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MONETARY POLICY SHOCKS IN A TWO-SECTOR OPEN ECONOMY

AN EMPIRICAL STUDY

by Ricardo Llaudes

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In 2007 all ECB publications feature a motif taken from the €20 banknote.

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Abstract

This paper studies the effects and the transmission mechanism of unexpected monetary policy shocks in an open economy setting within the context of a VAR framework. It considers an economy with two sectors, a tradable sector and a non-tradable sector. For a given country, economic sectors are defined according to the proportion of output that is exported to other countries. This paper departs from the standard literature in that it tries to isolate the differential effects that monetary policy shocks may have on these two distinct sectors of the economy. The results show that the behavior of these two sectors varies whithin a country, with the tradable sector showing a higher degree of responsiveness to policy shocks than the non-tradable. This result is robust across the different countries in the sample and for a synthetic aggregate. The evidence presented gives an indication that industrial structure may be an important component for the analysis of monetary policy.

Key Words: Monetary shock, small open economy, structural VAR.

JEL Classification: C32, E52, F31, F42

Non-technical summary

This paper seeks to add to the existing literature on the effects and the transmission mechanism of monetary policy shocks in an open economy setting. It will consider an economy with two sectors, a tradable sector and a non-tradable sector, and it will focus on the effects that monetary policy shocks have on these two distinct sectors of the economy. For a given country, economic sectors will be defined according to the proportion of output that is exported to other countries.

The approach in this paper departs from the standard literature in that it tries to isolate the differential effects that policy shocks may have on the tradable and non-tradable sectors of the economy, in contrast to the standard practice of using some measure of aggregate economic activity. As motivated by Dedola and Lippi (2005), this disaggregated approach is more helpful in the understanding of the monetary transmission mechanism than the aggregate one. This is because disaggregated data may be more informative than aggregate ones (given the idiosyncratic nature of sectoral production processes that can widely vary across sectors within a country) and because evidence of the heterogeneous industrial response to monetary policy may be lost with aggregation. Furthermore, by disaggregating the data into tradable and non-tradable sectors, this paper complements the vast theoretical literature on small open economies that explicitly makes this distinction in sectoral activity yet seldom brings any of its results to the data.

As it is common practice in the literature, I will use a structural vector autoregression approach (SVAR) to analyze the impact of monetary policy shocks in a set of 15 OECD countries. All countries in the sample can be considered small open economies with similar degrees of financial and industrial development. This feature of the data facilitates the comparison of results across countries and will allow for the construction of synthetic cross-country data. The estimation strategy will use two alternative approaches to the identification of the monetary policy shocks: The first approach uses a recursive identification scheme based on the Cholesky decomposition. The recursive structure is determined by the ordering of the variables in the VAR. The second approach relies on the structural VAR (SVAR) methodology. This facilitates the modelling of non-recursive structures and addresses the problem of the interpretation of contemporaneous correlations among variable. I will use a modified version of Kim's (1999) identification scheme that allows for both tradables and non-tradables to enter the estimation.

This paper extends this literature in several dimensions. First, whereas similar papers by Hayo and Uhlenbrock (2000), Ganley and Salmon (1997), and Barth and Ramey (2001) rely on the standard recursiveness assumption for the identification of monetary shocks, adding a subset of sectors to an aggregate VAR, our study uses both, recursive and non-recursive structures, adding a degree of comparability and robustness to the results. Second, most of the papers in the literature study one sector at a time, whereas our study adds different sectors simultaneously. Moreover, the literature tends to only focus on different subsectors within the industrial sector, limiting the scope and breadth of the analysis. Our study focuses on two very different sectors, the tradables and the non-tradables. Finally, while these papers focus on individual countries (only Dedola and Lippi (2005) use more than one country in their analysis), this paper expands substantially the sample, considering 15 OECD countries.

The results obtained show that both sectors, tradable and non-tradable, are sensitive to the effects of monetary policy. As a result of a contractionary monetary policy shock that raises the level of the interest rate and causes an appreciation of the exchange rate, both tradable and non-tradable output decrease in all countries in the sample. Another common feature of the results is that the reduction in tradable output is more pronounced than the reduction in non-tradable output. This can be explained by two complementary factors: Production of tradables, that is, manufacturing, may be more interest rate sensitive than non-tradables (service) production, so for a given increase in interest rates, tradable output will be more negatively affected. Secondly, a monetary contraction that leads to an appreciation of the exchange rate will result in a loss of price competitiveness of the domestic tradable goods in both international markets and in relation to the non-tradables sector. These two factors combined can explain the observed larger decline in tradable output. These results also hold when a synthetic aggregate of the data is constructed.

1 Introduction

This paper seeks to add to the existing literature on the effects and the transmission mechanism of monetary policy shocks in an open economy setting. It will consider an economy with two sectors, a tradable sector and a non-tradable sector, and it will focus on the effects that monetary policy shocks have on these two distinct sectors of the economy. For a given country, economic sectors will be defined according to the proportion of output that is exported to other countries.

The approach in this paper departs from the standard literature in that it tries to isolate the differential effects that policy shocks may have on the tradable and non-tradable sectors of the economy, in contrast to the standard practice of using some measure of aggregate economic activity. As motivated by Dedola and Lippi (2005), this disaggregated approach is more helpful in the understanding of the monetary transmission mechanism than the aggregate one. This is because disaggregated data may be more informative than aggregate ones (given the idiosyncratic nature of sectoral production processes that can widely vary across sectors within a country) and because evidence of the heterogeneous industrial response to monetary policy may be lost with aggregation. Furthermore, by disaggregating the data into tradable and non-tradable sectors, this paper complements the vast theoretical literature on small open economies that explicitly makes this distinction in sectoral activity yet seldom brings any of its results to the data.[1]

As it is common practice in the literature, I will use a structural vector autoregression approach (SVAR) to analyze the impact of monetary policy shocks in a set of 15 OECD countries. All countries in the sample can be considered small open economies with similar degrees of financial and industrial development. This feature of the data facilitates the comparison of results across countries and will allow for the construction of synthetic cross-country data. The estimation strategy will use two alternative approaches to the identification of the monetary policy shocks: The first approach uses a recursive identification scheme based on the Cholesky decomposition. The recursive structure is determined by the ordering of the variables in the VAR. The second approach relies on the structural VAR (SVAR) methodology. This facilitates the modelling of non-recursive structures and addresses the problem of the interpretation of contemporaneous correlations among variable. I will use a modified version of Kim's (1999) identification scheme[2] that allows for both tradables and non-tradables to enter the estimation.

This paper is part of the large body of empirical literature on the effects and trans-

[1] Sectoral disaggregation of output is found in Obstfeld and Rogoff (1999) and many others. For a broad overview of open-economy dynamic general equilibrium models see Lane (2003).

[2] Additional variations on Kims's (1999) model for identification of non-recursive structures can be found in Sousa and Zaghini (2004), Raddatz and Rigobon (2003), and others.

mission of monetary policy dating back to Sims' (1980) seminal work. The estimation approach builds on the methodology used in this context by Bernanke and Blinder (1992), Grilli and Roubini (1996), Christiano, Eichenbaum and Evans (1998), and Sims and Zha (1996), among others. The methodology in these papers is extended to the analysis of the sectoral effects and the sectoral transmission mechanism of monetary policy shocks. In this context, this study is more related to papers by Hayo and Uhlenbrock (2000), Ganley and Salmon (1997), Barth and Ramey (2001), and Raddatz and Rigobon (2003), that measure the industrial effects of monetary policy in Germany, the UK, and the US (for the latter two) respectively. Their results indicate that the sensitivity of output to changes in monetary policy differs substantially across industrial sectors. This paper also relates to work by Dedola and Lippi (2005) that reports evidence on the effects of monetary policy shocks on the industrial activity of 21 manufacturing sectors in five OECD countries (France, Germany, Italy, the UK, and the US), finding sizable and significant cross-industry differences in the effects of monetary policy but hardly detectable cross-country variability.

This paper extends this literature in several dimensions. First, whereas these papers rely on the standard recursiveness assumption[3] for the identification of monetary shocks, adding a subset of sectors to an aggregate VAR, our study uses both, recursive and non-recursive structures, adding a degree of comparability and robustness to the results. Second, most of the papers in the literature study one sector at a time, whereas our study adds different sectors simultaneously. Moreover, the literature tends to only focus on different subsectors within the industrial sector, limiting the scope and breadth of the analysis. Our study focuses on two very different sectors, the tradables and the non-tradables.[4] Finally, while these papers focus on individual countries (only Dedola and Lippi (2005) use more than one country in their analysis), this paper expands substantially the sample, considering 15 OECD countries.

The results obtained show that both sectors, tradable and non-tradable, are sensitive to the effects of monetary policy. As a result of a contractionary monetary policy shock that raises the level of the interest rate and causes an appreciation of the exchange rate, both tradable and non-tradable output decrease in all countries in the sample. Another common feature of the results is that the reduction in tradable output is more pronounced than the reduction in non-tradable output. In an open economy setting, this can be potentially explained by two complementary factors: Production of tradables, that is, manufacturing, may be more interest rate sensitive than non-tradables (service) production, so for a given increase in interest rates, tradable output will be more negatively affected. Secondly, a

[3] Only Raddatz and Rigobon (2003) use a non-recursive identification scheme applied to different components of US GDP.

[4] As the next section will show, the non-tradable sector will be identified with the service sector, while the tradable sector will be identified with the manufacturing sector.

monetary contraction that leads to an appreciation of the exchange rate will result in a loss of price competitiveness of the domestic tradable goods in both international markets and in relation to the non-tradables sector. Evidence in this paper gives some support to the argument that both these two factors combined can explain the observed larger decline in tradable output, although most of the larger decline can be attributed to the interest rate channel rather than the exchange rate channel. These results also hold when a synthetic aggregate of the data is constructed.

The remainder of this paper is organized as follows. In the next section I will focus on the classification of output between tradables and non-tradables, and will review some of the existing literature. In Section 4 I will present the methodology used in the identification of monetary policy shocks for both recursive and non-recursive structures. Section 5 will present and discuss the empirical results. A conclusion and summary of the main results will finalized the paper.

2 Two Sector Economies: Tradables and Non-tradables

This paper departs from the standard literature on monetary policy shocks and VARs in that it studies the effect of these shocks on an open economy that has two-sectors, a tradable sector and a non-tradable sector. Therefore, it is important to understand how this division of the economy into these two sectors can be implemented in practical terms and what the implications are.

It is common practice in the literature on open economies and exchange rate determination to distinguish between these two sectors, as trade is one of the most important links among countries and a channel for the transmission of shocks. The tradable sector is assumed to produce output or commodities that are easily exported and imported among countries.[5] At a theoretical level, this classification does not raise any further issues and can be easily assumed. However, at an empirical level, implementing this data breakdown is not as straightforward and raises a number of caveats. Owing to this, the existing amount of empirical literature employing this sectoral distinction is more limited. The implementation is complicated by the fact that it is difficult to separate those goods that are purely tradable from those that are not. Data on output are not disaggregated at a sufficient enough level to make this distinction clear. Furthermore, very few goods and commodities fall easily into the non-tradable category, since virtually all commodities are tradable to some extent within a given area. This area of trade being determined by transportation costs. Finally, the value or amount of tradable goods can be easily missmeasured as they may contain a non-tradable component.

[5] One of the main factors determining whether a good or service can be easily exported is its transportation costs. The higher the transportation costs, the less likely a good or service is to be traded.

An obvious benchmark to measure the tradability of a particular good is the extent to which the good is traded. De Gregorio, Giovannini, and Wolf (1994) use this benchmark to examine the time-series and cross-section behavior of the relative price of non-tradables in term of tradables for OECD sectoral data, where sectors are defined according to the level of tradability. They define a sector as tradable if more than 10% of its total output is exported. Given this measure, manufacturing is the most tradable of sectors (45.2% of its total production is exported), while services is the least tradable (4.3% of total production in the sector is exported). Therefore, they go on to treat manufacturing as the tradable sector and services as the non-tradable. Similarly, Engel (1999), using the same OECD's Sectoral Database, follows a similar classification in an attempt to measure the significance of the non-traded goods component in the U.S. real exchange rate movements. Finally, Betts and Kehoe (2001), using total trade data between the U.S. and Mexico, use the same procedure to identify those sectors that produce traded type of goods versus those that produce non-traded type of goods. They conclude that services is a non-tradable goods sector while manufacturing is a tradable goods sector.

Table 1. Distribution of economic activity across sectors

(Average 1970-2004)

	Agriculture	Manufacturing	Construction	Services
Australia	4.4	22.0	6.8	65.5
Austria	2.5	23.9	8.3	65.3
Belgium	1.4	22.0	5.0	71.6
Canada	3.0	25.3	6.4	65.5
Denmark	3.4	19.4	5.6	71.5
Finland	4.7	22.7	7.6	65.0
France	3.5	21.9	6.2	68.4
Germany	1.6	29.4	7.5	61.5
Italy	3.8	25.2	6.2	64.9
Netherlands	3.3	21.7	5.6	69.5
N. Zealand	6.6	22.4	4.8	66.2
Norway	2.4	33.6	5.4	58.6
Spain	4.7	22.7	7.6	65.0
Sweden	2.3	21.0	5.2	71.9
UK	1.9	25.8	5.1	67.0

Source: OECD Quarterly National Accounts and author's calculations.

This paper will follow the above mentioned classification and will therefore treat the service sector as the non-tradable and the manufacturing sector as the tradable. All the data on output come from the OECD's Quarterly National Accounts, that classifies output into the following main four groups of activity: Agriculture (plus hunting and fishing), manufacturing (and mining), construction, and services. An argument could be made to treat the construction sector as a non-tradable. However, I chose not to include it on the basis that the construction data show considerable inconsistencies in a number of countries. An alternative would be to drop these countries, but this would however considerably reduce the number of countries in the sample. Furthermore, as shown in Table 1, the share of construction in total output is rather small, so the impact from its exclusion should be rather limited as well. During the period 1970-2004, the average share of construction in total output across the countries in the sample ranges between 5-8%. This number can be compared to the share of services in total output, which averages between 59% and 72%.[6] From Table 1, it can also be seen that all these countries share similar economic structures. These are characterized by rather small agricultural and construction sectors (less than 10% of output), a manufacturing sector that accounts for roughly 1/4 of economic activity, and finally, a service sector that accounts for around 1/3 of economic activity. Another important characteristic of the data is the observed decline in the economic weight of the construction (and both agriculture and, to a lesser extent, manufacturing) sector across time, and an increase in the economic weight of the service sector.

Undoubtedly, the methodology employed for sectoral identification can be subject to improvement, as the tradable sector will contain non-tradable components and vice-versa. Ideally, one would like to analyze finely disaggregated data, comparable across countries, covering an appropriate span of time, and at least at the quarterly frequency to better account for dynamics. However, given the limited availability of data, the above described classification is probably the most feasible empirical approximation.

3 Methodology and the data

To investigate the response of tradables and non-tradables output to a monetary innovation I will rely on the structural VAR methodology, a tool widely used in the empirical on monetary policy.

Following Eichenbaum and Evans (1995) and Kim and Roubini (2000) among others, I

[6] The low value of 59% corresponds to Norway, which can be considered an outlier. Excluding Norway, the values for the share of services in economy range between 65-72%.

will assume that the economy can be described by the following structural form equation:

$$G(L)\, y_t = e_t, \tag{1}$$

where $G(L)$ is a matrix polynomial in the lag operator L, y_t is an $(n \times 1)$ vector of macroeconomic variables, and e_t is an $(n \times 1)$ vector of structural disturbances. These disturbances follow the standard assumptions:

$$E(e_t) = 0 \tag{2}$$

$$E\left(e_t e_s'\right) = \begin{matrix} \Sigma \text{ when } t = s \\ 0 \text{ when } t \neq s \end{matrix} \tag{3}$$

These assumptions imply that the disturbances e_t are serially uncorrelated, while the simultaneous relationships are captured by the matrix of second moments Σ; that is, $var(e_t) = \Sigma$. Σ is a diagonal matrix where the diagonal elements are the variances of the structural disturbances, so these disturbances are also assumed to be mutually uncorrelated.

From the structural equation, we can obtain the reduced form equation VAR, which is what I will be estimating,

$$y_t = \Gamma(L)\, y_{t-1} + u_t, \tag{4}$$

where $\Gamma(L)$ is a matrix polynomial (without a constant term) in the lag operator L, $var(u_t) = \Lambda$, and y_t is the same vector of macroeconomic variables as previously introduced.

As pointed out by Kim (1999), there are various methods to recover the parameters in the structural form equations from those parameters obtained via estimation of the reduced form equation. Two of the most popular methods are 1) to orthogonalize reduced form disturbances by Cholesky decomposition, as suggested by Sims (1980) and 2) to impose reasonable economic restrictions only on the contemporaneous structural parameters.

Following Kim (1999), let G_0 be the coefficient matrix on L^0 in $G(L)$, that is, the contemporaneous coefficient matrix in the structural equation, and let $G^0(L)$ be the coefficient matrix without the contemporaneous coefficient G_0 so that $G(L) = G_0 + G^0(L)$. Then, the parameters in the structural form equation and those in the reduced form equation are related by

$$\Gamma(L) = -G_0^{-1} G^0(L). \tag{5}$$

Moreover, the structural disturbances and the reduced form residuals are related by

$$e_t = G_0 u_t, \tag{6}$$

implying that

$$\Lambda = G_0^{-1} \Sigma G_0^{-1\prime}. \tag{7}$$

Using sample estimates of Λ, maximum likelihood estimates of Σ can be obtained. The right-hand side of Eq. (6) has $n \times (n+1)$ free parameters to be estimated. Since Λ contains $n \times (n+1)/2$ parameters, we need at least $n \times (n+1)/2$ restrictions. If we normalize the n diagonal elements of G_0 to 1's, we need at least $n \times (n-1)/2$ restrictions on G_0 to achieve identification.

In estimation, when the Cholesky decomposition is used, G_0 is assumed to be lower triangular. This is equivalent to imposing a Wold causal ordering, that is, a recursive scheme among the variables. On the other hand, the more general method of imposing restrictions on the contemporaneous parameters gets around the restrictiveness of the recursive structure, allowing for contemporaneous feedback among the variables. Both these identification schemes are further presented below.

3.1 Alternative methods for monetary shocks identification

The first identification scheme used in this paper is based on the recursive identification implied by the Cholesky decomposition. For each country in the sample, the VAR system contains the following set of variables,

$$\{P, TY, NTY, R, RER\},$$

where P is the domestic price level measured by the consumer price index, TY represents output in the tradable sector, NTY is output in the non-tradable sector, R is a short-term interest rate, and RER is the country's real exchange rate defined as

$$RER_t = er_t \frac{P_t^*}{P_t}$$

where for each time t, er denotes the nominal exchange rate, expressed as units of domestic currency per unit of U.S. dollars, P_t^* is the foreign price level, in this case, the U.S. consumer price index, and P_t is the domestic price level. One important difference between this vector of variables and others used in the literature is that money is not included in the system.[7]

In terms of structural and reduced form disturbances, the recursive scheme can be best

[7]Estimation of the VARs with money included in the vector of variables resulted in similar results in terms of the system's response to a policy shock.

represented by the following set of equations,

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 \end{bmatrix} \begin{bmatrix} u_t^P \\ u_t^{TY} \\ u_t^{NTY} \\ u_t^R \\ u_t^{RER} \end{bmatrix} = \begin{bmatrix} e_t^P \\ e_t^{TY} \\ e_t^{NTY} \\ e_t^R \\ e_t^{RER} \end{bmatrix} \tag{8}$$

where e_t^P, e_t^{TY}, e_t^{NTY}, e_t^R, and e_t^{RER} are the structural disturbances, and u_t^P, u_t^{TY}, u_t^{NTY}, u_t^R, and u_t^{RER} are the residuals in the reduced form equations. Both set of residuals are assumed to follow a normal distribution with zero mean and a constant variance.

The causal ordering implied by (8) is similar to the ones used by Eichenbaum and Evans (1995) and Grilli and Roubini (1996). This ordering implies that a contractionary monetary policy shock is measured as the component of a shock to a short-term interest rate that is orthogonal to P, TY, and NTY. These are the variables placed before the monetary instrument R. This corresponds to the assumption that monetary policy innovations affect the price level and output only with a lag. This ordering scheme also assumes that the monetary authority sets its policy variable after observing current values of the price level and the level of output. On the other hand, the exchange rate is ordered after the monetary policy variable. This placement allows current period developments in financial markets to affect the exchange rate contemporaneously.[8]

The second identification scheme used facilitates the modelling of non-recursive structures and addresses the problem of contemporaneous correlation among variables. The non-recursive structure can be represented by the following set of equations,

$$\begin{bmatrix} 1 & b_{21} & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 \end{bmatrix} \begin{bmatrix} u_t^{TY} \\ u_t^{NTY} \\ u_t^P \\ u_t^R \\ u_t^{RER} \end{bmatrix} = \begin{bmatrix} e_t^{TY} \\ e_t^{NTY} \\ e_t^P \\ e_t^R \\ e_t^{RER} \end{bmatrix}. \tag{9}$$

The equations above are similar to those used by Kim (1999) and Sousa and Zaghini (2004) but with output disaggregated into tradables and non-tradables and excluding money. As in these two studies, the identifying structure implies that real activity, that is, tradable and non-tradable output, is assumed to respond to price and financial variables only with

[8] It is important to note that the results obtained using the Cholesky decomposition are not affected by the ordering of the variables. Estimations using alternative schemes show that the results are robust to the ordering. This is indicative that the monetary policy shocks under study are truly exogenous to the economy.

a lag. That is, they are not affected contemporaneously by the interest rate, the price level, or the exchange rate. On the other hand, tradable and non-tradable output respond to each other contemporaneously. The third equation relates prices to the level of activity. The fourth equation describes the behavior of the monetary authority, which sets the interest rate after observing the value of the exchange rate, but not the current value of output or the price level.[9] Finally, following Kim (1999), the real exchange rate equation is assumed to be an arbitrage equation capturing a kind of financial market equilibrium and is assumed to react immediately to changes in the other variables. Therefore, all the other variables enter this equation.

3.2 The data

Estimations are based on quarterly data for a set of 15 OECD countries. Therefore, all countries in the sample can be considered small open economies with similar degrees of financial and industrial development, which facilitates the comparison of results across countries. Data are largely obtained from the IFS and the OECD databases. Following Eichenbaum and Evans (1999) and others, all the variables are entered in the system in log-levels, except for the interest measure that is entered as a percent. In addition, all data except the interest rate and exchange rates, are seasonally adjusted.[10] No seasonal dummies are included. Samples start at different periods based on the country, always using the largest span of data available.

Variables are entered in the system with varying lag lengths depending on the country. Lag length for each country model was determined using information criteria.[11] Number of lags included ranges from 4 to 7 lags. This contrasts with other similar studies that impose the same lag length in every country.

4 Empirical results

This section describes the results obtained, presented by means of charts and tables. The charts show the dynamic impulse response of the variables of interest, that is, R, P, TY, NTY, and RER to a one standard deviation positive (contractionary) monetary

[9] As Sims and Zha (1998) and Sousa and Zaghini (2004) point out, this policy rule is based on the assumption of information delays that limit the ability of the monetary authority to react to price and output developments.

[10] In some cases, the original data available were non-seasonally adjusted, such as the output and the consumer price indexes for a number of countries. In these cases, I used the X-12 procedure from the U.S. Census Bureau to seasonally adjust the data.

[11] AIC and BIC information criteria were calculated for each country and for each specification of the model. This yielded different optimal lag lengths for each country.

shock. For each set of figures, the dashed lines represent plus- and minus-two-standard-deviation error bands.[12] The dynamic response is presented for a four-year horizon (16 quarters). Estimation is run on a country by country basis using both identification methods, the recursive (or Cholesky) and the non-recursive. A synthetic, aggregate result has been derived from the individual country results, using each country's economic size to aggregate the results.[13]

Results are first presented for the synthetic data, followed by the individual country analysis.

4.1 Aggregate results

Figure 1 on the next page shows the synthetic, aggregate results.[14] The left-hand column shows the results obtained using the recursive method for identification while the right-hand column shows results derived from the non-recursive method. Overall, both methodologies lead to very similar results, with the exception of the real exchange rate's response to the monetary shock. In the case of the recursive estimation method, the real exchange rate barely reacts to the shock, while in the case of the non-recursive method, the real exchange rate appreciates as result of the contractionary shock (as shown by a declined in the units of domestic currency per US dollar). The non-reaction of the exchange rate to a monetary shock in the recursive estimation may be a reflection of the *exchange rate puzzle*. As indicated by Sims and Zha (1996) and Cushman and Zha (1997) this is a well-known puzzle of the recursive VAR literature, whereby monetary contractions lead to currency depreciations instead of appreciations. A solution to this *puzzle* was found in the use of non-recursive estimation methods. The results in this paper confirm these conjectures for the behavior of the real exchange rate. For this reason, I will concentrate on the non-recursive estimation in the description of the results.

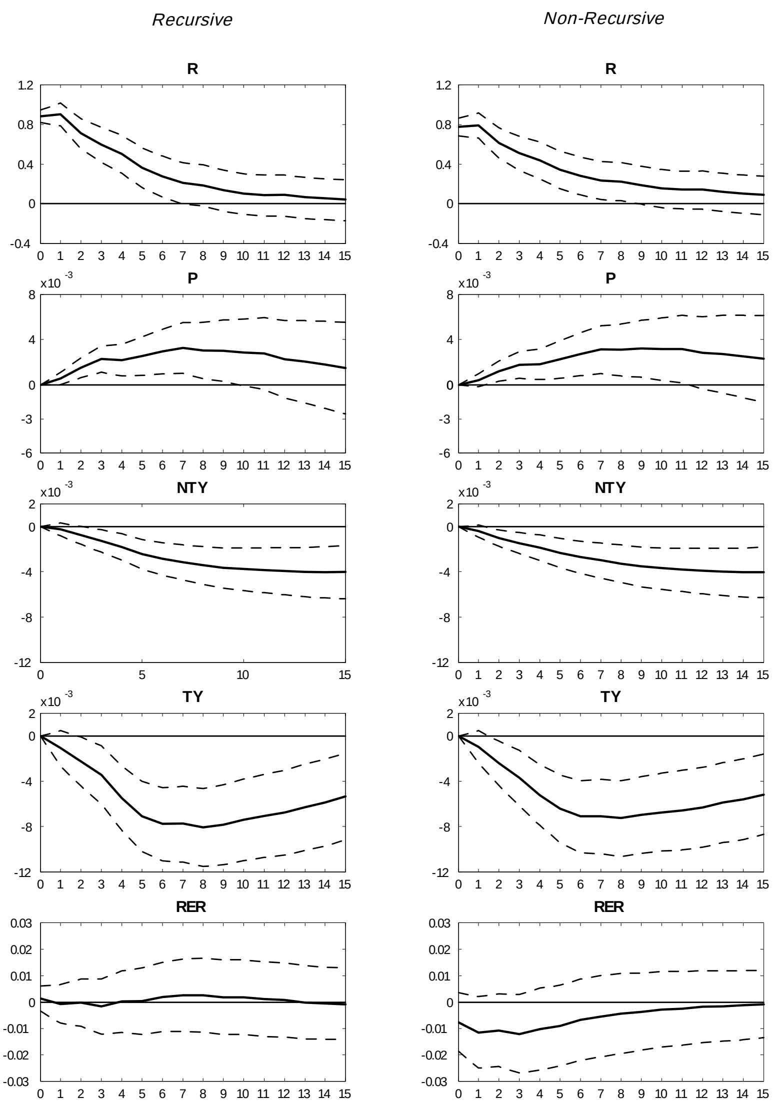
As a result of the monetary contraction, the short-term interest rate, R, increases, reflecting the tighter policy stance by the monetary authority. Following the initial increase, the interest rate gradually declines overtime to reach its long-run equilibrium. Considering now the response of prices to the monetary shock, Figure 1 shows that prices increase as a result of a contractionary monetary policy shock, remaining persistently higher in the long-run. This counterintuitive result (policy tightenings are typically followed by declines

[12] Standard error bands were generated using the method described in Doan (2000). I used a Monte Carlo simulation of 1000 draws.

[13] Economic size is determined by the country's Gross Domestic Product measured in constant $US and obtained from the IMF's World Economic Outlook Database.

[14] Confidence bands for the aggregate are computed as the weighted average of the individual countries' error bands. This takes into account the estimation uncertainty at the country level. Weights used are determined by economic size.

Figure 1: Aggregate response to a contractionary monetary policy shock



in prices) is another well-documented puzzle of the VAR literature.[15] As regards the real exchange rate, the chart shows that a monetary contraction is followed by an immediate appreciation of the local currency that exceeds its long-run appreciation. This is evidence of the exchange rate over-shooting found in Dornbusch (1976). In the long-run, the exchange rate returns to its original equilibrium value. This appreciation of the exchange rate can be explained by the higher level of the interest rate that makes domestic assets more attractive to foreign investors. This leads to increasing inflows of foreign capital that bid up the local currency. Eichenbaum and Evans (1995) obtain similar results but find no evidence of over-shooting; they show that the exchange rate peaks with a delay.

Finally, focusing on the two variables of interest, tradable and non-tradable output (NTY and TY in the third and fourth rows respectively), Figure 1 shows that as a result of the contractionary policy shock, both tradable and non-tradable output decrease. However, the negative response of the tradable sector is considerably more pronounced than the response of the non-tradable sector. Furthermore, as the individual country analysis will show, this result is consistent across countries in the sample. Therefore, a contractionary monetary policy shock is shown to have a greater negative impact on the tradables sector of the economy than on the non-tradables. The figure also shows that the negative response of tradable output reaches its peak response considerably sooner than the non-tradable output. This higher sensitivity to policy shocks in the tradable sector (namely manufacturing) can in principle be explained by two effects that are largely negligible in the non-tradable sector (namely services): The first one is the direct effect of the policy shock via higher interest rates, while the second one is an indirect effect via the exchange rate. As regards the former effect, tradables (or manufacturing), by the nature of their production structure, are typically considered to be more responsive to interest rate changes than non-tradables (or services).[16] As regards the latter effect, an appreciation of the domestic currency causes domestic exports to become more expensive in foreign markets, and therefore, the tradable sector becomes less price competitive. Moreover, tradable goods prices increase relative to the price of non-tradable goods, resulting in a relative loss in competitiveness. This exchange rate effect will cause economic activity and output in the tradable sector to decline relative to the non-tradable sector. Results by Gourinchas (1999) support this argument. He uses a model that looks at the effect of changes in the real exchange rate on job creation by sector. Using data for France he shows that tradable sector employment growth is more responsive to exchange rate movements than non-tradable employment growth, with larger simultaneous increases in

[15] Sims (1992) argues that this may be due to the fact that the monetary authority has knowledge of inflationary pressures and therefore acts to reduce the effect of these pressures.

[16] Furthermore, manufactured products are usually durables, and purchases can be time-shifted. This may be less true of services, and make durables purchases more volatile.

job destruction and decreases in job creation in the tradable sector. Therefore, the larger negative response of the tradable sector to a policy shock can be attributed to a twofold effect: One direct via the interest rate and one indirect via the exchange rate and the implied loss in competitiveness. A later section in this paper will provide evidence giving some support to this argument. Additionally, it will be shown that interest rate effects account for most of the larger negative response of the tradable sector

4.2 Country results

The aggregate results are confirmed by a country by country analysis. The individual country figures contained in Figure 3 of the Appendix show that results are consistent across procedures, with similar reactions to the policy shock. Once again, it is only the exchange rate that exhibits differing behavior from one procedure to another. In a majority of countries (11 out of 15) the exchange rate is higher when the non-recursive method is used. In only two countries (Canada and the Netherlands) does the exchange rate show a significant decrease in value when using the non-recursive method instead of the recursive. As regards the response of output by sector, the different charts show that as a result of a contractionary policy shock both tradable and non-tradable output decrease. Comparing across countries and across sectors, the charts also show that the tradable sectors' negative response to the shock is considerably more pronounced than the non-tradables' response.[17] This pattern holds for every country in the sample except the Netherlands, where the non-tradables' response drifts downwards at the end of the horizon whereas the tradables' remains steady. The peak response for both sectors tends to take place 1-2 years after shock, although the peak for tradables typically comes earlier. As was the case in the aggregate results, the country by country analysis shows that the tradable sector is more interest rate sensitive than the non-tradable sector.

The results obtained graphically can also be analyzed quantitatively. To quantify the output effects of monetary policy across sectors and across countries, I have constructed three summary measures of this impact. These are the sector's output elasticity to a 1 percentage point interest rate increase after 8 quarters, the maximum elasticity recorded, and the average of the elasticities recorded between 8 and 12 quarters after the shock (so single peaks have less influence on the impact measure). These measures facilitate the comparison of results across countries: The size of the policy shock is equal to one standard deviation of the structural innovation and therefore, it varies across countries. By normalizing with respect to the size of the shock, results across countries are strictly comparable.[18]

[17] To facilitate comparison, both set of results for tradables and non-tradables are plotted with the same scale.

[18] When making comparisons across countries one should take into account that the diversity of these

Tables 2 and 3 contain the results of this quantitative analysis (Table 2 for the recursive method and Table 3 for the non-recursive). Once again, both identification methods employed throughout the paper yield very similar results. Moreover, all three elasticity

Table 2. Elasticity of sectoral output to a monetary policy shock

(Recursive estimation)

	Non-Tradables			Tradables			$H_0 : \overline{TY} > \overline{NTY}$
	Max.	8-qtr.	8-12 qtr.	Max.	8-qtr.	8-12 qtr.	*[p-value]*
Australia	-0.35	-0.33	-0.32	-0.49	-0.49	-0.46	[0.06]*
Austria	-0.39	-0.25	-0.26	-1.17	-1.01	-0.97	[0.00]***
Belgium	-0.46	-0.43	-0.43	-1.26	-1.26	-1.20	[0.00]***
Canada	-0.59	-0.44	-0.43	-1.27	-1.27	-1.22	[0.00]***
Denmark	-0.13	-0.12	-0.10	-0.73	-0.22	-0.28	[0.00]***
Finland	-0.73	-0.60	-0.57	-1.55	-1.53	-1.50	[0.00]***
France	-0.57	-0.36	-0.35	-1.20	-1.19	-1.18	[0.00]***
Germany	-0.39	-0.34	-0.34	-0.93	-0.88	-0.83	[0.00]***
Italy	-0.35	-0.23	-0.25	-1.19	-0.51	-0.50	[0.00]***
Netherlands	-1.36	-0.57	-0.58	-0.96	-0.64	-0.72	[0.94]
N. Zealand	-0.50	-0.45	-0.46	-0.73	-0.68	-0.63	[0.98]
Norway	-0.55	-0.49	-0.49	-1.03	-0.83	-0.84	[0.00]***
Spain	-0.31	-0.23	-0.22	-0.47	-0.44	-0.42	[0.01]**
Sweden	-0.48	-0.33	-0.34	-1.83	-1.81	-1.75	[0.00]***
UK	-0.77	-0.74	-0.70	-1.32	-1.32	-1.23	[0.09]*

Note: Statistical significance at the 10% (*), 5% (**), and 1% (***) for the one-sided hypothesis test that the average response to a monetary policy shock is greater in the tradable sector than in the non-tradable sector.

measures convey a similar message: The tradable sector is more responsive (more negative elasticity) to a monetary shock than the non-tradable sector. For all countries, except for the Netherlands when using the maximum elasticity measure, the impact of policy on the tradable sector is greater than the impact on the non-tradable sector, regardless of the elasticity measure used. As shown in Table 2, elasticities for the non-tradable sector range from -0.13 to -0.77 (excluding Netherlands with -1.36) when using the maximum elasticity measure and from -0.10 to -0.70 when using the 8-12 quarters elasticity measure. On the other hand, elasticities for the tradable sector range from -0.47 to -1.83 when the maximum elasticity measure is used, and from -0.28 to -1.75 when the 8-12 quarters elasticity measure

sectors across countries may imply problems in comparability, as in some countries the service sector may be relatively more trade oriented than in others.

is used. To support this quantitative analysis, the right-most column in Table 2 shows the results for the one-sided test that the average response to a contractionary monetary policy shock is greater in the tradeable sector than in the non-tradeable.The p-values for the test confirm that for most countries in the sample (except for the Netherlands and New Zealand) the larger average response by the tradable sector is statistically significant at the 10% level or better, with significance at the 1% for most countries.

Similarly, Table 3 provides equivalent results when the non-recursive estimation method is used. The results from the one-sided test again show that the larger response by the tradable sector is statistically signifcant in most countries at the 10% level or better.[19] Broadly speaking, similar conclusions can be extracted, confirming the results presented above.

Table 3. Elasticity of sectoral output to a monetary policy shock
(Non-recursive estimation)

	Non-Tradables			Tradables			$H_0 : \overline{TY} > \overline{NTY}$
	Max.	8-qtr.	8-12 qtr.	Max.	8-qtr.	8-12 qtr.	*[p-value]*
Australia	-0.34	-0.31	-0.33	-0.49	-0.46	-0.49	[0.07]*
Austria	-0.29	-0.22	-0.21	-1.16	-1.03	-1.05	[0.00]***
Belgium	-0.37	-0.35	-0.35	-1.24	-1.20	-1.24	[0.00]***
Canada	-0.50	-0.34	-0.34	-1.20	-1.15	-1.20	[0.00]***
Denmark	-0.16	-0.12	-0.14	-0.76	-0.33	-0.27	[0.00]***
Finland	-0.59	-0.49	-0.52	-1.26	-1.23	-1.26	[0.00]***
France	-0.74	-0.44	-0.44	-1.39	-1.38	-1.39	[0.00]***
Germany	-0.41	-0.34	-0.34	-0.99	-0.93	-0.98	[0.00]***
Italy	-0.62	-0.48	-0.46	-1.17	-0.33	-0.28	[0.72]
Netherlands	-1.37	-0.72	-0.68	-0.97	-0.81	-0.82	[0.74]
N. Zealand	-0.64	-0.51	-0.50	-0.86	-0.80	-0.86	[0.31]
Norway	-0.53	-0.47	-0.48	-1.03	-0.84	-0.84	[0.00]***
Spain	-0.27	-0.20	-0.21	-0.44	-0.40	-0.42	[0.01]**
Sweden	-0.45	-0.33	-0.32	-1.62	-1.56	-1.59	[0.00]***
UK	-0.79	-0.71	-0.74	-1.33	-1.24	-1.33	[0.09]*

Note: Statistical significance at the 10% (*), 5% (**), and 1% (***) for the one-sided hypothesis test that the average response to a monetary policy shock is greater in the tradable sector than in the non-tradable sector.

[19] For the non-recursive estimation, in addition to the Netherlands and New Zealand, results from the test fail to be significant for Italy.

4.3 The pre-EMU period

In 1999, the national currencies of the eleven Member States of the Economic and Monetary Union[20] ceased to exist independently when their exchange rates were set at fixed rates against each other. This effectively implied that these currencies were no longer allowed to fluctuate with respect each other. Instead of their previous individual currencies, the Member States adopted the euro as their national currency. Under this new regime, references to individual currencies in euro area countries become more difficult to interpret and their use in empirical analyses should be treated with caution and with the due caveats.

This section of the paper checks the robustness of the results to the introduction of the euro in the euro area countries in the sample. These countries (Austria, Belgium, Finland, France, Germany, Italy, Netherlands, and Spain) account for over 90% of euro area output. For these countries, a similar analysis is conducted but restricting the sample to the pre-euro period. Focusing on the pre-euro period allows for a more clear interpretation of the impact of exchange rate fluctuations on the tradable and non-tradable sectors of the economy.

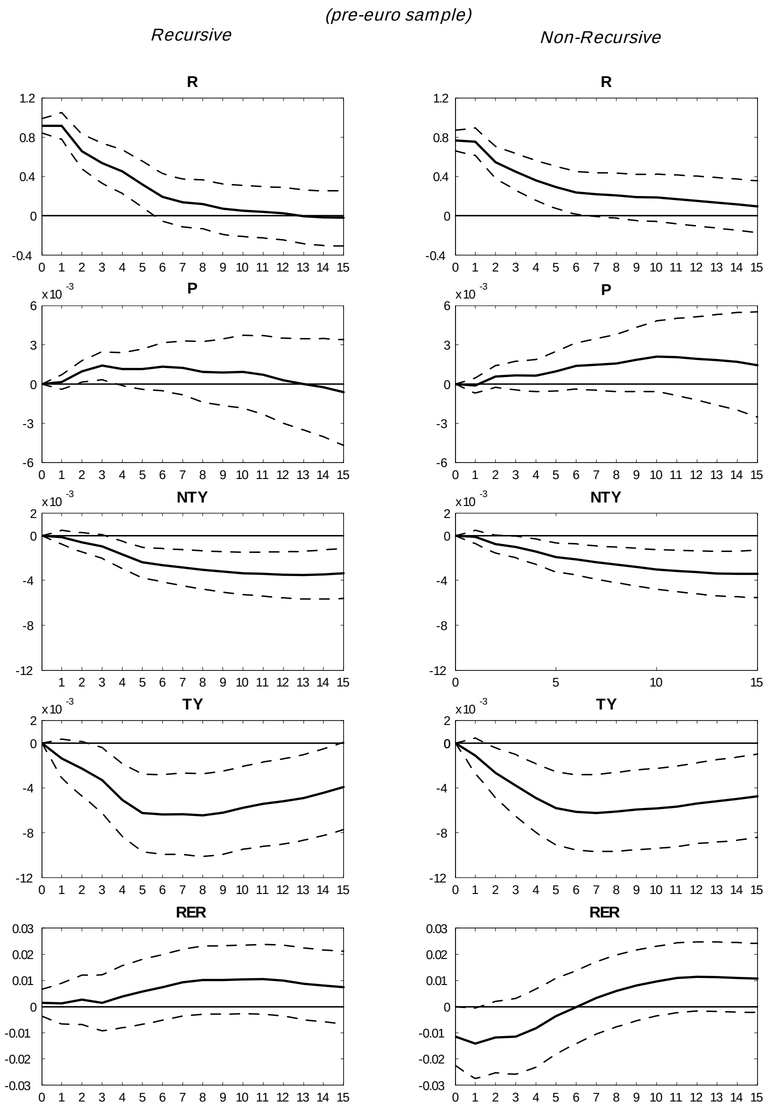
Similar to the full-sample analyses, I am using the recursive and the non-recursive identification methods to trace out the impact of a contractionary monetary policy shocks on the tradable and non-tradable sectors. In a similar manner and for ease of presentation, I have aggregated the impulse response functions to obtain a synthetic euro area response.

The results obtained, shown in Figure 2, present a very similar picture to the one obtained under the full-sample estimation. Once again, both identification methods produce similar responses in the variables of interest. As a result of a contractionary monetary policy shock both tradable and non-tradable output decline. However, it is again evident that the decline in output in the tradable sector (TY) is more pronounced and with an earlier peak then the decline in output in the non-tradable sector (NTY). As regards the real exchange rate response, there are again some differences across methodologies, with a more significant appreciation of the exchange rate in the short-run under the non-recursive method. Comparing these results for the exchange rate with the full-sample results, one can see that the long-run depreciation (increase in the exchange rate) observed in thepre-euro results is not present in the full-sample results. This difference could be related to the greater variability in the exchange rate of the pre-euro period.

Overall, the analysis has shown that the results are robust to the choice of sample period, and that the introduction of the euro did not bring with it a change in the sectoral response to monetary policy shocks in the member countries.

[20] The eleven original adopting countries were: Austria, Belgium, Finland, France, Germany, Italy, Ireland, Luxembourg, Netherlands, Portugal, and Spain. Greece joined the euro area on January 1^{st}, 2001.

Figure 2: Aggregate response to a contractionary monetary policy shock



4.4 Assessing the impact of the exchange rate: The closed economy case

Previous sections in this paper have shown that the response of tradable output (as measured by manufacturing sector output) to a monetary contraction is more pronounced than the response of non-tradable output (measured by service sector output) to the same shock. It has furthermore been argued that in an open economy framework, two factors, higher interest rate sensitivity and the impact of changes in the exchange rate, can potentially explain these differences. This section will attempt to disentangle the impact of these two factors by assuming a closed economy setting. This implies that the impact from the exchange rate is assumed to be zero and any difference in the response to a monetary shock with respect to the open economy case could then be largely attributed to exchange rate effects.[21] *A priori*, the response of manufacturing[22] output to a contractionary shock in the closed economy case would be expected to be less pronounced (negative) than in the open economy setting, as the exchange rate appreciation of the open economy case would no longer have negative implications for competitiveness in the manufacturing sector. On the other hand, services output ought to remain largely unaffected by the economic setting.

The implementation of the closed economy case in the VAR setting would therefore imply the following vector of variables:

$$\{P, TY, NTY, R\}.$$

The closed economy responses for manufacturing and services to a monetary shock, together with the open economy responses are presented graphically in Figure 4 of the Appendix. Focusing on the manufacturing sector (right column) and looking across countries, the decline in manufacturing output is smaller in the closed economy case than in the open economy case in 9 out of the 15 countries. In 3 countries (Belgium, Finland, and New Zealand) the results are mixed, with closed economy output moving around open economy output. In one country, France, there are no major differences in the two cases. This result can be considered somewhat surprising given the observed response of the exchange rate to the policy shock. Finally, for Germany and Canada the results show a stronger contraction in the closed economy case than in the open economy case, at odds with our prior prediction. Focusing now on service sector output, we can see largely negligible differences between the open economy results and the close economy results in

[21] That is, any difference between the open economy and the closed economy in terms of results should be the result of exchange rate effects.

[22] In a closed economy setting it is no longer sensible to classify output as tradable or non-tradable, as no output is traded. Therefore, this section will divide output between manufacturing and services.

roughly half the countries, giving support to the argument that the service sector should remain largely unaffected by exchange rate movements. Therefore, this graphical analysis largely supports the argument that both factors, interest rates and exchange rates, are important in explaining the responses across economic sectors to a policy shock. It can also be observed from this graphical analysis that direct interest rate effects are the main transmission mechanism of policy shocks, and that exchange rate effects only account for a small portion of the impact. This latter effect is depicted graphically by the small gap between the closed economy response and the open economy response. The gap itself represents the size of the exchange rate effect.

Table 4. Average elasticity of output to a monetary policy shock
Closed economy vs. Open economy

	Closed Economy			Open economy		
	Serv.	Manuf.	Ratio	Serv.	Manuf.	Ratio
Australia	-0.16	-0.25	0.64	-0.21	-0.31	0.67
Austria	-0.26	-0.54	**0.48**	-0.27	-0.79	**0.34**
Belgium	-0.36	-0.84	**0.43**	-0.34	-0.86	**0.39**
Canada	-0.57	-1.20	**0.48**	-0.40	-1.01	**0.40**
Denmark	-0.10	-0.27	**0.37**	-0.10	-0.31	**0.32**
Finland	-0.36	-1.19	0.30	-0.46	-1.18	0.39
France	-0.29	-0.86	0.34	-0.29	-0.87	0.34
Germany	-0.25	-0.62	0.40	-0.27	-0.54	0.50
Italy	-0.26	-0.41	**0.63**	-0.20	-0.48	**0.42**
Netherlands	-0.70	-0.51	**1.37**	-0.59	-0.62	**0.95**
N. Zealand	-0.36	-0.39	0.92	-0.37	-0.37	1.00
Norway	-0.38	-0.66	**0.58**	-0.41	-0.72	**0.57**
Spain	-0.19	-0.40	**0.48**	-0.16	-0.43	**0.37**
Sweden	-0.31	-1.32	**0.23**	-0.30	-1.42	**0.21**
UK	-0.56	-0.70	**0.80**	-0.55	-0.77	**0.71**

Note: Bold entry indicates that the closed economy ratio of elasticities is greater than the open economy ratio, implying that exchange rate effects help to explain differences across sectors.

Turning to the quantitative analysis of the results, Table 4 shows the average sectoral elasticity to a policy shock in the closed economy framework and in the open economy framework, together with the ratio of service output elasticity to manufacturing output elasticity for both economic settings. A ratio of elasticities for the closed economy ratio greater than the ratio for the open economy implies that the introduction of exchange rate effects helps to explain (and to augment) the differences in responses across sectors to a monetary shock. Inspection of Table 4 shows that in 10 (in bold) out of the 15 countries the closed economy ratio is greater than the open economy ratio. Therefore, for these 10 countries, when we move from a closed economy setting to an open economy setting and allow for exchange rate effects, manufacturing sector output becomes more responsive to interest rate shocks in relation to service sector output, increasing the gap between the two and reducing the ratio.

Overall, the analysis in this section seems to give some indication that both interest rate effects and exchange rate effects are important in determining and explaining the response of sectoral output to a policy shock. Furthermore, the graphical analysis has shown that direct interest rate effects are the main transmission mechanism for policy shocks, with some, but limited effects coming from the exchange rate. These results should nonetheless be interpreted with a great deal of caution for a number of reasons: exchange rate responses as well as other variables responses to a contractionary policy shock show counterintuitive patterns in a number of countries (such as exchange rate puzzle or price puzzle) and are moreover difficult to properly identify; tests for differences in responses in the open economy versus the closed economy show that in most countries these responses are not statistically different.

5 Conclusions

This paper has studied the effects of monetary policy shocks on a set of small open economies using a VAR approach. Departing from the standard literature on the subject, the paper has approached this analysis trying to find evidence of the differential effects that monetary policy and exchange rate fluctuations may have on the tradable and non-tradable sectors of the economy. For a given country, economic sectors have been defined according to the proportion of output that is exported to other countries. This type of analysis and sectoral classification, frequently used in the theoretical literature related to open economy macroeconomics are more infrequent in the empirical literature. A number of problems related to the availability of data and the ability to precisely identify output or activity by sector of origin limit their applicability. This paper has taken a stab at solving some of these issues.

The results obtained have show that both sectors, tradable and non-tradable, are sensitive to the effects of monetary policy. As a result of a contractionary monetary policy shock both tradable and non-tradable output decrease in all countries in the sample. Another common feature of the results is that the reduction in tradable output is more pronounced than the reduction in non-tradable output. This can be explained by two complementary factors: Production of tradables, that is, manufacturing, may be more interest rate sensitive than non-tradables (service) production, so for a given increase in interest rates, tradable output will be more negatively affected. Secondly, a monetary contraction may lead to an appreciation of the exchange rate and in turn may result in a loss of price competitiveness of the domestic tradable goods in both international markets and in relation to the non-tradables sector. This paper presents some evidence supporting the argument that these two factors combined can explain the observed larger decline in tradable output. Furthermore, this paper shows that in an open economy setting direct interest rate effects are the main transmission mechanism for policy shocks, with some, but limited effects coming from the exchange rate. Additionally, peak responses to the contractionary shock tend to occur at an earlier date in the tradable sector than in the non-tradable sector. Finally, the results in this analysis have been shown to be shown to be robust to the chosen identification method for the VAR. These results also hold when a synthetic aggregate of the data is constructed. The evidence presented gives an indication that industrial structure may be an important component for the analysis of monetary policy.

The analysis and results in this paper suggest a number of avenues for future research. The recursive and near-recursive identification methods employed are somewhat problematic, with some variables responses presenting counterintuitive results and moreover difficult to properly identify. Alternative identification methods such as those proposed by Faust (1998) and Faust *et all* (2003, 2004) might help improve on some of these shortcomings. Alternatively, further disaggregation of the data may provide greater insight on the impact of policy shocks in different sectors of the economy.

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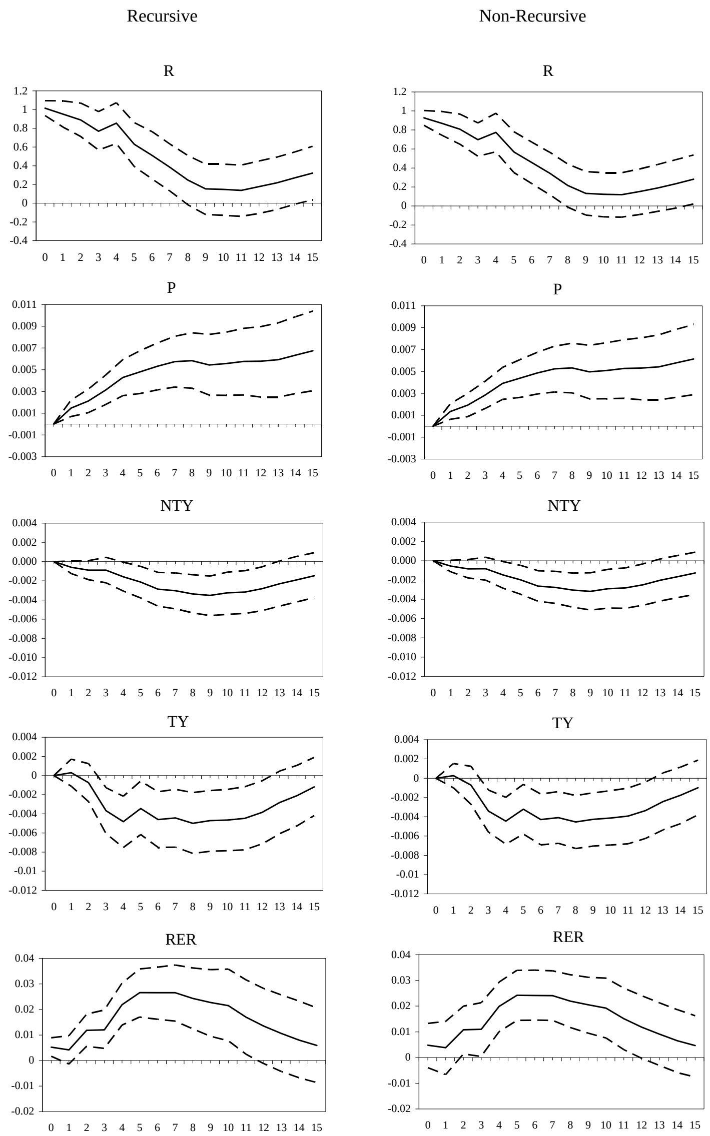
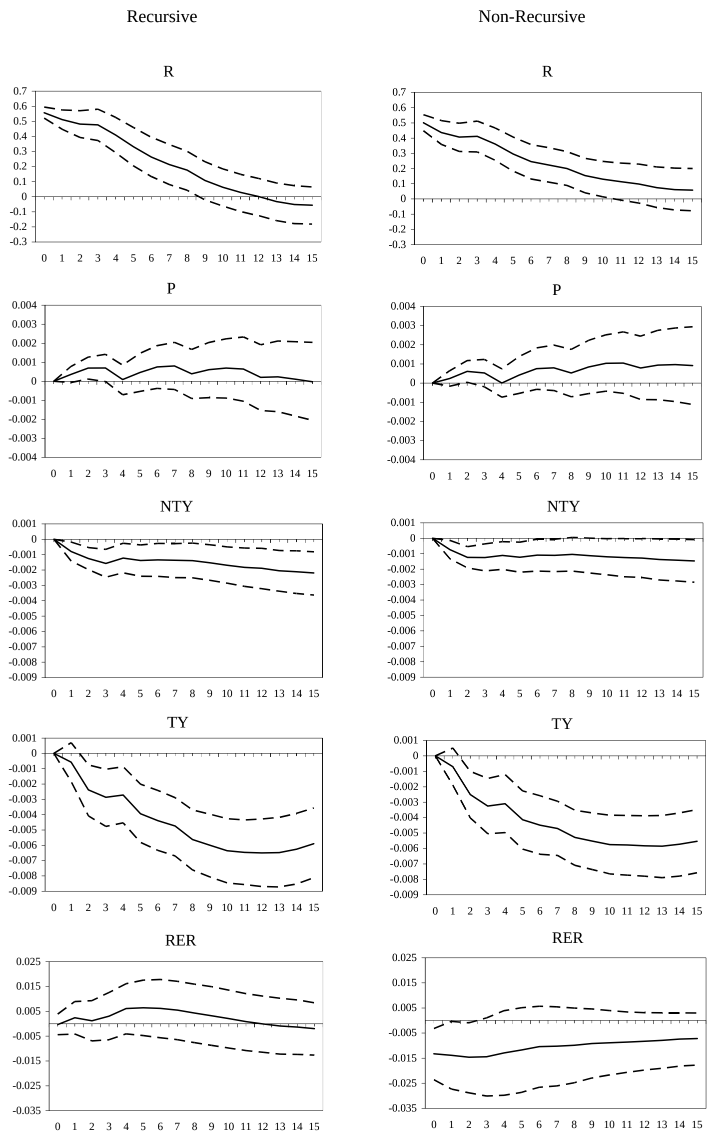
Figure 3: Country impulse response to a monetary policy shock

AUSTRALIA (1974Q3 - 2004Q4)

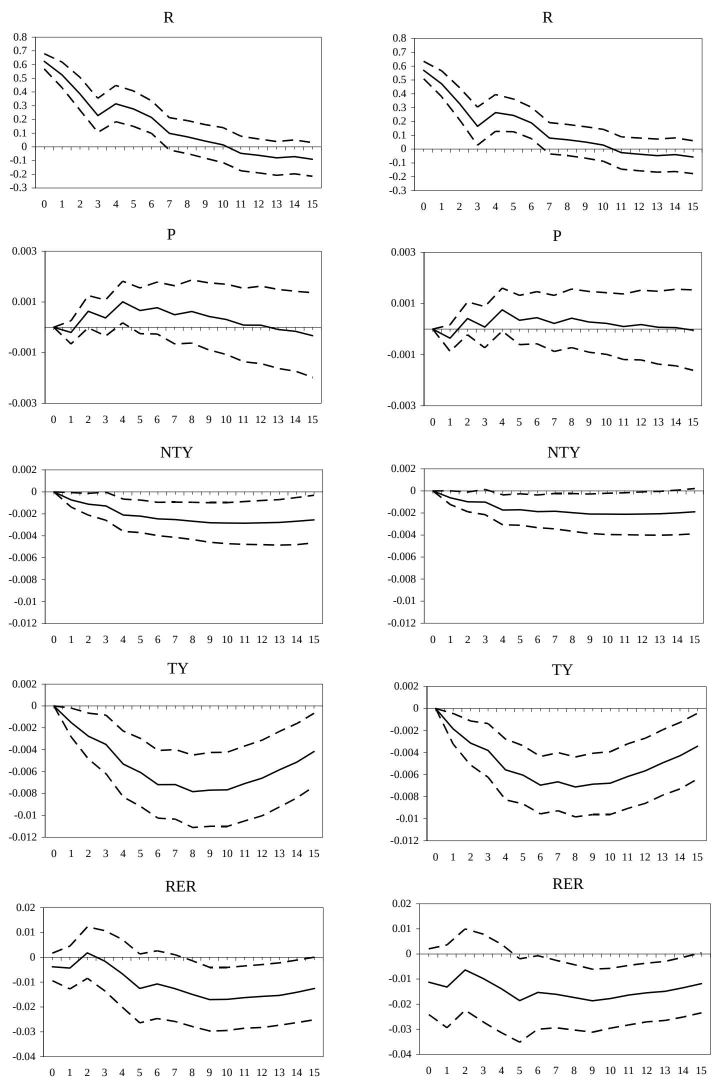


AUSTRIA (1965Q1 - 2004Q4)

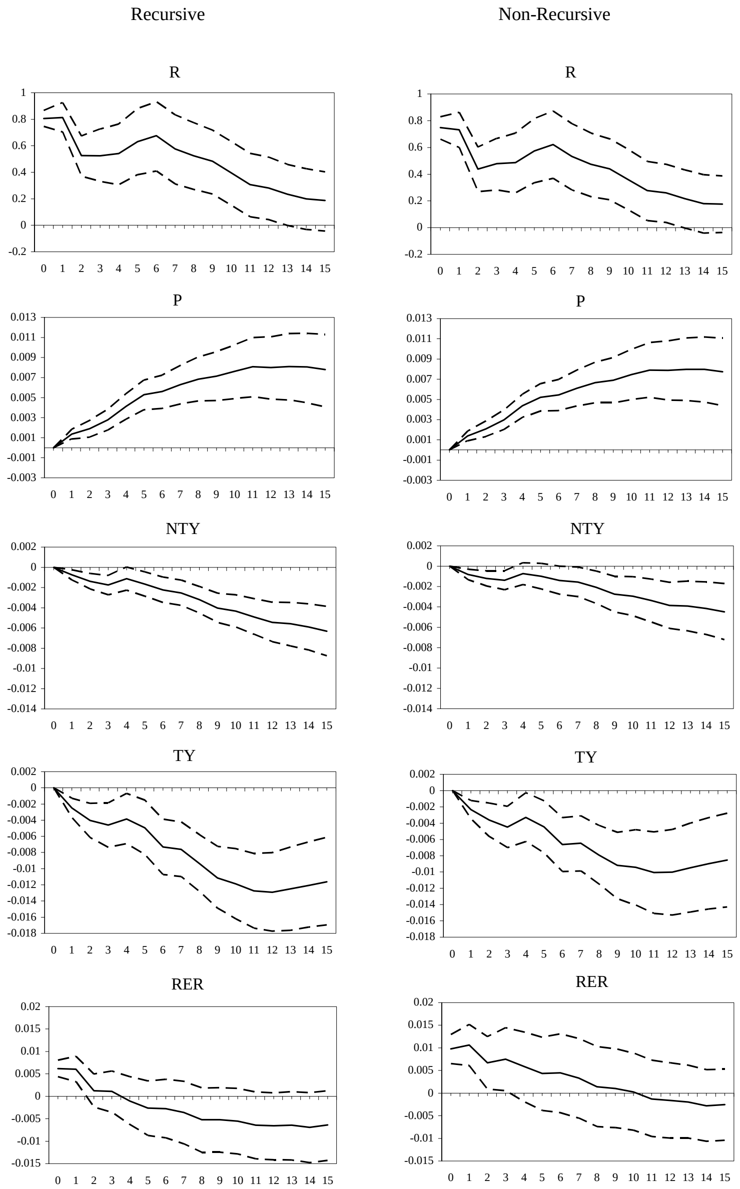


BELGIUM (1980Q1 - 2004Q4)

Recursive Non-Recursive

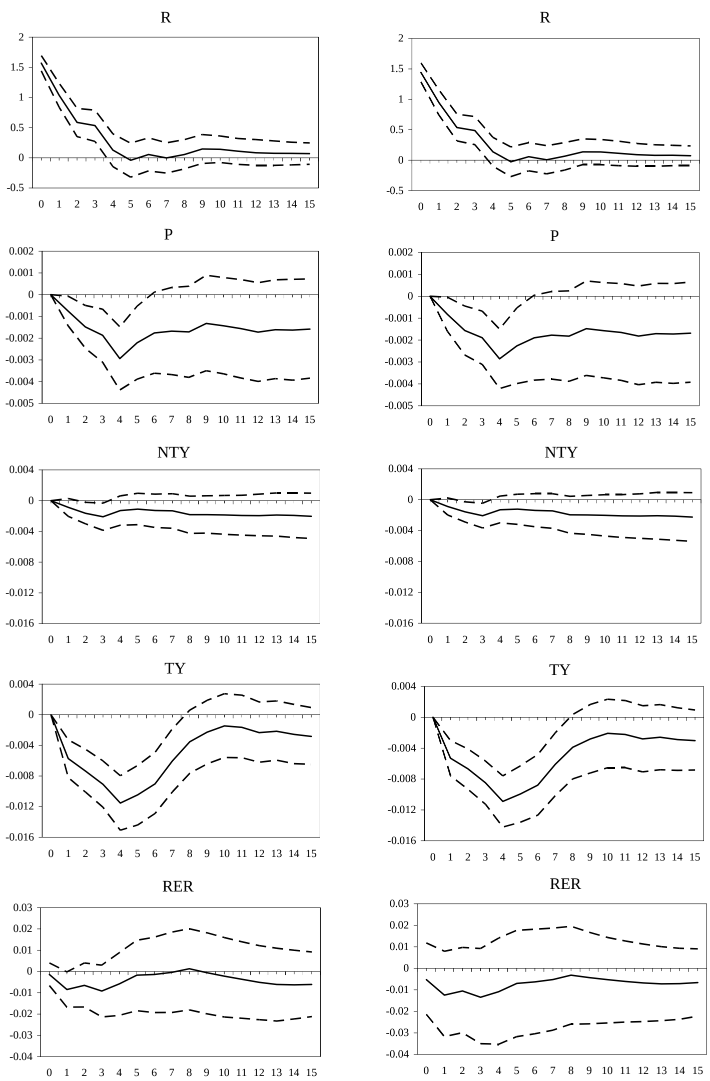


CANADA (1975Q1 - 2004Q4)

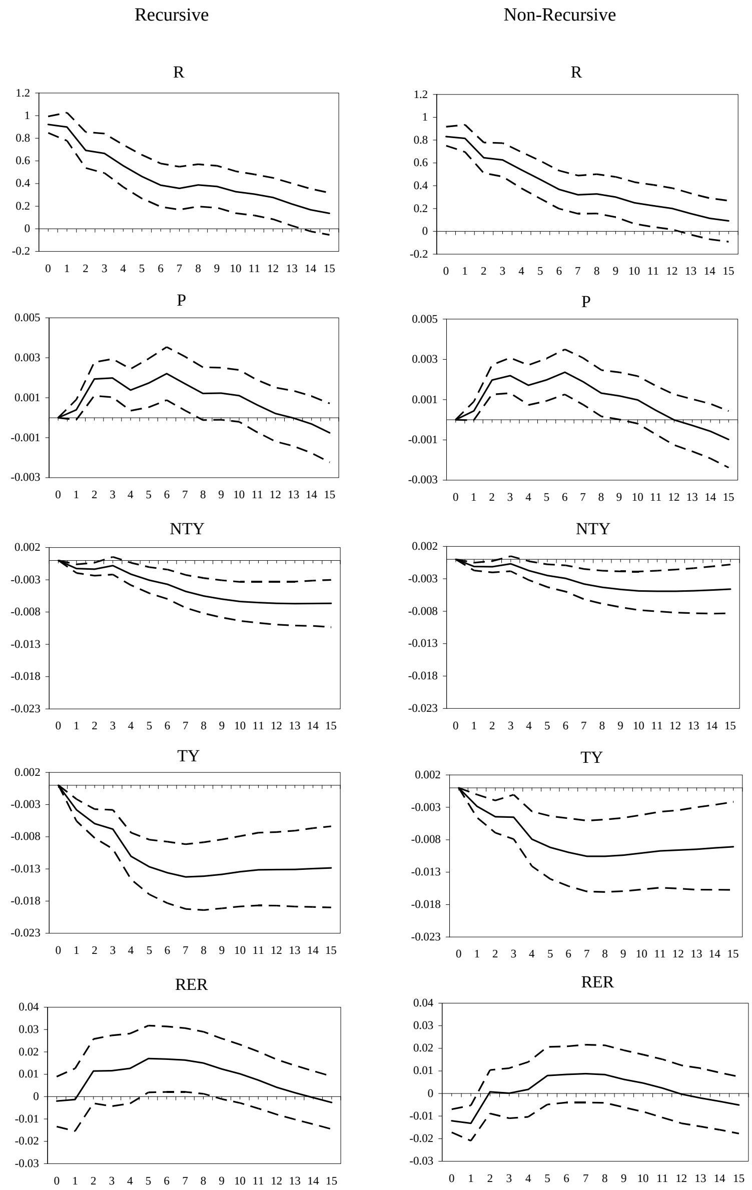


DENMARK (1977Q1 - 2004Q4)

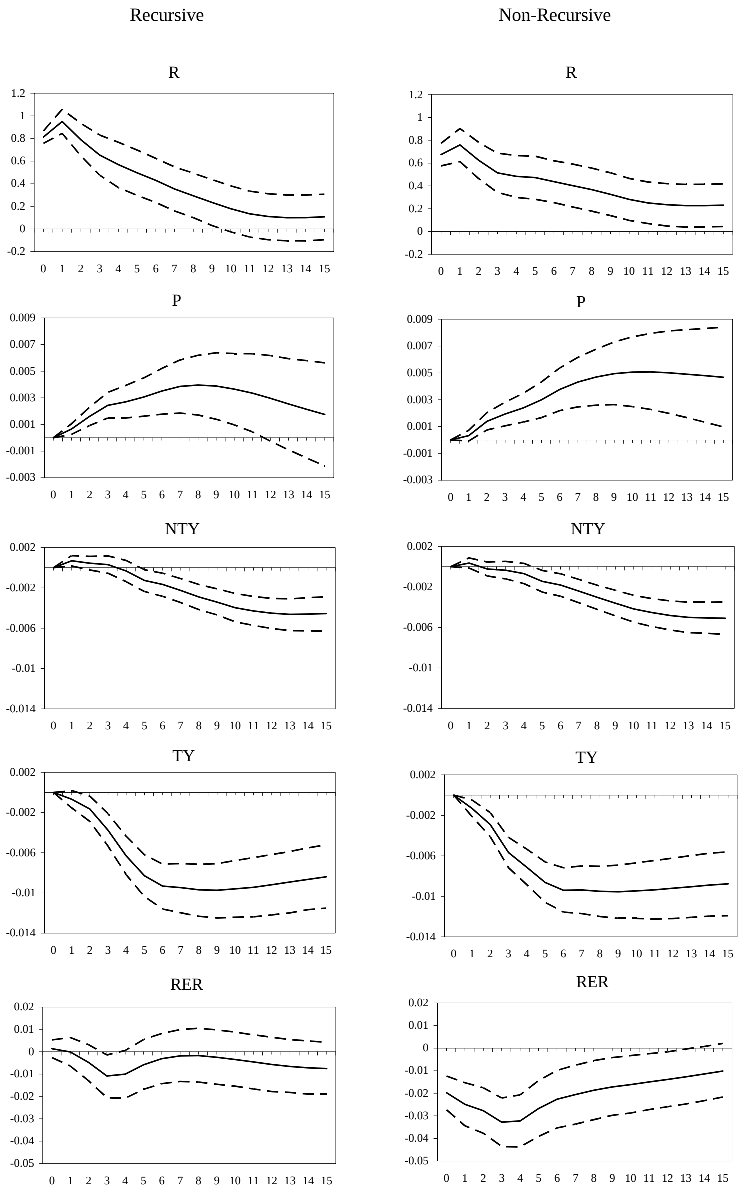
Recursive　　　　Non-Recursive



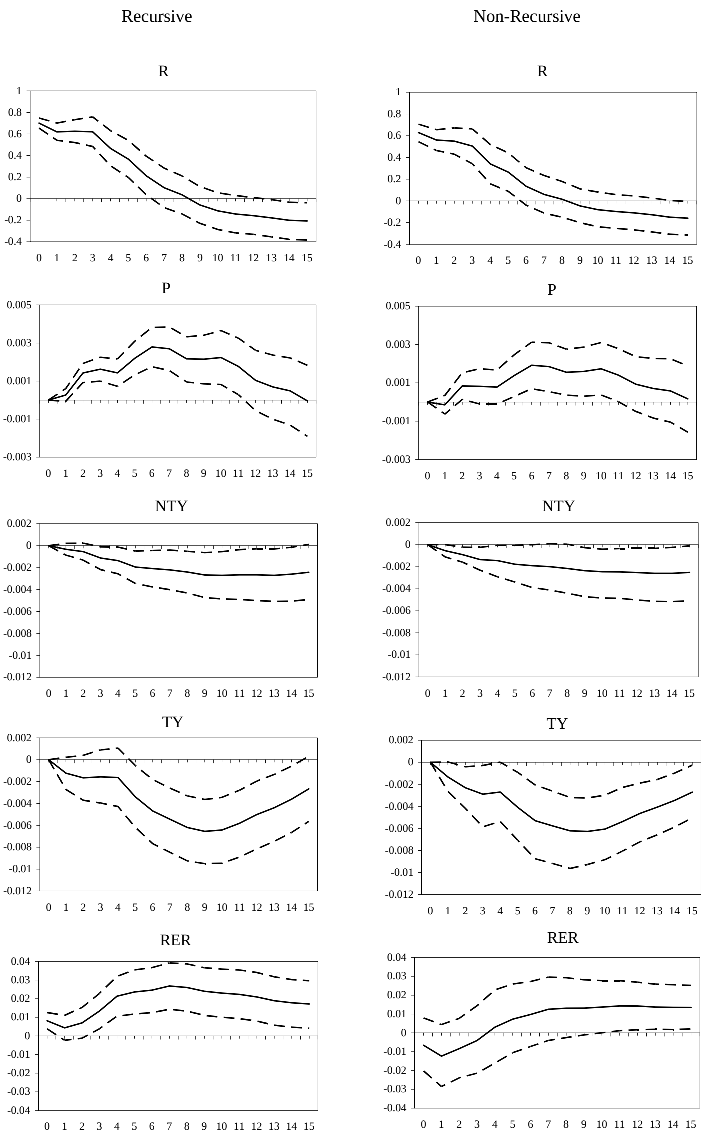
FINLAND (1975Q1 - 2004Q4)



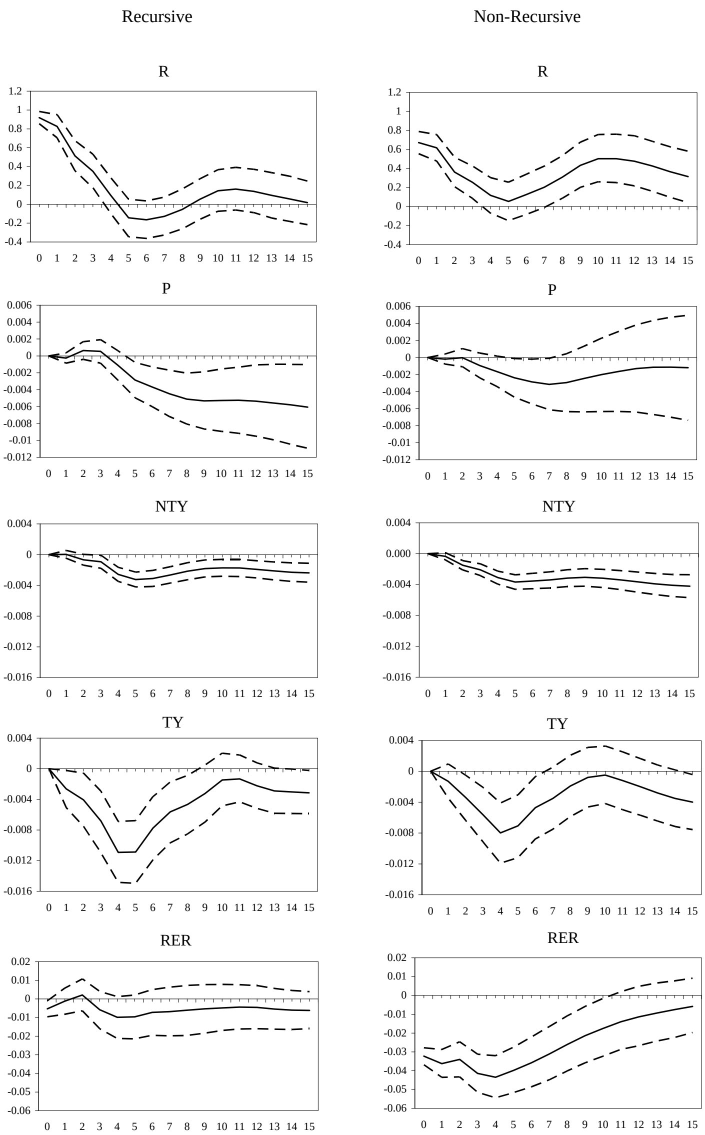
FRANCE (1970Q1 - 2004Q4)



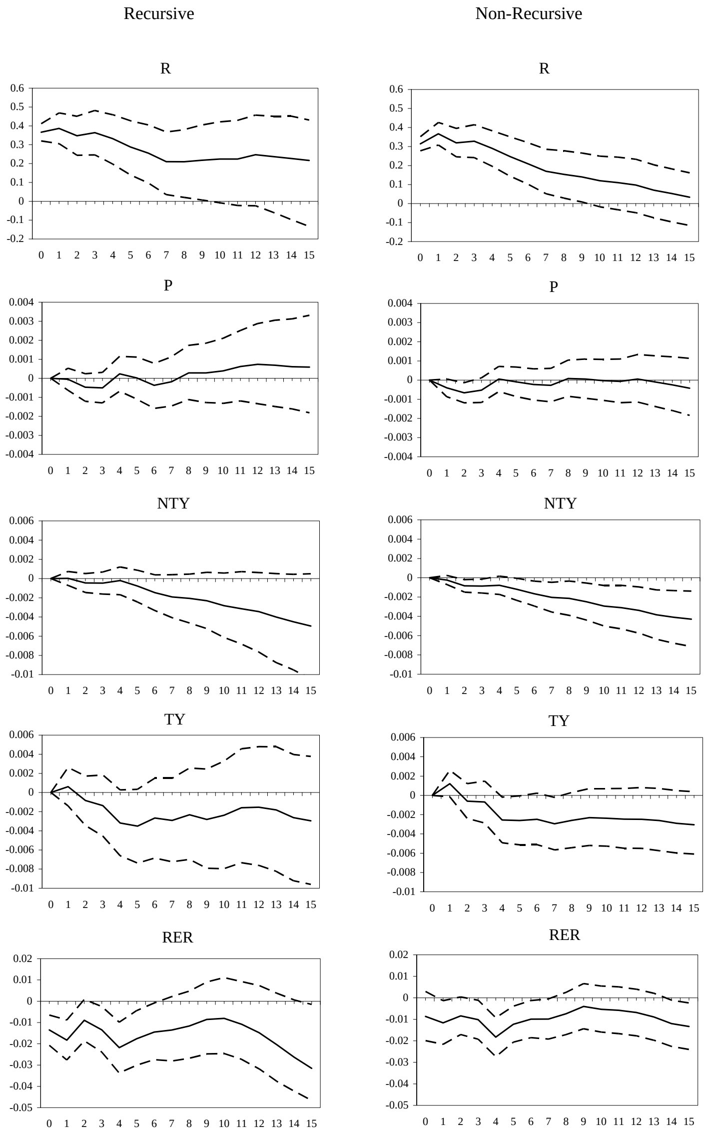
GERMANY (1970Q1 - 2004Q4)



ITALY (1970Q3 - 2004Q4)

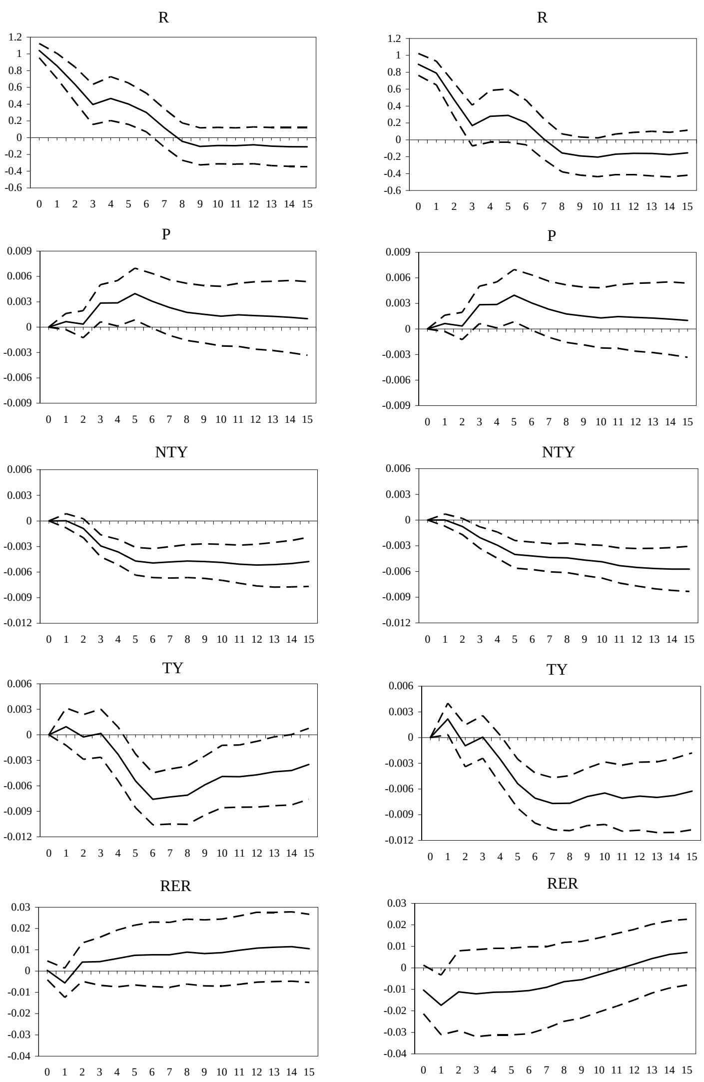


NETHERLANDS (1987Q1 - 2004Q4)

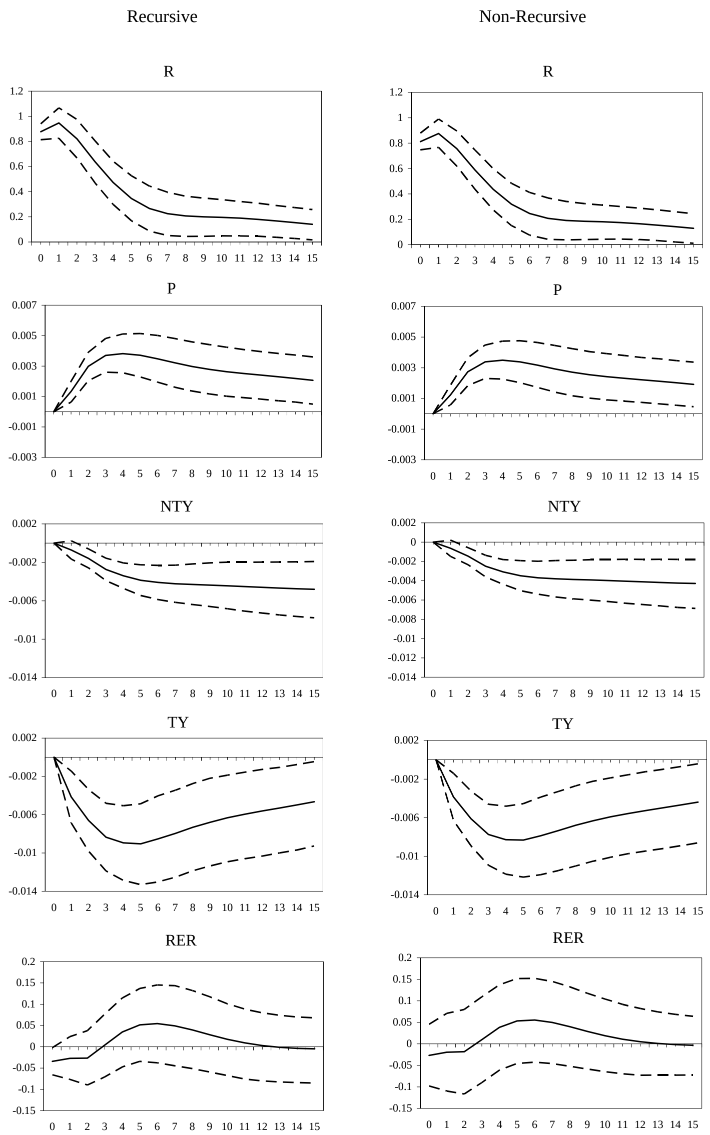


NEW ZEALAND (1977Q2 - 2004Q4)

Recursive Non-Recursive

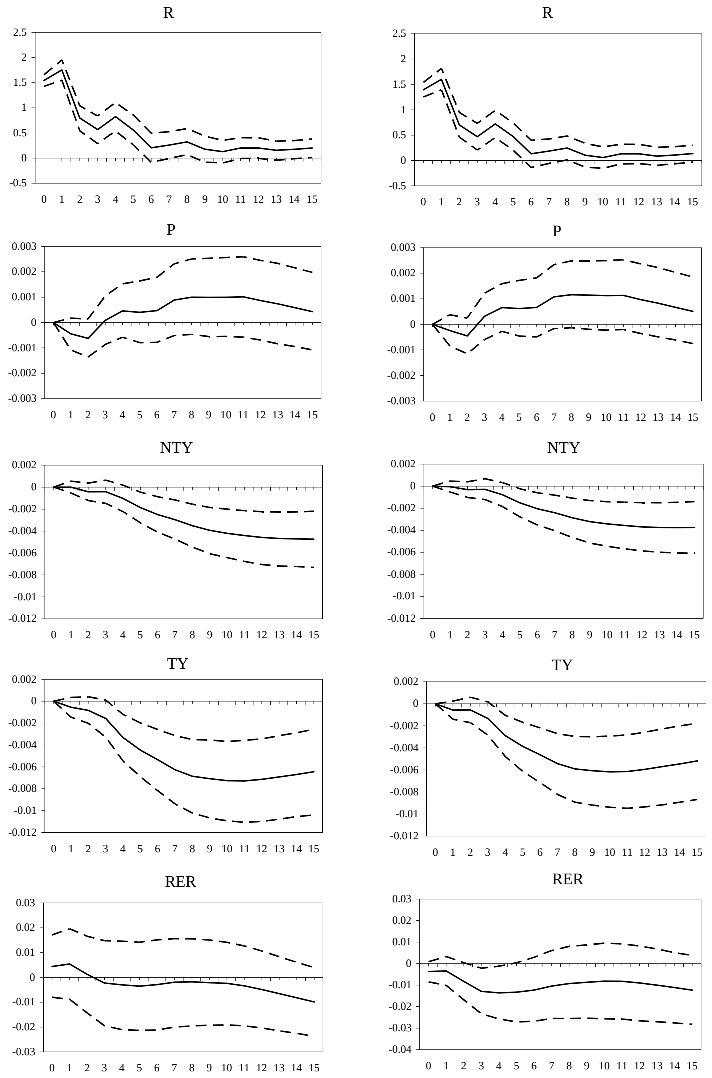


NORWAY (1978Q3 - 2004Q4)

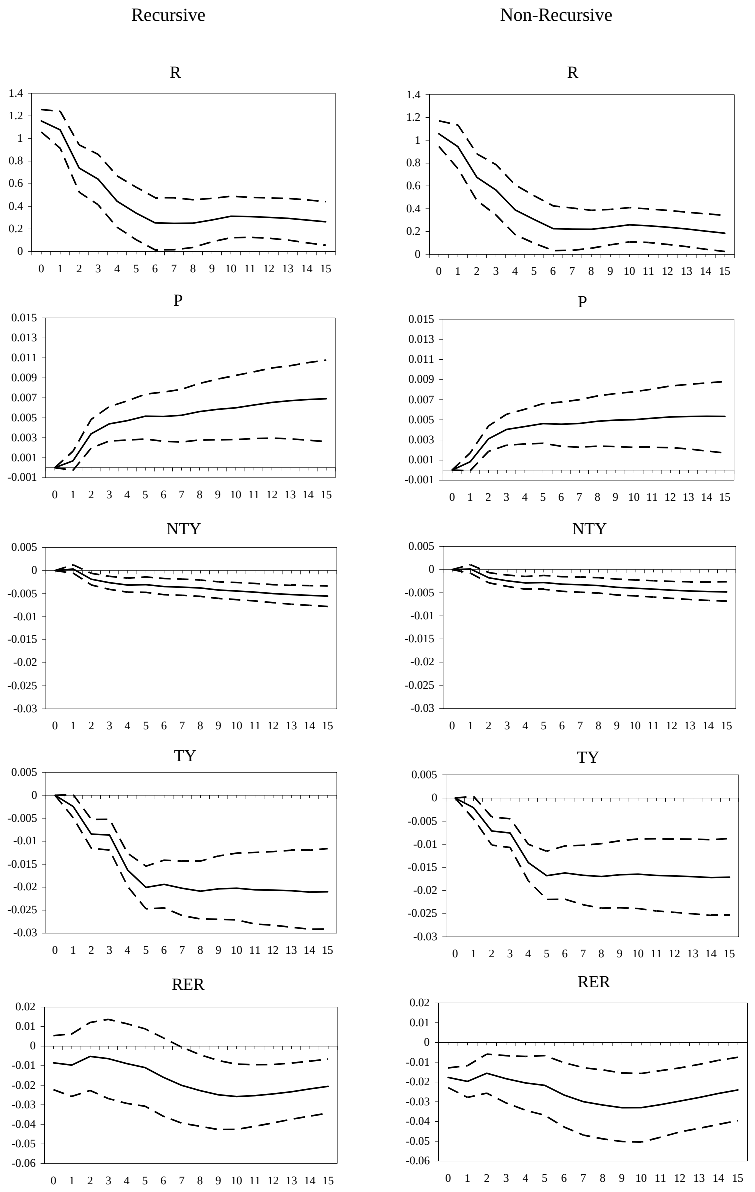


SPAIN (1980Q3 - 2004Q4)

Recursive | Non-Recursive



SWEDEN (1980Q1 - 2004Q4)



UK (1969Q2 - 2004Q4)

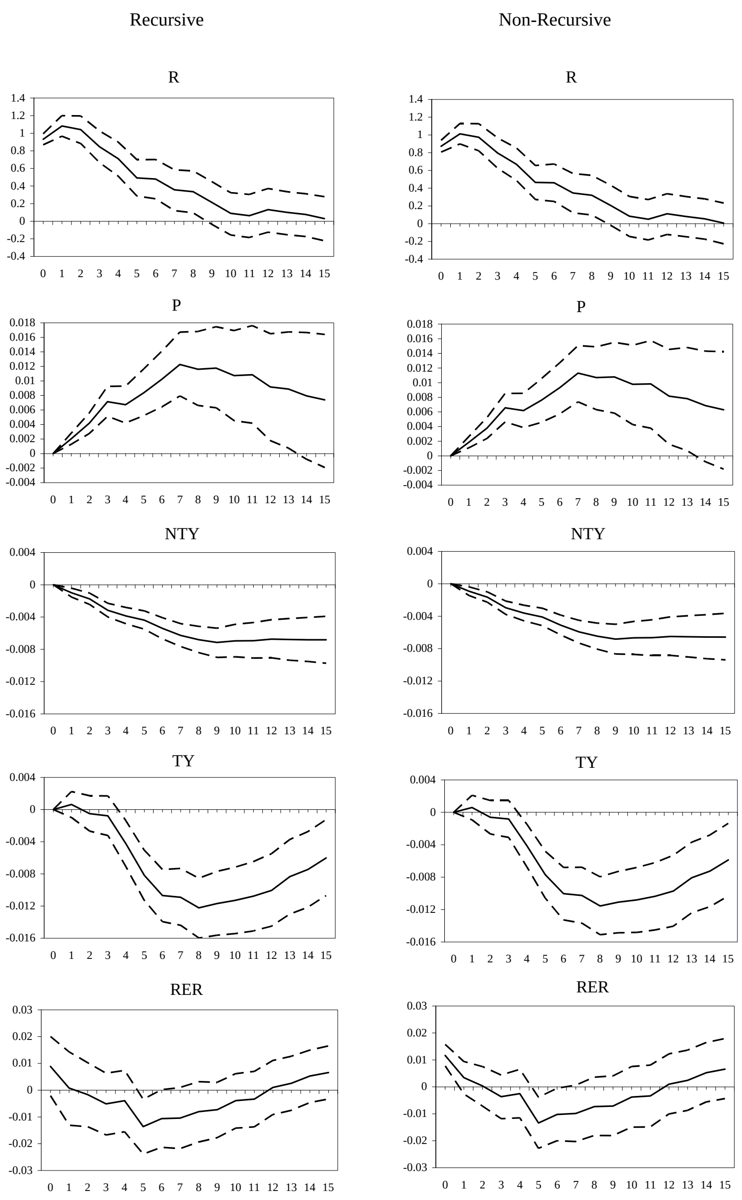
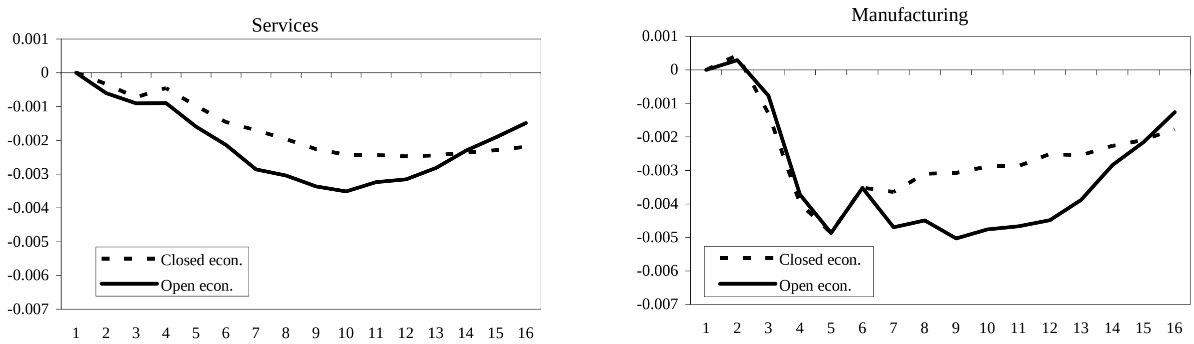
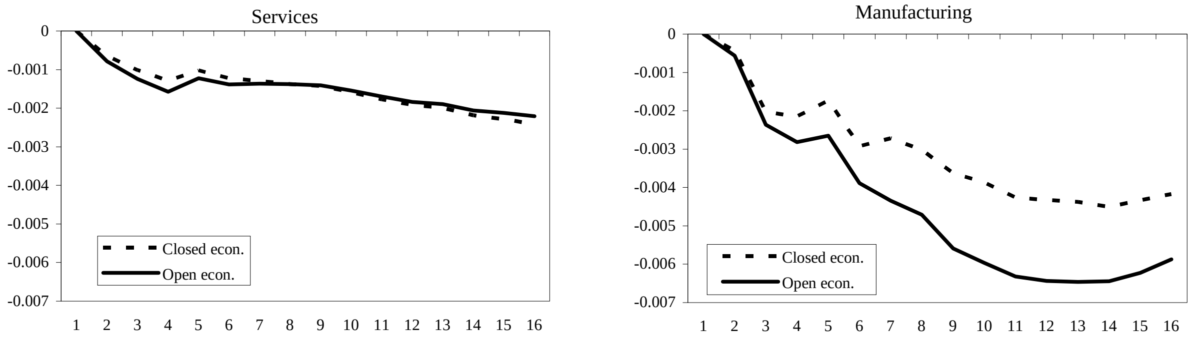


Figure 4: Closed economy vs. open economy impulse responses

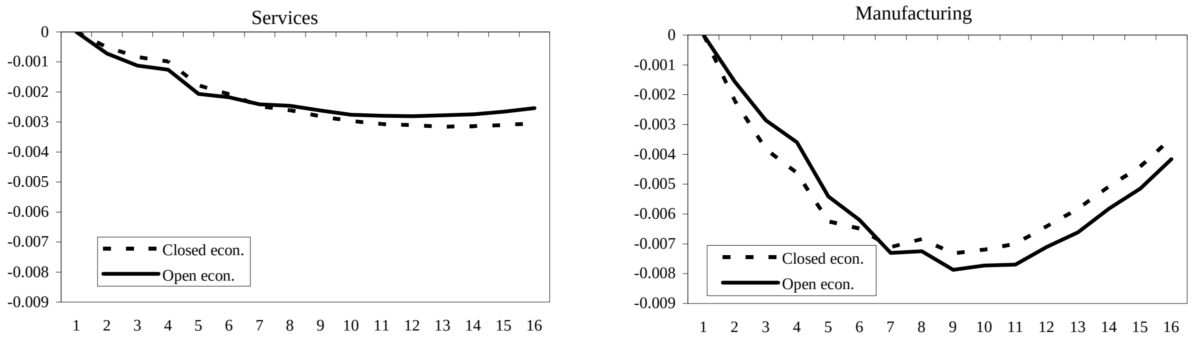
Australia



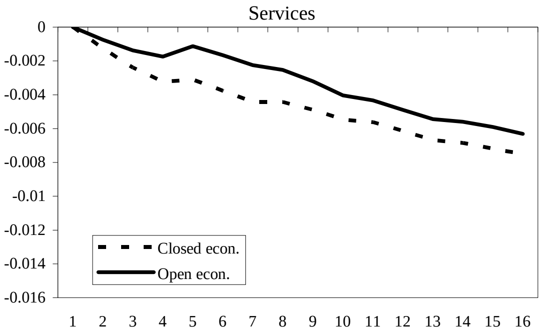
Austria

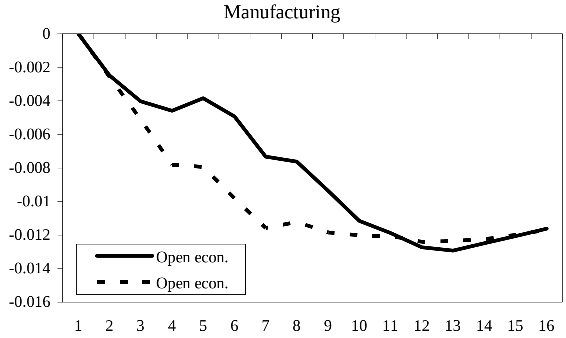


Belgium

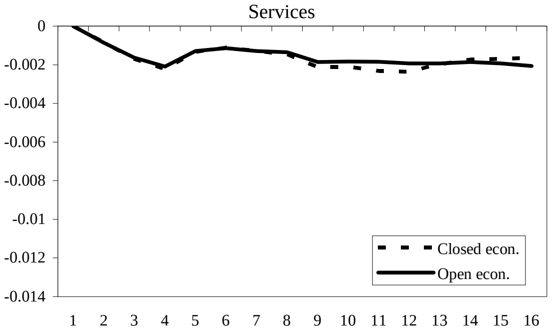


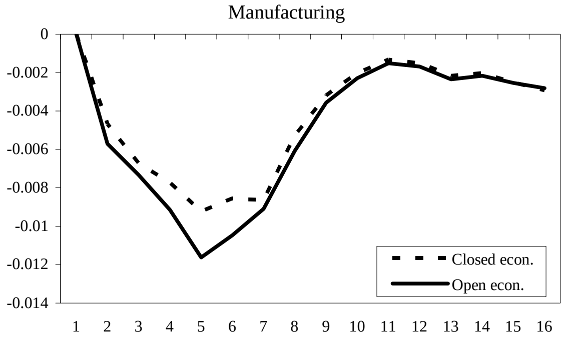
Canada



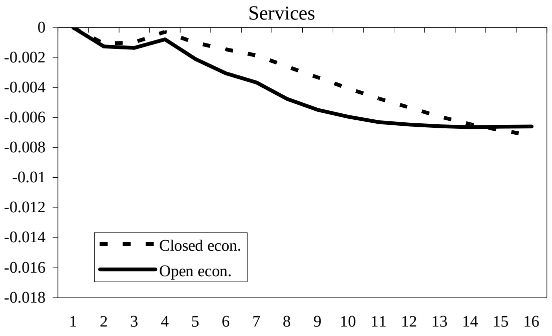


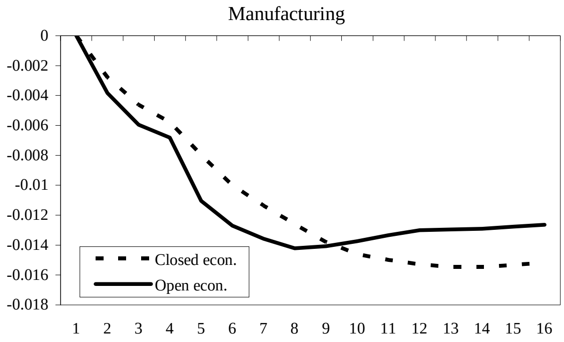
Denmark



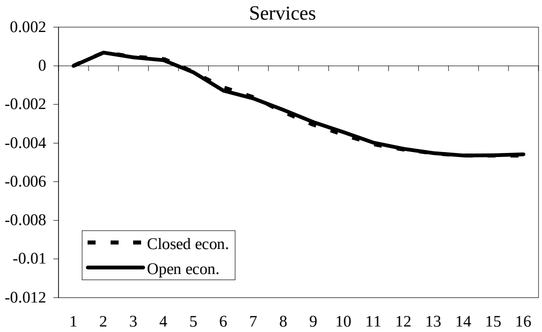


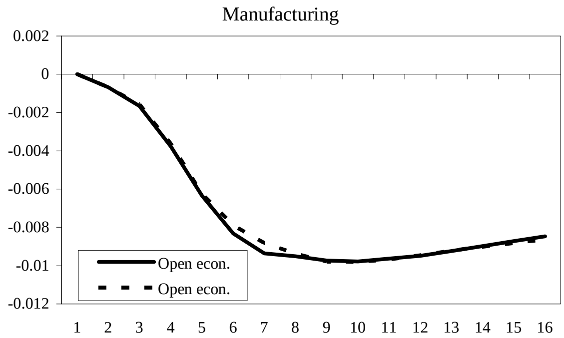
Finland



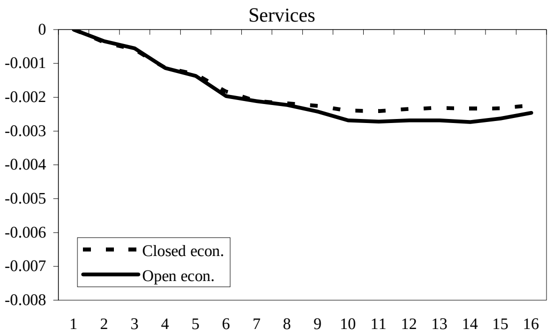


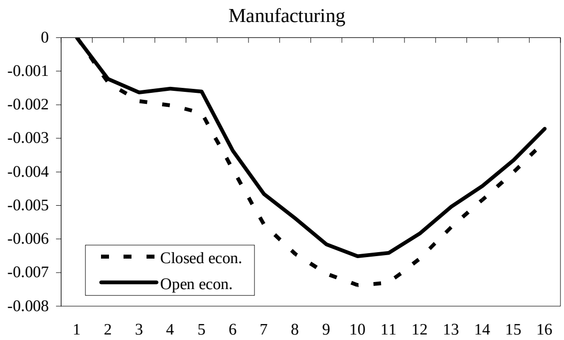
France



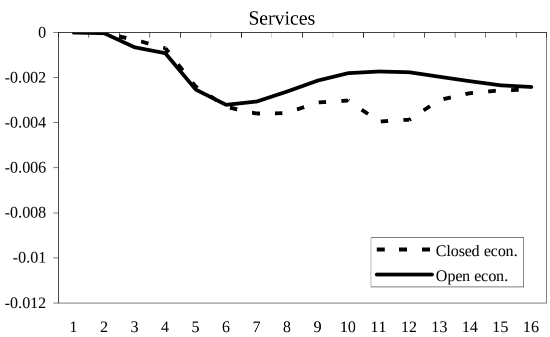


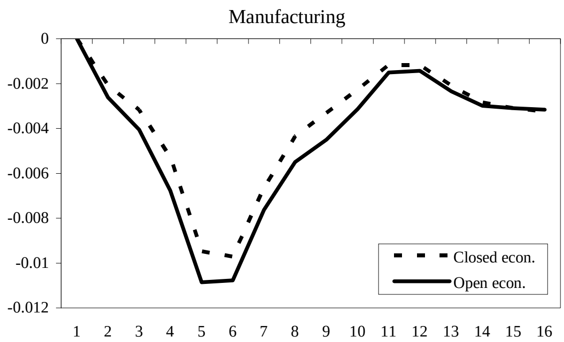
Germany



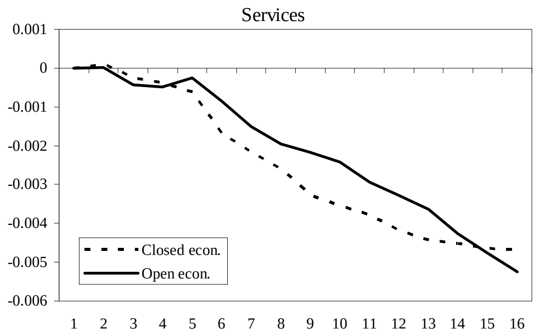


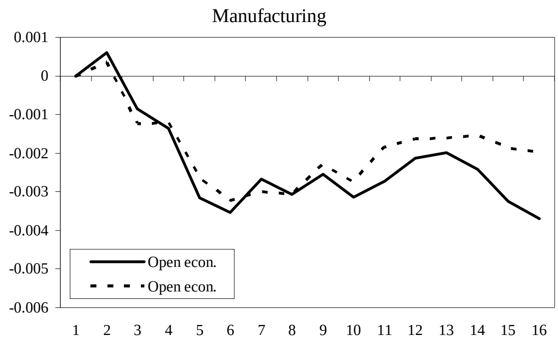
Italy



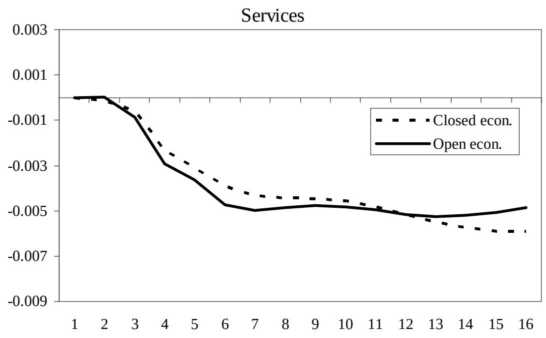


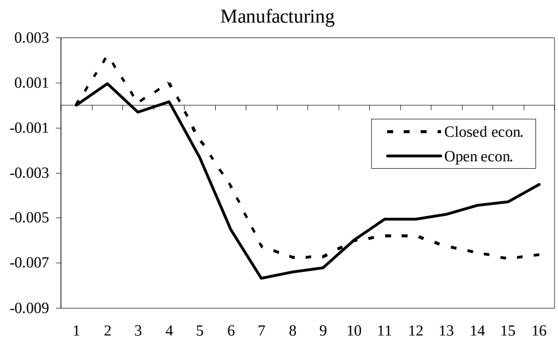
Netherlands



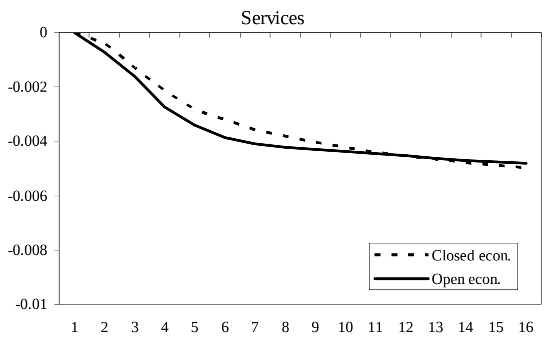


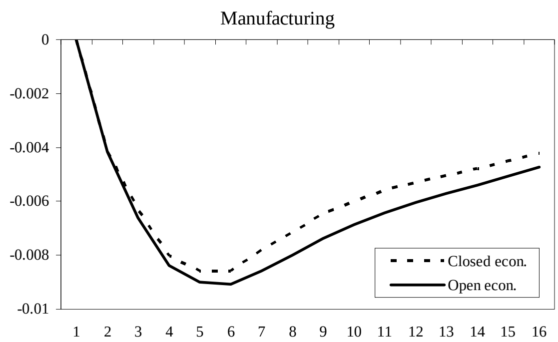
New Zealand



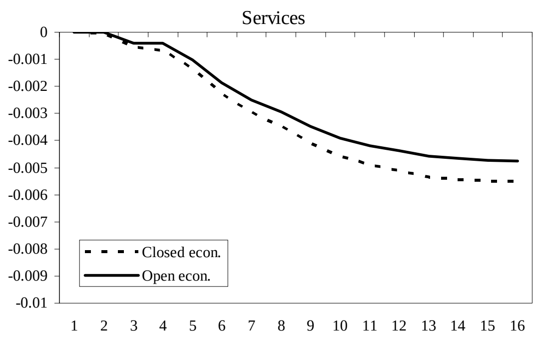


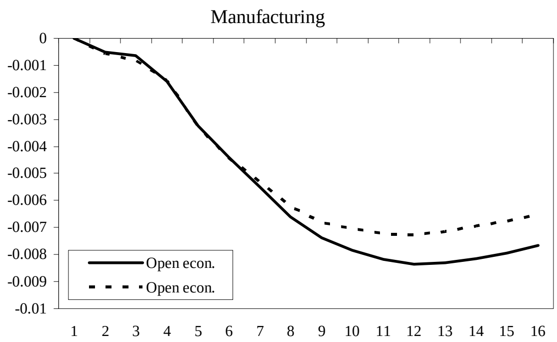
Norway



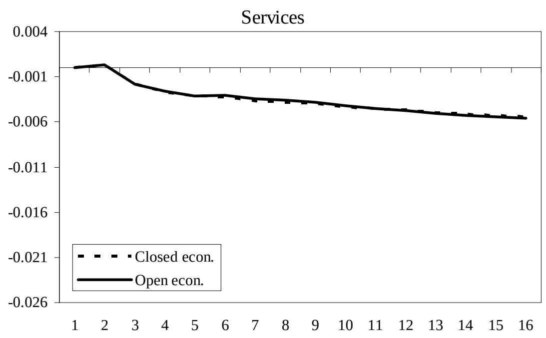


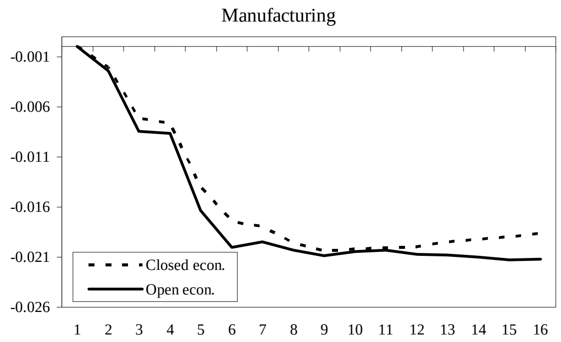
Spain



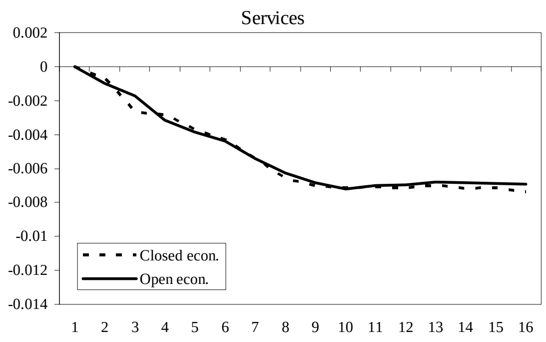


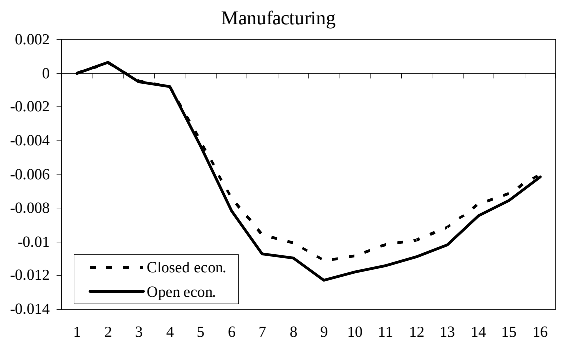
Sweden





UK





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