in the resolution of trade asymmetries for goods as well as services would be very useful for the EA-IOT calculations. Also further research into the differences in the COMEXT and SUT totals would be useful.
2. Improved timeliness.
  - SUT/IOT. This project was carried out at the end of 2007 but 2003 was the most recent year for which a SUT/IOT for the EA was feasible. In fact, even at that stage, three of the countries did not have tables for 2003 although the ESA transmission programme requires the annual transmission of SUT tables at t+36 months. Currently SUT for 2006 for 7 out of 27 member states are not published yet on the Eurostat website. IOT are only published every 5 years on a mandatory base. Annual publication is based on voluntary base.
  - MED. The extrapolation of the IOT was feasible up to 2005. If the MED for value added per NACE, consumption etc became available more quickly then the IOT could have been extrapolated to 2006.
3. More detailed availability of data.
  - Value added and output per NACE. The IOT is currently 30 by 30 commodities. The supported detail would improve, perhaps even to

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<sup>9</sup> In this project, the SUT for 2003 for France became available when we had nearly finished the project. Updating our calculations using the new data took less than 2 days.



60 by 60, if the data on value added and output were provided in more than NACE30. These figures are required in steps 1 and 6. This problem is now tackled in the current transmission program.

- Availability of data by commodity group. It would be helpful if the final demand aggregates were assigned to commodity groups (CPA classification). Although breakdowns are available for final consumption of households (COICOP) and final consumption of government (COFOG), these are functional classifications that do not necessarily translate well into CPA02. Breakdowns of imports and exports are obtained using COMEXT and ITS data; and GFCF data is broken down using a highly aggregate classification.
- Specifically a commodity breakdown of changes in stocks would be welcomed. The transmission program only provides for MED country-level totals of stock changes. As a consequence the extrapolation per commodity is very poor. Information of the changes in stocks per CPA02 would improve this situation.

#### 4. New data

- Re-exports. This project has shown that re-exports are a significant, and growing, share of total EA exports. The current estimates are only based on Dutch data but would benefit if new data becomes available for Germany, France and Belgium.
- Quarterly data. Figure 4 shows the attributed shares per quarter. These were calculated by using the annual shares from the IOT and quarterly aggregates. The calculations would benefit from more detailed quarterly data such as re-exports or household per quarter. For example, the consumption per COICOP per quarter would help to better estimate the attributed GDP share for consumption for a quarter.
- SUT. In step 2 the use tables is converted from purchaser prices to basis prices using the most recent IOT. This would be more accurate if use tables on TLS (Product related taxes less subsidies) and TTM (trade and transport margins) were available. For some time IPTS (Institute for Prospective Technology Studies) works on compilation of use tables basic prices for EU27 member states from 1995 on.
- SUT. In step 3 the use table is split into an imported and domestic part using the most recent IOT. This would be more accurate if use tables separating imported and domestic use were available.
- It would be very useful if the national (use of) imports tables included direct geographical breakdowns, as this would reduce a large number of estimations from the compilation that rely on COMEXT data. New SUT arrangement includes geographical

breakdown for intra/extra EU27 and EA/non-EA member states. The latter are not used/filled yet.

- As new countries enter the euro area the macro-economic data which were used in the six steps will also have to be provided for the new countries. Often, this is already the case.

Each of these suggestions would constitute an improvement in the quality of the resulting EA IOT. However, the feasibility of introducing these data availability improvements is beyond the scope of this study.

## **6. Conclusions**

In the field of analysing economic growth, the “net-exports” method is very prevalent. In this paper we have shown that the attribution method, which is based on input-output models, is superior to the net-exports method. This also explains why the attribution method is increasingly being used by policy institutes including the ECB. The method has only gained in relevance because of the financial crisis which makes the analyses of the sources of recovery even more important.

In our paper we have illustrated the various methods by applying them to the annual and quarterly growth rates of the Euro area (EA). To do so input-output tables for three years were constructed for the EA. We have also suggested a number of statistical improvements which would improve the analysis of growth of the EA. Some of these suggestions are now included in the transmission program, but in some cases only on a voluntary base.

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