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Tuomas Saarenheimo

Economics Department
14.5.1996

Monetary Policy for Smoothing Real Fluctuations? – Assessing Finnish Monetary Autonomy

SUOMEN PANKIN KESKUSTELUALOITTEITA • FINLANDS BANKS DISKUSSIONUNDERLAG

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Abstract

The possible participation of Finland in the Stage III of the European Monetary Union would constitute a major change in the operating environment of the Finnish economy. As a member of the common currency area, Finnish interest and exchange rates would no longer be determined by domestic monetary policy or domestic financial market reactions, but would instead be given by the European Central Bank and the European financial markets. Would this increase the severity of business cycles in Finland? This is the question the present paper seeks to analyze.

In the first part of this paper, we review and evaluate the existing econometric work on the consequences of the European Monetary Union. Although the empirical work on the subject is abundant, it suffers from a narrow focus. Most of the research follow a highly simplistic empirical implementation of the traditional Keynesian theory of optimal currency areas and measure the desirability of a currency union is by cross-country correlations of certain macroeconomic variables. We find the results obtained in those studies hard to interpret, and argue that – particularly when measured in a mixed exchange-rate system as has prevailed in Europe – simple macroeconomic correlations do not convey any meaningful information about the desirability of a currency union.

In the second part we present an alternative approach to the empirical analysis of the topic. We construct a structural vector error-correction system to quantify the extent to which monetary autonomy has served to stabilize the real economy in Finland. This model is applied to analyze directly the consequences of Finland's possible entry into the European Monetary Union.

The results suggest that monetary autonomy has played some role in insulating the real economy from the effects of shocks. In particular, adjustments of the nominal exchange rate appear to have stabilized the real interest rate and, consequently, smoothed the changes in domestic demand. However, this role has been relatively small, and given the uncertainties involved, it is possible that the effect has actually been negligible. Overall, we find no strong evidence to support a claim that monetary autonomy has served to stabilize significantly the Finnish economy.

Key words: EMU, optimal currency area, Finland, structural VAR models

Tiivistelmä

Suomen mahdollinen osallistuminen Euroopan rahaliiton kolmanteen vaiheeseen merkitsisi huomattavaa muutosta Suomen talouden toimintaympäristössä. Yhteisvaluutta-alueen jäsenenä Suomen korkotaso ja valuuttakurssi määräytyisivät Euroopan keskuspankin politiikan ja euroopan rahamarkkinoiden reaktioiden seurauksena – Suomen mahdollisuudet vaikuttaa korkojen ja valuuttakurssin määräytymiseen olisivat vähäiset. Olisiko tästä seurauksena suhdannevaihtelujen jyrkentyminen Suomessa? Tähän kysymykseen etsitään vastausta käsillä olevassa tutkimuksessa.

Tutkimuksen ensimmäisessä osassa esitellään ja arvioidaan olemassa olevaa Euroopan rahaliiton vaikutuksia tutkivaa ekonometristä tutkimusta. Aihetta on tutkittu lukuisissa empiirisissä töissä, mutta analyysi kärsii näkökulman kapeudesta. Alan tutkimukset ovat pääsääntöisesti noudattaneet yksinkertaista empiiristä sovellusta perinteisestä keynesiläisestä optimaalisten valuutta-alueiden teoriasta. Tässä sovelluksessa valuuttaunionin toimivuutta mitataan makrotaloudellisten muuttujien korrelaatioilla eri maiden välillä. Tällaisille korrelaatioille on vaikea antaa mielekästä tulkintaa. Tutkimuksen johtopäätös on, että – erityisesti Euroopassa vallinneen kaltaisessa puolijoustavassa valuuttakurssijärjestelmässä – yksinkertaiset makrotaloudelliset korrelaatiot eivät tarjoa käyttökelpoista informaatiota valuuttaunionin eduista tai haitoista.

Tutkimuksen toisessa osassa esitellään vaihtoehtoinen analyyiskehikko. Rahataloudellisen autonomian merkitystä suhdannevaihtelujen hillinnässä analysoidaan rakenteellisella moniulotteisella virheenkorjausmallilla. Mallin avulla arvoidaan yhteisvaluutta-alueen mahdollisen jäsenyyden vaikutuksia Suomen talouteen.

Tulosten mukaan rahataloudellinen autonomia on jossain määrin kyennyt hillitsemään ulkoisten shokkien välittymistä reaalitalouteen. Erityisesti valuuttakurssin muutokset näyttävät hillinneen reaalisen korkotason vaihteluita ja sitä kautta tasanneen kotimaista kysyntää. Tämä vaikutus on kuitenkin ollut melko vähäinen, ja tuloksiin liittyvien epävarmuuksien valossa on mahdollista, että kyseinen vaikutus on käytännössä ollut mitätön. Tutkimus ei siten löydä vahvaa tukea väitteelle, jonka mukaan rahataloudellinen autonomia olisi hillinnyt Suomen talouden suhdannevaihteluita.

Asiasanat: EMU, optimaalinen valuutta-alue, Suomi, rakenteelliset VAR-mallit

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1 Introduction

How will the behavior of the Finnish economy be affected if it gives up its own currency and joins the common currency introduced with Stage III of the European Monetary Union? Will asymmetric shocks lead to exacerbated economic fluctuations as the country no longer can use monetary policy to defuse those shocks?

Such questions have enormous scope. To provide a complete answer one would have to determine the mechanisms for monetary policy transmission, term structure and exchange rate determination, and wage and price formation. Armed with a good understanding of those mechanism one could, in principle, determine the role played by monetary autonomy in smoothing the real economy and evaluate the cost of forsaking it.

Understandably, researchers have generally preferred less complicated strategies. The most common framework for discussing the desirability of a common European currency appears to be a piece of Keynesian analysis called the theory of "optimal currency areas" (OCA). Being Keynesian, the OCA framework takes as a given that monetary policy can control monetary conditions and that it is an effective and efficient tool in steering the real economy. Put simply, this theory says that since the currency area's monetary policy cannot be geared to smooth fluctuations in a particular member country, an optimal currency area should consist of countries with highly symmetrical economic fluctuations. The only criterion for a currency area is whether the shocks a particular set of countries face are sufficiently similar to warrant a common monetary policy.

A plethora of empirical research has been directed at the symmetricity of fluctuations within the European Union. The typical result is that the European Union as a whole exhibits highly asymmetrical economic fluctuations and therefore does not form an OCA, but that there exists a core group of EU–countries that appears to be quite homogeneous and forms a more suitable candidate for a currency area. These findings have been interpreted to suggest that a larger EMU would not be economically desirable.

This paper has two parts. The first offers a short review of the empirical literature on currency areas and assesses the merits and relevance of that work on the question of a common European currency. We conclude that the existing econometric work is not very helpful for policy decisions. Generally, the focus of the work has been narrow and its connections to desirability of a currency union remote. Consequently, the results are hard to interpret.

In the second part of the paper we construct an econometric model which we use to address directly the question we see as the most relevant in connection to the possible entry of Finland into the EMU: What role has monetary autonomy played in smoothing the effects of shocks on the real economy. We find that although monetary autonomy has played a role in smoothing real fluctuations, its role seems to have been relatively small.

2 "Optimal" currency areas and the value of monetary autonomy

2.1 When does the theory apply?

The theoretical foundation for the theory of optimal currency areas was laid by Robert Mundell in his seminal work in 1961. Mundell described a model in which two countries are subject to asymmetric real shocks. In Mundell's model, the degree of asymmetry of the shocks between the two countries determines the usability of exchange rate in stabilizing the economies against the shocks and hence, the cost of giving up monetary policy when switching to a common currency. Faithful to the Keynesian tradition, the theory builds on the implicit assumption that monetary policy has perfect control over monetary conditions.[1]

With the rise of neoclassical economics, the concept of OCAs spent a decade in virtual oblivion, only to experience a remarkable revival at the beginning of the 1990s, as European monetary unification gained momentum. Today, the term "optimal currency area" has found its way from obscure economic journals into large circulation newspapers, in which it frequently assumes meanings seldom more than remotely related to the one originated in the work of Mundell.

Mundell himself had a quite realistic view of the scope of applicability of his work. He did not claim to offer a comprehensive picture of what the optimal size of an currency area is. He specifically pointed out that his model only considers "... the stabilization argument, to which end it is preferable to have many currency areas, and not the increasing costs which are likely to be associated with the maintenance of many currency areas" (Mundell 1961, p. 622). One can reasonably argue that the term "optimal currency area" is a misnomer; within the framework of this theory, no currency area bigger than a single economic agent can be optimal. The OCA theory is a theory about the *costs* of fixed exchange rates; it has nothing to say about the benefits of monetary unification.

Mundell was also explicit in defining the crucial assumptions on which his theory builds; namely, wage stickiness and money illusion. These reservations seem to have been lost in much of the recent discussion on the subject. This narrowing of focus is most evident when reading newspapers, but also all too apparent in many serious economic studies.

What criteria should we consider when weighting the optimality of a currency area from an individual country's point of view? It is evident that the existence of asymmetricity of shocks is by itself not a sufficient condition for monetary autonomy to be necessary or useful for stabilizing the real econ-

[1] In what follows, we make a distinction between monetary policy and monetary conditions. By monetary conditions we mean everything that comes with monetary autonomy: most importantly, autonomous interest rates of all maturities and the exchange rate. Monetary policy is an important determinant of monetary conditions, but by no means the only one.

omy. Minimally, the following two additional conditions are required for this conclusion:

1. Money has to matter; ie, there needs to be a sufficient amount of nominal stickiness in the economy so that changes in the monetary conditions, expected as well as unexpected, affect the real economy.

2. Monetary authorities need to have sufficient control over monetary conditions.

The first item relates to the issues taken up by the rational expectations school of thought. For monetary policy to be usable as a stabilization tool, it is not enough that unexpected monetary changes have effects; unpredictable policies must, in the long run, be random and random policies do not stabilize. To be stabilizing, monetary policy needs to be effective also when the policy actions are planned and predictable.

The second item includes issues such as the monetarist critique. Friedman (1960) argued that since monetary policy works with a long and variable lag, an activist monetary policy is likely to end up exacerbating the fluctuations rather than smoothing them. But even if the skills and knowledge of the monetary authorities were perfect, this is not sufficient for monetary autonomy to help smoothing fluctuations. For that purpose, central banks need not only to understand the dynamics of the financial markets, they also have to be able to control them. This is the hard part. Central banks, in general, only have direct control over short interest rates. Exchange rates and the shape of the yield curve have dynamics of their own with market sentiment playing an important role.

So are these necessary conditions in place? While most economists would agree that the first condition holds — ie money does matter enough for monetary conditions and, as a part of them, monetary policy to have real effects in the short run — the second condition is a much more open question. First, Friedman's argument clearly has merits: timing and portioning of monetary policy are notoriously difficult, and central banks are regularly blamed for not being able to foresee or prevent fluctuations. Second, when steering the exchange rate and the term structure of interest rates, the financial markets more often than not disobey the central bank's wishes; and there is little evidence that this happens in a stabilizing manner. The abundant theory on bubbles and speculative attacks points out reasons for exchange rate instability, and the theories are confirmed by episodes such as the appreciation of the US dollar in mid-1980s and the turmoils in the ERM. Econometric studies have found little support on the hypothesis that changes nominal exchange rates carry any stable relation to economic fundamentals (at least in the short run), far less that they have been in any sense optimal to the countries in question (see, for example, Chinn and Meese 1995).

The question of the effectiveness of monetary autonomy in stabilizing the real economy is essentially concerned with the signal-to-noise ratio of monetary policy; whether the contribution of the central bank's successful actions, or equivalently, the stabilizing reactions of the financial markets (signal), dominates the unsuccessful actions and other unstabilizing events originating from the monetary side of the economy (noise). If the signal-to-noise ratio is poor, then monetary autonomy is more likely to be destabilizing. This question is essentially an empirical one.

2.2 How to interpret empirical results?

A complete exploration of the role of monetary autonomy in real stabilization is a non-trivial and, in all probability, unrewarding task. Hence, in practice, the majority of the existing empirical work on the optimality of the EMU has followed the less ambitious approach of measuring asymmetries between the potential entrants; ie measuring the cross-country correlations of certain macroeconomic variables.

Vaubel (1978), and more recently Eichengreen (1991), chose to study the behavior of real exchange rates, the idea being that fluctuations in the real exchange rate reflect adjustments to asymmetric shocks. They found that real exchange rate fluctuations in Europe have generally been large in comparison to what is observed among regions of the USA. Hence, their conclusion is that the EU is less of an optimal currency area than the USA.

Another common approach has been to test the degree of asymmetricity in the fluctuations of real output, either aggregate output, or output disaggregated to industry level (see, for example, Bayoumi and Prasad 1995, Bini-Smaghi and Vori 1993, Helg, Manassa, Monacelli and Rovelli 1995). Here the results vary a bit more. In most cases, however, the result seems to be that for the (former twelve-country) EU as a whole, shocks are to large extent asymmetric (again compared with regions of the USA), whereas for some core group of countries, shocks are more synchronized. Hence, a subset of EU countries might form an optimum currency area.

Somewhat simplified, the empirical work overall seems to say that there is a core-group of countries in which the exchange rates (both nominal and real) have been relatively stable and output fluctuations synchronized, and a fringe-group of countries which have experienced volatile exchange rates and idiosyncratic output shocks. So how should we interpret these findings? The answer is not at all straightforward, and one can think of various quite divergent interpretations for the results.

It is of course possible that the simple interpretation is indeed correct; that the asymmetry in output fluctuations does reflect genuinely idiosyncratic changes in the fundamentals which exchange rate changes have been able to smooth only incompletely. If this is the case, then the cost involved in depriving monetary autonomy is likely to be large. However, it is just as possible that those numbers indicate that exchange rate changes have been impotent in smoothing asymmetric shocks, in which case the cost of monetary union is small. Finally, and going one step further, the findings are also consistent with the interpretation that the large and erratic swings in exchange rates have actually been the *cause* of real fluctuations, particularly in the countries on the EU fringe. Such a source of instability could be diminished by forming a monetary union and hence, a monetary union would improve real stability. The point is that the sheer measurement of cross-country correlations between macroeconomic variables does not provide a sufficient basis for inference of the effects of a monetary union; one cannot separate the effects of real shocks from those of monetary shocks or of the monetary propagation mechanism. In order to identify the sources of instability, one needs a more structured approach.

A recent branch of empirical work (see Erkel-Rousse and Melitz 1995, Bayoumi and Eichengreen 1992) has used structural vector autoregressions (SVARs) to address the role of monetary policy in real fluctuations. In a representative work, Erkel-Rousse and Melitz identify the effect of monetary policy with shocks to relative velocity and calculate its effect on output. However, by concentrating on the effects of the structural shocks this line of work stops at least one step short of answering the essential question about the role of monetary autonomy. Identifying the effects of monetary autonomy with shocks to monetary variables is theoretically correct as long as one subscribes to the strict interpretation of Lucas: ie that only unexpected monetary policy has real effects. Such an interpretation, however, completely eliminates the role of monetary policy in real stabilization and renders the whole discussion of optimal currency areas futile. If monetary policy is to be of use for stabilization purposes, then not only the unexpected component of monetary policy, but also planned (and therefore predictable) policy must have real effects. Hence, to determine the complete bearing of monetary autonomy on real fluctuations one has to identify the real effects of predictable (endogenous) monetary reactions as well as the effect of shocks related to monetary autonomy.

As has been discussed above, the empirical separation of the monetary policy reaction function and the financial market reaction function is notoriously difficult. But assuming for the moment that this could be done, then in a VAR framework, the unpredictable part of monetary policy could be identified—as Erkel-Rousse and Melitz did—with structural monetary policy shocks. The predictable part of monetary policy would be estimated as the monetary policy reaction function. An dynamic response of, say, domestic demand to a monetary policy shock would then reflect both the effects of unpredictable monetary policy (to the extent that monetary shocks affect domestic demand directly) and the effects of predictable monetary policy (as the endogenous dynamic response of monetary policy to the original shock affects domestic demand). Similarly, the endogenous response of monetary policy to real shocks also contributes to the propagation of those shocks to real variables. For example, a negative foreign demand shock may induce a loosening of monetary policy which, in turn, affects the response of domestic demand to the shock. This role of monetary policy is, practically by definition, fully predictable.

In short, a change in monetary policy regime (such as joining a monetary union) affects the economy in three ways: it changes the nature of monetary policy shocks; it changes the propagation mechanism of those shocks; and it changes the propagation mechanism of real shocks.[2]

[2]The list includes only the immediate effects of a monetary policy change; any changes in

When analyzing the effects of a monetary union from the perspective of a small country, the fact that separation of the monetary policy reaction function from the financial market reaction function is difficult does not really complicate things too much. The structural equation that determines the behavior of the monetary variables will be an amalgam of those two reaction functions. In a monetary union, a small country will lose them both, so there is no compelling reason to try and separate them.

3 Structural vector autoregressions and policy analysis

In this paper we apply the structural VAR approach — or more precisely, the structural vector-error-correction approach — to the analysis of the effects of losing monetary autonomy. Econometric analysis of changes in policy regime is always a troublesome task, and it becomes even more troublesome when the action we contemplate is unlike any historically observable event. Entering the European Monetary Union is clearly an extreme example in this respect; it is a once-and-for-all event with no precedents.

Simple VAR models are useful tools for forecasting. Their appeal stems from their atheoretical nature — VARs are purely statistical models that summarize the data in a convenient way. As such, they offer minimal possibilities for the econometrician to manipulate the results so as to produce desired results. On the other hand, a VAR model is usually a poor tool for policy analysis. The individual equations in a VAR system do not generally represent any behavioral or causal relations. Hence, to condition forecasts on a policy variable that originally was modeled as endogenous by just deleting the particular equation and treating the variable as exogenous is fallacious (see Sargent 1984, Leamer 1985, and Sims 1986 for a discussion on these issues). Policy analysis usually requires determination of the economic structure behind the reduced form parameters.

Structural VAR models represent an attempt to identify the underlying economic structure from the reduced form VAR-estimates. Once the economic structure is identified, the model can, in principle, be used to policy analysis. In principle, because even if the structural parameters (unlike the reduced form parameters) do have an economic interpretation ("price elasticity", etc.), it still generally far from clear how invariant these parameters are with respect to specific policy changes. Due to data limitations, any vector autoregressive macro model is necessarily highly aggregative and there is little scope to pretend that in such a setting the parameters could truly represent the "deep" parameters, ie the stable parameters of the agents' objective functions. Hence, structural VARs are as vulnerable to the Lucas critique as ordinary structural macro models.

In this paper, we will settle for a rather humble definition of "structural

the behavior of the economic agents—which a shift in the monetary policy regime is likely to induce—are not included.

model". The structural form is that parameterization of the linear model which represents the dependence of the chosen macro variables on the relevant policy variables in the way that is least sensitive to changes in the rules that govern the behavior of the policy variables. We are not able to provide any deep insight into how this least sensitive form can be found. Economic theory is of some help, but usually the number of structural parameters to define exceeds the number of the restrictions obtained from sound economic theory. In the end, judgement must be used, and some sensitivity analysis should be applied to the results.

3.1 Identifying a structural error-correction model

The system we consider consists of p endogenous variables which we denote (in vector format) by X_t.[3] The structural form of the system can be written as

$$\Theta_0 \Delta X_t = \sum_{i=1}^{k} \Theta_i \Delta X_{t-i} + \Pi X_{t-1} + \Lambda \varepsilon_t, \qquad E(\varepsilon_t \varepsilon_t') = I. \tag{1}$$

We assume that all the variables in X_t are stationary after differencing. The matrix Π is nonzero if there is cointegration between the variables. The vector ε_t represents the primary shocks that run the economy. The fact that these shocks are mutually uncorrelated is less an assumption than a part of the definition of a primary shock: correlation between shocks indicates either causality between the shocks or a common underlying cause, both of which contradict with the concept of a primary shock.

The parameters in (1) cannot be estimated on the basis of the data only. There exists an infinity of possible parameterizations of the structural form which are observationally equivalent; ie fit the data equally well. Instead we can estimate a VAR system (or EC system) which is the (unique) reduced form representation of the model:

$$\Delta X_t = \sum_{i=1}^{k} A_i \Delta X_{t-i} + K X_{t-1} + u_t, \qquad E(u_t u_t') = \Sigma, \tag{2}$$

where u_t is the vector of the reduced form errors and the error covariance matrix Σ is generally non-diagonal. The reduced form parameters are nonlinear functions of the structural form parameters: $A_i = \Theta_0^{-1}\Theta_i$, $K = \Theta_0^{-1}\Pi$ and $\Sigma = \Theta_0^{-1}\Lambda\Lambda'(\Theta_0^{-1})'$. Obviously, the number of structural parameters is greater than the number of reduced form parameters, and therefore in order to recover the structural form from the reduced form estimates one needs to impose restrictions. The number of restrictions needed depends on what one intends to do with the model. If one only aims to identify the primary shock vector ε_t to calculate impulse responses etc., it suffices to identify the $p \times p$ matrix $\Phi_0 \equiv \Theta_0^{-1}\Lambda$. Since the identity $\Sigma = \Phi_0'\Phi_0$ provides $p(p+1)/2$ independent pieces of information towards that goal, the number of additional identifying

[3] Introducing exogenous variables in the model would be straightforward. For compactness, we assume all variables are endogenous.

restrictions needed is $p(p-1)/2$. This is the standard error orthogonalization problem familiar from VAR applications. If, on the other hand, one intends to use the model for policy analysis in which the data generating process of one or more of the variables is altered, it is necessary to identify the full structural form, ie solve for matrices Θ_0 and Λ separately. In this case, an additional set of $p \times p$ restrictions are needed (actually $p \times (p-1)$ after the normalization of Θ_0).

We shall first look into the smaller identification problem. The traditional approach to error orthogonalization has been to restrict Φ_0 directly (see Sims 1985 and Bernanke 1986). Usually this has been done by assuming the matrix lower triangular. In effect, this imposes a recursive structure on the contemporaneous effects of the shocks. The problem with this strategy is that it is generally difficult to come up with a plausible recursive ordering. More often than not, one can imagine the within-period effects going in both directions.

More recently, a number of studies have sought to identify Φ_0 indirectly by imposing restrictions on the long-run effects of the shocks. This strategy can be illustrated as follows. As shown by Johansen(1991), the vector error-correction system (2) has a Granger representation:

$$\Delta X_t \quad = \quad u_t + \textstyle\sum_{i=1}^{\infty} B_i u_{t-i} \tag{3}$$

If there is no cointegration present (2) reduces to an ordinary VAR model, and the coefficient matrices of the Granger representation can be calculated simply by inverting the VAR lag polynomial: $I + B_1 L + B_2 L^2 + ... = (I - A_1 L - ... - A_k L^k)^{-1}$. In this case the matrix $B \equiv I + \sum_{i=1}^{\infty} B_i$ which represents the long-run effects of u_t on X_t is given by A^{-1} where $A \equiv I - \sum_{i=1}^{k} A_i$. On the other hand, if K has rank $r > 0$, the calculation of the B_i matrices is more complicated. As Johansen shows, the long run matrix B can still be determined and it is given by $B = b_{\perp}[a'_{\perp} A b_{\perp}]^{-1} a'_{\perp}$. Here $a_{\perp}$ and $b_{\perp}$ are the orthogonal complements of the $p \times r$ matrices a and b for which $ab' = K$.

Correspondingly, the structural form (1) has the Granger representation

$$\Delta X_t \quad = \quad \textstyle\sum_{i=0}^{\infty} \Phi_i \varepsilon_{t-i}. \tag{4}$$

Again, if Π is zero, the matrix $\Phi = \sum_{i=0}^{\infty} \Phi_i$ representing the long-run effects of the structural shocks can be calculated as $\Phi = \Theta^{-1}$ where $\Theta = \Theta_0 - \sum_{i=1}^{k} \Theta_i$. Otherwise, if Π has rank $r > 0$, the matrix Φ is given by $\Phi = \beta_{\perp}[\alpha'_{\perp} \Theta \beta_{\perp}]^{-1} \alpha'_{\perp}$ where $\alpha\beta' = \Pi$. In either case the identification of the structural shocks can be based either on their short run relation to the reduced form errors

$$u_t = \Phi_0 \varepsilon_t \tag{5}$$

or on the long-run relation

$$B u_t = \Phi \varepsilon_t. \tag{6}$$

Together these two imply that $B\Phi_0 = \Phi$. Since B is given (estimated from the data), restrictions imposed on the long-run effects Φ translate to restrictions on the short-run elements Φ_0. The motivation behind this indirect approach is that since economic theory often has strong implications for the long-run but is mostly silent about the short run, long-run restrictions are easier to back up with sound economic theory. Despite certain problems concerning the robustness of the results[4], this method has gained considerable popularity recently (see Blanchard and Quah 1989, King et al. 1991, Galí 1992, DeSerres and Guay 1995).

The tradition in the literature is to call a model a 'structural' vector autoregression if it identifies the structural shocks; in other words, if it determines the matrix Φ_0. It might be more appropriate to refer such a model as 'semi-structural' vector autoregression, since it still hides the complete contemporaneous specification of the model, ie the decomposition of Φ_0 into (the inverse of) Θ_0 and Λ. While in the identification of Φ_0 both long-run and short-run restrictions can be used, the further decomposition must be based on short-run restrictions alone. There are only a handful of studies which apply a full structural identification of vector autoregression: Blanchard (1989) uses this approach to construct a Keynesian aggregate-demand / aggregate-supply vector autoregression. Giannini, Lanzarotti and Seghelini (1995) apply a similar model to Italy. The essential question in this identification problem is whether a certain shock has *direct* contemporaneous effect on a variable or if it only affects the variable through contemporaneous changes in other variables. In the former case, the shock is transmitted through the matrix Λ; in the latter, through both Λ and Θ_0. In case the model includes exogenous variables, one could also utilize *a priori* information of their short-run or long-run effects to impose restrictions on Θ_0. Imposing such short-run restrictions is straightforward. Long-run restrictions become cumbersome if, as in the model of this paper, the exogenous variables are included in the cointegration space.

Notice that the short-run identification procedure is not affected by the presence of cointegration. Any contemporaneous restrictions are just as sensible in an error-correction framework as they are in the VAR system. In contrast, the potential for long-run identification is generally more limited when the variables are cointegrated. In that case the long-run effects matrices Φ and B have reduced rank $p - r$; ie the number of feasible candidates for long-run identifying restrictions is limited by the cointegrating restrictions. If a theoretical implication is supported by the data to the extent that it is included to the cointegration space, it can no more be used to identify the structural model. For example, if (the logs of) domestic prices, foreign prices, and the exchange rate are found to cointegrate with coefficients $(-1, 1, 1)$, there is no point to impose a restriction that monetary shocks cannot have a long-run effect on real exchange rate. Since the cointegration result indicates precisely that *no* shock has a long-run effect on real exchange rate, such a restriction

[4]Faust and Leeper (1994) demonstrate that identification based on long-run properties will support reliable structural inferences only if the underlying economy satisfies strong restrictions. More precisely, they show that for any m-parameter VAR, one can find another m-parameter functional form with any desired long-run properties that fits the data equally well. Hence, the way long-run restrictions show up in the short-run properties of the model depends strongly on VAR structure being a good approximation of the true structure of the economy.

would be tautological and would not serve to identify the structural shocks.[5]

In this paper we combine long-run and short-run restrictions on the effects of the structural shocks to identify the structural model. We also test the sensitivity of the results with respect to the identification scheme by experimenting with different sets of restrictions.

4 The econometric model

In this section we formulate an error-correction model for the Finnish economy and define different sets of identification restrictions needed to construct the structural representation. The model consists of five endogenous variables: exports to west (x), domestic demand (d), domestic consumer prices(p), trade-weighted nominal exchange rate (e) and 3-month money market real rate (r).[6] Exogenous variables include foreign demand for imports (m^*), terms of trade (tot), and trade-weighted foreign consumer price index (p^*). The data is quarterly and seasonally adjusted and runs from 1970Q1 to 1994Q4.

During the estimation period, the structures of the Finnish economy have changed considerably. Most notably, in the fall of 1992 Finland abandoned its fixed exchange rate regime (or more precisely, a target zone regime) which it had—more or less successfully—followed since the beginning of the period, switching to a floating currency regime. It is likely that the estimated dynamics reflect more closely those under the target zone regime than those under the floating exchange rate. It is quite conceivable that the present regime does do a better job in smoothing real fluctuations than the previous one. Since there is inadequate data from the present regime for estimating a model of this magnitude, we do not offer a solution for that problem.[7]

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[5]Formally speaking, a feasible long-run restrictions cannot lie in the space spanned by the columns of β. A long-run restriction takes the form $\gamma'\Phi = 0$ where γ is a $n \times 1$ vector. The vector γ can be decomposed into the directions β and $\beta_\perp$ so that for some vectors a_1 and a_2 it holds that $\gamma = \beta a_1 + \beta_\perp a_2$. Substituting this into the long-run restriction an utilizing the properties of Φ the long-run restriction shrinks to $a_2'\beta_\perp'\Phi = 0$. Hence, in order for the restriction to be nontrivial, vector a_2 must be nonzero.

[6]We used real instead of nominal interest rate, since the stability of the former is less disputable. We calculated real interest rate by deducting from the nominal interest rate the annualized inflation rate over the previous two quarters. The analysis of the role of monetary autonomy will, of course, concern the behavior of nominal interest rates (and nominal exchange rate). That poses no problem since the nominal interest rate can be recovered from the equations for real interest rate and inflation.

For the period of credit rationing (roughly the first 15 years of the estimation period) no 3-month money market rate is available. However, using the covered interest rate parity, an implicit money market rate can be recovered on the basis of the spot and forward exchange rates vis-a-vis to a country that has such money market rate.

[7]Another notable structural change is the liberalization of financial markets in the late 1980s, which likely has affected both interest rate and exchange rate dynamics. A similar disclaimer applies here as well.

4.1 Integration and cointegration

First we tested the order of integration of the data. The logs of exports, domestic demand and exchange rate were clearly $I(1)$ variables, whereas the real interest rate appeared stationary. Consumer prices gave some indications of being $I(2)$ which would make inflation an $I(1)$ variable. On the other hand, inflation difference $\Delta p - \Delta p^*$ was found to be stationary. Hence, we decided to treat Δp as a stationary series which, during the estimation period, has undergone a structural break that is captured by the exogenous variable Δp^*. All exogenous variables were judged to be $I(1)$. The slight evidence of nonstationarity in foreign inflation was considered a consequence of a structural break in the monetary policy regime.

Next, we tested for the existence of cointegration between the $I(1)$ variables. The data gave indications of the existence of two or three cointegrating vectors between x, d, p, e, m^*, tot, and p^*. When domestic price homogeneity was imposed (ie the coefficients on p and e were restricted to $(a, -a)$), two cointegrating vectors remained.[8] These two vectors, ec_1 and ec_2, were used in the vector error-correction estimation. They are given by

$$\begin{aligned} ec_1 = \quad & -0.155\,x + 0.023\,d + (e-p) + 0.327\,m^* \\ & \quad +1.23\,tot + 2.02\,p^* - 0.018\,trend \\ ec_2 = \quad & x - 0.434\,d - 0.0054\,(e-p) - 0.471\,m^* \\ & \quad +1.05\,tot + 0.60\,p^* - 0.013\,trend. \end{aligned}$$

Obviously, to obtain economic interpretations of the cointegrating vectors we would have to choose suitable linear combinations of these two. Since the interpretations play no role in the subsequent analysis, we do not go into that exercise.

The two error correction variables impose two linear restrictions on the long run behavior of the system. Hence, the rank of the matrix of long-run effects B is reduced from 5 to 3.[9] The long-run effects of shocks are restricted by two long-run relations between exports, domestic demand and the real exchange rate.

The reduced form estimates are presented in Table 1. The results are typical for a system of this size; most of the individual coefficients are not significantly different from zero. Particularly the equation for exports is rather poorly determined. In contrast, the error-correction variables seem to have a significant explanatory power in all equations; eight of the ten error-correction coefficients are significantly different from zero. Both error-correction terms have a significant coefficient in the equation for the real interest rate which does not itself enter into the cointegrating relations.

[8]The restriction of homogeneity with respect to domestic prices was actually rejected by the data, but not overwhelmingly so. Because of the strong prior view that a rescaling of all nominal variables cannot have real effects, we nevertheless chose to maintain the restriction.

[9]Although B has rank 3, the shocks actually have long-run effects on only two linear combinations of the variables. Since the real interest rate is assumed stationary the long-effect of shocks on r is by definition zero. Instead, the last row of the B represents the effects of the reduced form shocks on cumulative sum of r, which does not have a relevant economic meaning in this context.

Table 1 **Reduced form parameters**

	Δx_t	Δd_t	Δp_t	Δe_t	Δr_t
Δx_{t-1}	-0.2527	-0.1416	0.0315	-0.0308	0.0986
	-(1.63)	-(2.91)	(2.10)	-(0.45)	(1.68)
Δx_{t-2}	0.1393	-0.0018	0.0135	-0.0653	0.1029
	(1.16)	-(0.05)	(1.17)	-(1.22)	(2.26)
Δd_{t-1}	0.3238	-0.2584	0.0100	-0.1198	-0.0991
	(0.97)	-(2.46)	(0.31)	-(0.80)	-(0.78)
Δd_{t-2}	-0.1483	-0.1069	0.0015	-0.0142	-0.0348
	-(0.48)	-(1.11)	(0.05)	-(0.10)	-(0.30)
Δp_{t-1}	-1.5886	-0.0537	0.0384	-0.0028	-2.3130
	-(1.33)	-(0.14)	(0.33)	-(0.01)	-(5.11)
Δp_{t-2}	-0.6735	-0.4324	0.0104	0.5711	0.5453
	-(0.58)	-(1.19)	(0.09)	(1.11)	(1.24)
Δe_{t-1}	0.1558	-0.0922	-0.0022	0.3089	0.0420
	(0.57)	-(1.08)	-(0.08)	(2.55)	(0.41)
Δe_{t-2}	0.0423	-0.0745	-0.0489	0.0246	-0.1203
	(0.16)	-(0.91)	-(1.94)	(0.21)	-(1.22)
r_{t-1}	-0.0708	0.0241	0.0301	0.1417	0.7280
	-(0.23)	(0.25)	(1.02)	(1.05)	(6.32)
r_{t-2}	-0.0353	-0.0817	-0.0657	0.0356	-0.2421
	-(0.13)	-(0.99)	-(2.59)	(0.30)	-(2.43)
$ec_{1,t-1}$	0.1800	0.1120	0.0438	-0.1135	0.0913
	(1.49)	(2.96)	(3.76)	-(2.11)	(2.00)
$ec_{2,t-1}$	-0.3425	0.1915	-0.0377	-0.0734	-0.1279
	-(2.22)	(3.97)	-(2.53)	-(1.07)	-(2.19)
Δm^*_{t-1}	0.4591	0.1934	-0.0443	-0.0801	-0.0625
	(1.75)	(2.35)	-(1.75)	-(0.68)	-(0.63)
Δm^*_{t-2}	0.1593	0.0691	-0.0716	-0.0457	0.0108
	(0.52)	(0.72)	-(2.41)	-(0.33)	(0.09)
Δtot_{t-1}	-0.3532	0.2103	0.0690	-0.1680	-0.0743
	-(1.32)	(2.51)	(2.67)	-(1.41)	-(0.73)
Δtot_{t-2}	-0.6164	-0.0290	-0.0030	0.1166	0.0045
	-(2.07)	-(0.31)	-(0.10)	(0.88)	(0.04)
Δp^*_{t-1}	0.1877	-0.2816	0.7276	0.3950	-0.7299
	(0.08)	-(0.40)	(3.33)	(0.39)	-(0.85)
Δp^*_{t-2}	0.7595	0.5670	0.3420	-0.4813	1.4112
	(0.35)	(0.82)	(1.61)	-(0.49)	(1.69)
const.	0.6969	-0.9506	0.0100	0.5572	0.2223
	(1.13)	-(4.91)	(0.17)	(2.02)	(0.95)
σ	0.0549	0.0172	0.0053	0.0245	0.0208

4.2 Structural identification

Next we proceed to identify the structural model. We shall assume that of the five independent shocks that run the system three are originated from the real economy and two are domestic monetary shocks that can only exist under monetary autonomy. The three real shocks are assigned rather tentative interpretations which are meant to be consistent with the assumed properties of the shocks. We do not assign separate interpretations to the two monetary shocks, although one could imagine one shock stemming from domestic monetary policy and the other from financial market reactions.

The shocks are identified on the basis of the following restrictions:

- Shock ε_1: "Foreign preference shock". This shock has an direct immediate effect on exports, exchange rate and real interest rate. Its contemporaneous effect on domestic demand and prices is limited to what is transmitted through changes in exchange rate and interest rate. The long-run effects of this shock are not restricted.

- Shock ε_2: "Domestic demand shock" is assumed to have a direct immediate effect on all variables except exports. Its long-run effects are restricted to zero.

- Shock ε_3: "Domestic supply shock". The effects of this shock are not restricted. It has both immediate effect on all variables and unrestricted long-run effects.

- Shocks ε_4&ε_5: "Monetary shocks". These two shocks are assumed to have a direct immediate effect only on the real interest rate and the exchange rate. Their contemporaneous effects on real variables are limited to what is channeled through exchange rate changes to prices and through real interest rate to domestic demand. For the purposes of this paper, it is not necessary to identify these shocks separately.

- In addition, changes in domestic demand are allowed to have a contemporaneous effect on prices.

Let us denote $\Delta X_t = [\Delta x_t, \Delta d_t, \Delta p_t, \Delta e_t, r]'$ and $\varepsilon_t = [\varepsilon_{1,t}, \varepsilon_{2,t}, \varepsilon_{3,t}, \varepsilon_{4,t}, \varepsilon_{5,t}]'$. Then the above restrictions can be presented formally as follows:

$$\Theta_0 \Delta X_t = \sum_{i=1}^{k} \Theta_i \Delta X_{t-i} + \alpha\beta' X_{t-1} + Z_t + \Lambda\varepsilon_t$$

$$\Theta_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & \theta_{25} \\ 0 & \theta_{32} & 1 & \theta_{34} & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}, \quad \Lambda = \begin{bmatrix} \lambda_{11} & 0 & \lambda_{13} & 0 & 0 \\ 0 & \lambda_{22} & \lambda_{23} & 0 & 0 \\ 0 & \lambda_{32} & \lambda_{33} & 0 & 0 \\ \lambda_{41} & \lambda_{42} & \lambda_{43} & \lambda_{44} & \lambda_{45} \\ \lambda_{51} & \lambda_{52} & \lambda_{53} & \lambda_{54} & \lambda_{55} \end{bmatrix},$$
$$\Phi = \begin{bmatrix} \phi_{11} & 0 & \phi_{13} & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & \phi_{45} \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} \end{bmatrix}, \tag{7}$$

where $\Phi = \beta_\perp[\alpha'_\perp \Theta \beta_\perp]^{-1}\alpha'_\perp$, and Z_t represents the effects of known exogenous variables. Since the rank of the long-run matrix Φ is reduced by the two cointegrating vectors, the entries marked by a dot are linearly dependent on other entries.

The contemporaneous effects of the shocks are assumed to be mostly direct effects. The within-period dependencies between the endogenous variables are limited to three: interest rate affects domestic demand; and domestic demand and exchange rate affects prices. Particularly, the parameterization in (7) seems to indicate that interest rate and exchange rate do not react contemporaneously to changes in other endogenous variables. This formulation does not actually contain any restrictions and is therefore inconsequential.[10] Instead, as will later come apparent, allowing exchange rate changes to have a contemporaneous effect on consumer prices will play a significant role in the results.

The three matrices in (7) have altogether 31 free parameters, whereas the reduced-form parameters provide 30 independent bits of information (15 from the symmetric covariance matrix Σ, 15 from the reduced-form long-run matrix A with rank 3). This mismatch arises because we have not separated the two monetary shocks, and hence the lower right 2×2 submatrix of Λ is still underidentified. For calculation purposes we identify it by the restriction $\lambda_{45} = 0$. The choice of this final identification restriction is immaterial for the results. It can be verified that the restrictions imposed are independent of each other and do therefore identify the structural matrices. The technique used to calculate the structural coefficients is presented in the technical appendix.

The point estimates of the structural coefficients are presented in Table 2. As can be seen, all contemporaneous dependencies between the endogenous variables have the expected sign: a rise in real interest rate decreases domestic demand, and prices react positively to an increase in domestic demand and a depreciation of the exchange rate. The immediate elasticity of consumer prices with respect to exchange rate changes is estimated to be almost 0.47, which is rather high.

[10] We could assume that the effect of real shocks on monetary variables is not direct but is instead transmitted through contemporaneous changes in the real variables (ie through the 2×3 lower left submatrix of Θ_0 instead of the 2×3 lower left submatrix of Λ) without affecting any simulation results. As long as *all* shocks are allowed to have an independent contemporaneous effect on the exchange rate and the real interest rate, the exact manner in which this effect is decomposed to direct and indirect effects is unimportant.

Table 2 **Structural parameters**

	Δx_t	Δd_t	Δp_t	Δe_t	Δr_t
Δx_t	1	0	0	0	0
Δd_t	0	1	0.0420	0	0
Δp_t	0	0	1	0	0
Δe_t	0	0	0.4718	1	0
Δr_t	0	-0.3631	0	0	1
Δx_{t-1}	-0.2527	-0.1058	0.0520	-0.0308	0.0986
Δx_{t-2}	0.1393	0.0356	0.0444	-0.0653	0.1029
Δd_{t-1}	0.3238	-0.2944	0.0773	-0.1198	-0.0991
Δd_{t-2}	-0.1483	-0.1195	0.0127	-0.0142	-0.0348
Δp_{t-1}	-1.5886	-0.8935	0.0420	-0.0028	-2.3130
Δp_{t-2}	-0.6735	-0.2344	-0.2410	0.5711	0.5453
Δe_{t-1}	0.1558	-0.0769	-0.1441	0.3089	0.0420
Δe_{t-2}	0.0423	-0.1182	-0.0573	0.0246	-0.1203
r_{t-1}	-0.0353	0.2885	-0.0378	0.0356	-0.2421
r_{t-2}	-0.0353	-0.1696	-0.0790	0.0356	-0.2421
$ec_{1,t-1}$	0.1800	0.1451	0.0927	-0.1135	0.0913
$ec_{2,t-1}$	-0.3425	0.1450	-0.0111	-0.0734	-0.1279
Δm^*_{t-1}	0.4591	0.1707	-0.0146	-0.0801	-0.0625
Δm^*_{t-2}	0.1593	0.0730	-0.0530	-0.0457	0.0108
Δtot_{t-1}	-0.3532	0.1834	0.1394	-0.1680	-0.0743
Δtot_{t-2}	-0.6164	-0.0273	-0.0568	0.1166	0.0045
Δp^*_{t-1}	0.1877	-0.5466	0.5530	0.3950	-0.7299
Δp^*_{t-2}	0.7595	1.0794	0.5452	-0.4813	1.4112
constant	0.6969	-0.8699	-0.2131	0.5572	0.2223
$\epsilon_{1,t}$	0.0488	0	0	0.0001	0.0011
$\epsilon_{2,t}$	0	0.0131	0.0051	-0.0081	0.0049
$\epsilon_{3,t}$	-0.0049	-0.0073	0.0107	-0.0184	0.0024
$\epsilon_{4,t}$	0	0	0	0.0087	0.0015
$\epsilon_{5,t}$	0	0	0	0	0.0177

Since the structural coefficients are generally nonlinear functions of the reduced form parameters, they have non-normal distributions. Standard errors could in principle be calculated by simulations, but their interpretation would be difficult for several reasons. A better picture of the uncertainties involved can be conveyed by the simulated distributions of the impulse responses presented later in this section.

5 The role of monetary autonomy

5.1 Forecast variances and impulse responses

Once the structural model is identified, the effects of lost monetary autonomy can be studied by removing the effects of the two monetary shocks and treating the exchange rate and the nominal interest rate as exogenous variables; ie as constants. Of course, the real interest rate continues to be endogenous as the rate of inflation is still determined domestically.

How should such an analysis be interpreted? First, with this approach we implicitly assume that neither the monetary authorities nor the financial markets in the hypothetical monetary union react to developments in the Finnish economy. This assumption is probably a reasonable approximation of the reality. Second, we make the even stronger assumption that there are no linear dependencies between the structural shocks that affect the Finnish economy and the shocks that run the unionwide economy and consequently its monetary conditions. This assumption may or may not hold in practice; without knowing the participants and the actual monetary policy of the future monetary union, an answer is difficult to provide. Some tentative testing indicated that this may be a reasonable approximation of reality, so we continued on the basis of that assumption.[11]

Table 3 presents the variance decompositions of x, d, and p with and without monetary autonomy. The table shows the conditional forecast standard error (conditional on the exogenous variables) of the variables and the percentage contributions of the structural shocks — five shocks under monetary autonomy and three shocks in a monetary union. If monetary autonomy has served to stabilize the real economy, we would expect to observe larger standard errors for x and d in the latter regime — ie in the right-hand part of the table.[12]

According to the left-hand side decomposition in Table 3, the effects of monetary shocks on the real variables under the present regime seem to be limited. Monetary shocks appear to have no role in explaining the variance of exports and their effects on domestic demand are modest; for horizons up to 4 quarters, less than 20 % of the forecast variance of domestic demand stems from monetary shocks. In contrast, monetary shocks explain a large part of the variability of the nominal variables and real interest rate.

Losing monetary autonomy does appear to increase real variability slightly. For horizons of two quarters and more, conditional standard error of exports volume is increased by 5–7 %. The greater variance is due to a marked increase in the effect of domestic supply shocks on exports. The forecast variance of the level of domestic demand also increases with the loss of monetary autonomy. The difference is greatest in the 4-quarter horizon when the standard error increases close to 30 %. In the longer term the standard error increases by approximately 10 %. The variance of the consumer prices increases in the short

[11]More precisely, we assumed that the future European monetary policy would resemble the German and French monetary policies as experienced in recent history. We regressed the German and French interest rates and exchange rates (weighted with Finnish trade weights) on their own lags and on the present and lagged values of the estimated structural shocks from the VAR model at hand. If German and French interest and exchange rates react to the same shocks as Finnish rates, then the structural shocks estimated for Finland should have explanatory power in these regressions. We found no such evidence.

[12]Notice that the conditional variance of the forecast is not a direct measure of the variability of those variables. Part of the variability due to changes in the exogenous variables. The complete effect of monetary autonomy on real variability depends also on how the transmission mechanism of the exogenous variables is affected.

Table 3 **Forecast error decomposition**

		with mon. autonomy						without mon. autonomy			
		σ	contribution of					σ	contribution of		
	q		ε_1	ε_2	ε_3	ε_4	ε_5		ε_1	ε_2	ε_3
x	1	0.0491	99.00	0.00	1.00	0.00	0.00	0.0491	99.00	0.00	1.00
	4	0.0654	84.66	1.16	13.03	0.71	0.44	0.0686	72.85	3.49	23.66
	8	0.0725	79.16	1.23	18.44	0.61	0.56	0.076	66.55	3.66	29.80
	16	0.0776	74.21	1.08	23.64	0.56	0.51	0.0829	61.19	3.27	35.54
	28	0.0841	68.08	0.92	30.09	0.48	0.44	0.0901	56.78	2.80	40.42
d	1	0.0154	0.07	54.09	28.25	0.13	17.46	0.015	0.00	76.26	23.74
	4	0.0282	19.87	27.39	37.22	1.72	13.8	0.0367	4.38	13.68	81.94
	8	0.0505	34.45	8.82	50.13	0.63	5.97	0.0578	13.20	6.09	80.70
	16	0.0810	34.90	3.44	59.07	0.25	2.34	0.0905	21.26	2.99	75.75
	28	0.1099	33.32	1.87	63.40	0.14	1.27	0.1225	25.60	1.79	72.62
p	1	0.0047	0.00	14.01	11.97	73.69	0.32	0.0118	0.00	23.14	76.86
	4	0.0103	13.14	10.35	3.74	71.16	1.61	0.0192	1.01	29.87	69.12
	8	0.0189	32.47	4.62	1.41	59.89	1.62	0.0256	1.12	30.29	68.59
	16	0.0347	46.78	1.80	1.69	49.18	0.56	0.0298	2.97	29.20	67.83
	28	0.0533	53.41	1.00	1.83	43.52	0.24	0.0308	4.13	28.18	67.69
e	1	0.0219	0.00	13.76	70.53	15.71	0.00				
	4	0.0481	7.99	10.86	53.75	22.67	4.73				
	8	0.0617	24.16	7.00	38.58	24.04	6.22				
	16	0.0747	37.60	4.91	27.17	25.94	4.38				
	28	0.0859	42.27	3.81	21.60	29.00	3.31				
r	1	0.0186	0.34	6.85	1.69	0.65	90.47	0.0000	–	–	–
	4	0.0263	3.19	4.70	3.27	11.56	77.28	0.0345	1.24	25.67	73.09
	8	0.0272	7.30	4.78	3.88	10.86	73.18	0.0371	2.98	25.10	71.92
	16	0.0273	7.70	4.86	4.16	10.75	72.54	0.0379	3.19	25.44	71.37
	28	0.0273	7.70	4.86	4.16	10.75	72.54	0.0381	3.21	25.53	71.26

term, but decreases in the long term. An interesting feature is that the long-run contribution of foreign demand shocks to price variability diminish radically in a monetary union. The likely interpretation is that in both scenarios, the long-run effect of foreign demand shocks on the *real* exchange rate is rather small; as in a monetary union exchange rate does not react, the long-run reaction of prices must be small as well.

Perhaps the most pronounced effect of giving up monetary autonomy is the increase in the variability of the real interest rate. With monetary autonomy, nominal interest rates tend to follow the rate of inflation, whereas in a monetary union, changes in the domestic rate of inflation are fully transmitted to the real interest rate.

Figures 1–4 print the impulse responses of the same variables. For each impulse response, the median response is plotted together with the 25% and 75% fractiles; ie, 50% of the draws fall between the boundaries. The distributions of the impulse responses were calculated on the basis of a Monte Carlo simulation consisting of 1000 draws from the estimated distribution of the re-

Figure 1 **Impulse responses of exports**

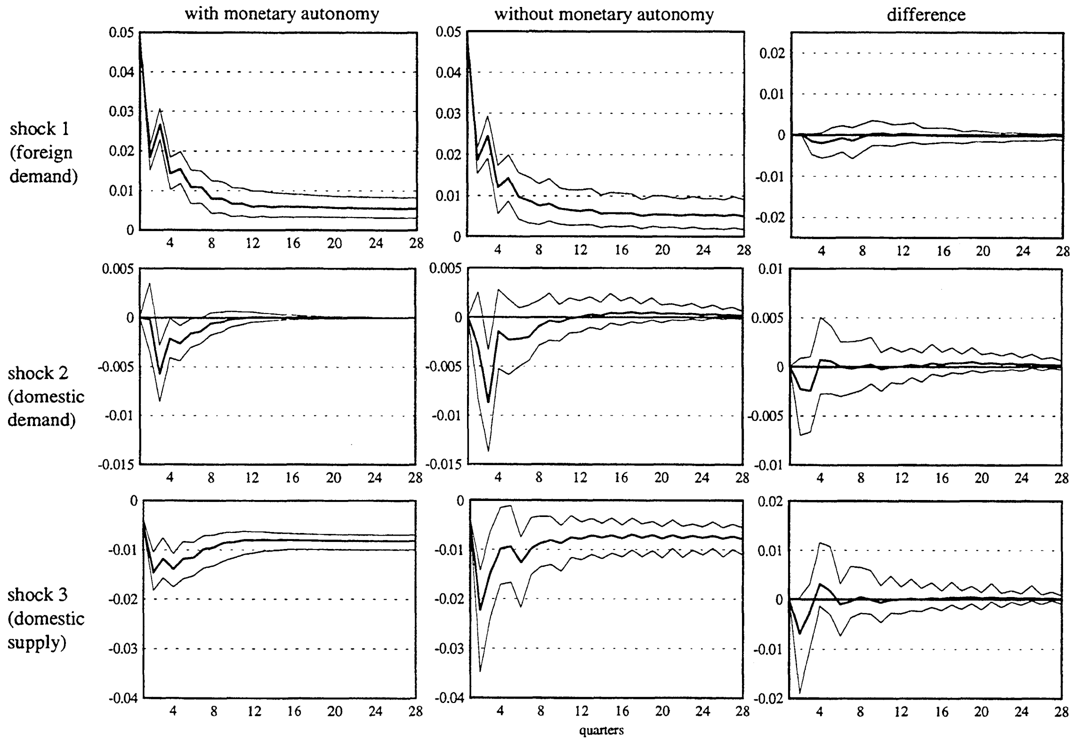


Figure 2 **Impulse responses of domestic demand**

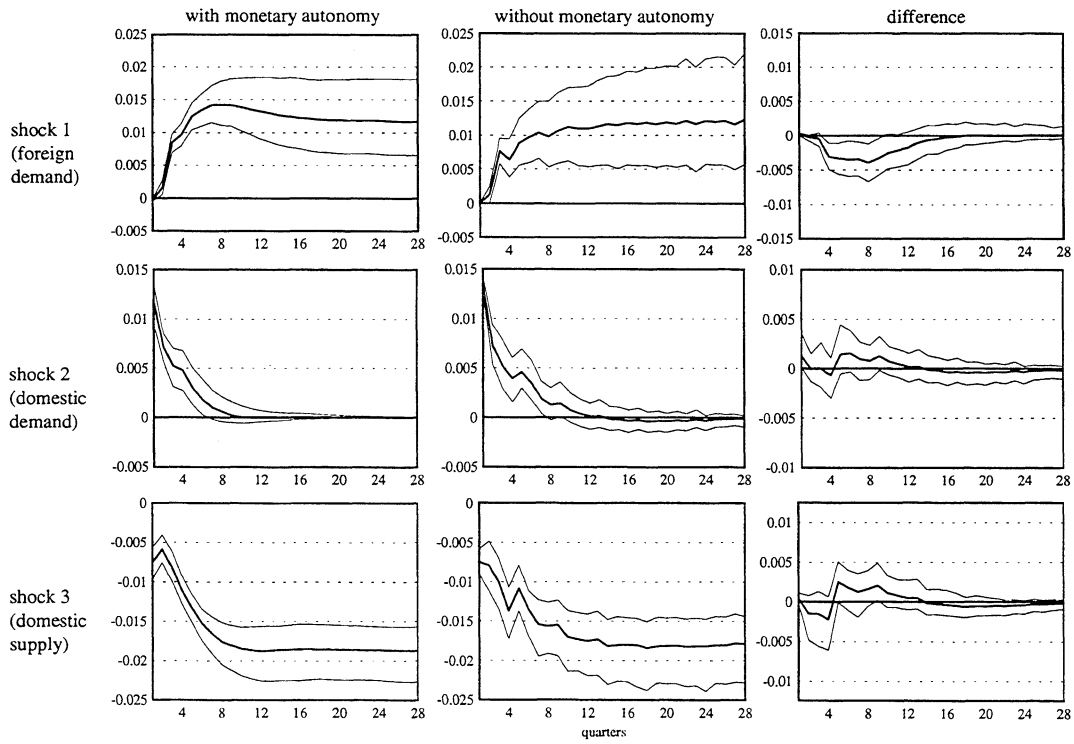
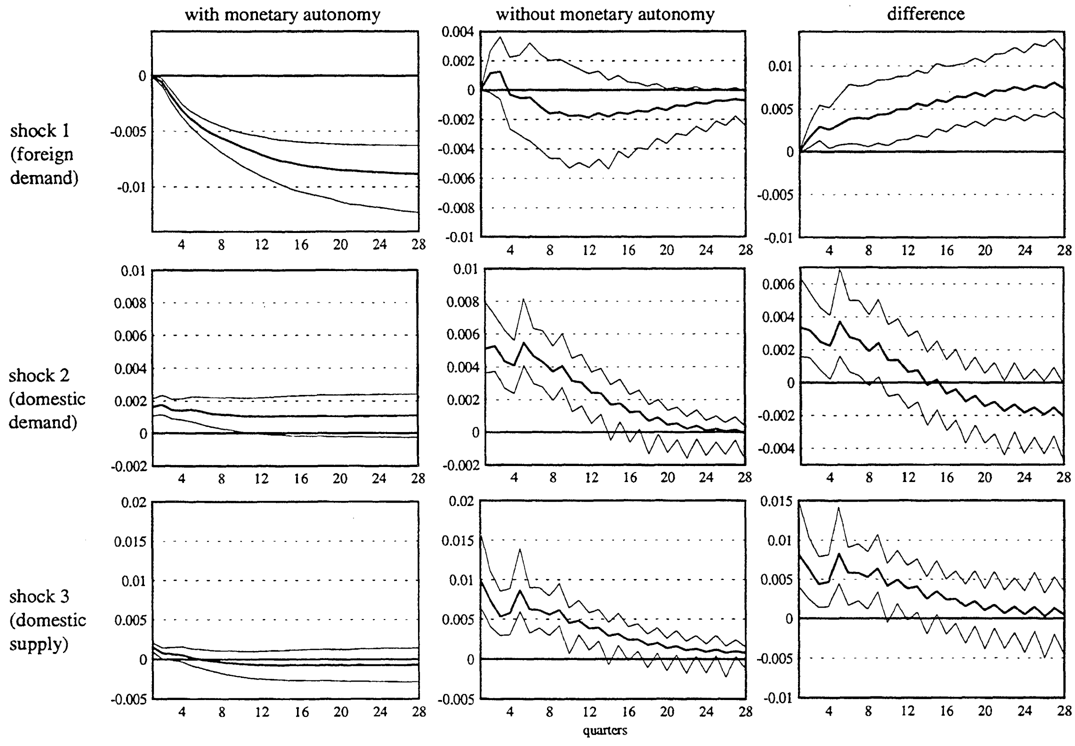


Figure 3 **Impulse responses of consumer prices**



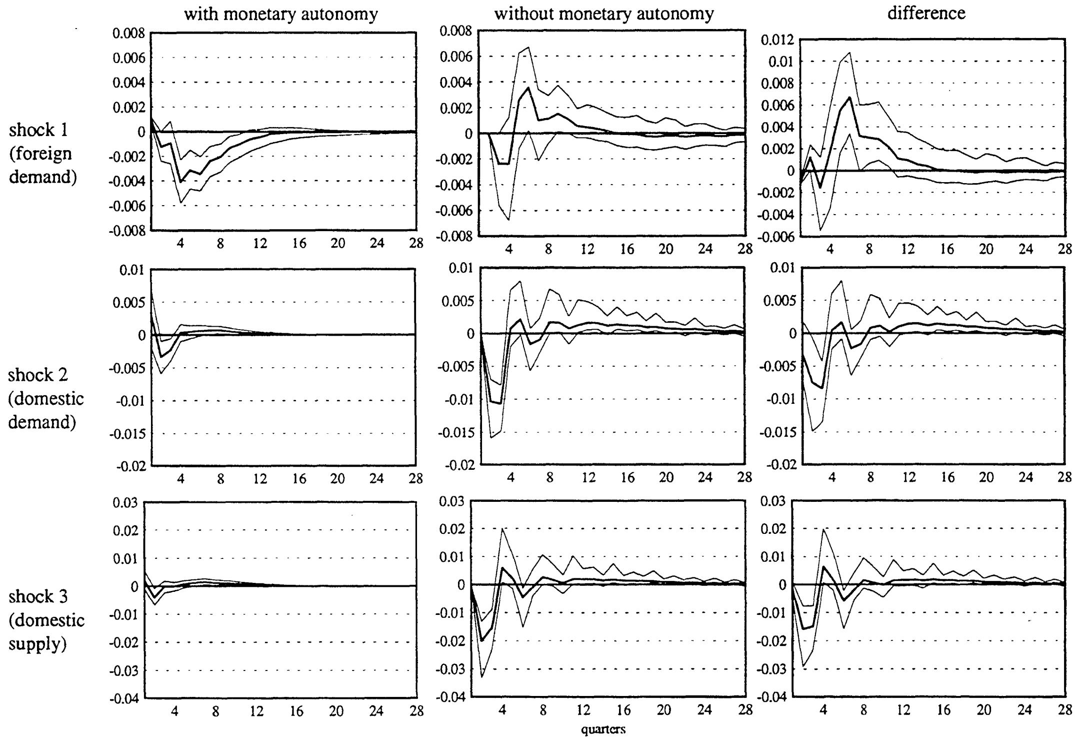
duced form parameters. The first column of impulse responses are those with monetary autonomy, the second without monetary autonomy, and the third the difference of these two. Note that since the median of differences generally differs from the difference of medians, the bold line in the third column is not the difference between the corresponding lines in the other two columns.

The estimated distributions of impulse responses without monetary autonomy proved to be highly non-normal: the distributions were generally skewed and fat tailed. Roughly 75% of the draws were nicely concentrated around the median, while close to 20% produced an unstable model that diverged from the cointegration space. Furthermore, as is evident from the impulse responses, oscillating behavior was common.

Notwithstanding the stability problems, the impulse responses look quite interesting. Losing monetary autonomy seems to have a minor effect on the response of exports to all shocks. The median responses are almost identical across the scenarios, but the distributions are somewhat wider without monetary autonomy. The same holds for domestic demand: there is some evidence that monetary autonomy serves to dampen the short-run response of domestic demand to the shocks, although the differences are rather small. A zero effect would fit well within normal confidence intervals.

As with the variance decomposition above, the effect of monetary autonomy on the impulse responses of consumer prices is much more evident. Under monetary autonomy, all shocks have a long run effect on prices. In the monetary union scenario these effects are transitory and seem to disappear within roughly 7 years. Hence it appears that in the absence of endogenous exchange

Figure 4 **Impulse responses of real interest rate**



rate changes, price changes take over the role of nominal adjustment mechanism.

As is to be expected, the behavior of real interest rate is clearly affected by the introduction of a monetary union (see Figure 4). As the variability of inflation increases, so does the variability of the real interest rate. This effect is, however, rather imprecisely estimated. Looking at the third column of Figure 4 which depicts the change in the responses of the real interest rate brought about by the monetary union, we see that zero is mostly well within the normal confidence intervals.

The results fit together in a rather consistent manner. They suggest that insufficient flexibility of prices would not be a problem in a monetary union. Nominal adjustment through domestic prices in a monetary union is estimated to be not much slower than adjustment through exchange rate changes in the present regime. Hence, the variability of exports would not be much affected by a monetary union. On the other hand, the results indicate that the use of domestic prices as the nominal adjustment mechanism may increase the variability of the real interest rate. This, in turn, is estimated to show up as an increase in the variability of domestic demand.

A word of caution is in order regarding the interpretation of these results. During the estimation period, changes in the nominal exchange rate were mostly in one direction: the markka has weakened considerably in relation to the trade-weighted basket. Similarly, consumer inflation has been comparatively high. Hence, the estimate of price flexibility is based on a series of episodes in which the rate of inflation increased as a result of exchange rate depreciation. In a monetary union, the nature of required price flexibility is different: attaining the same level of real exchange rate flexibility as under monetary autonomy likely requires occasional deflationary periods. The linear framework does not qualitatively separate inflation and deflation; adjusting a 2 % inflation down to 2 % deflation takes just as much as getting down from 6 % to 2 %. If, in reality, the downward flexibility of prices (or particularly wages) decreases at low or negative values of inflation, then the results presented are likely to overstate price flexibility in a monetary union and underestimate role of monetary autonomy in smoothing real fluctuations.

5.2 Sensitivity analysis

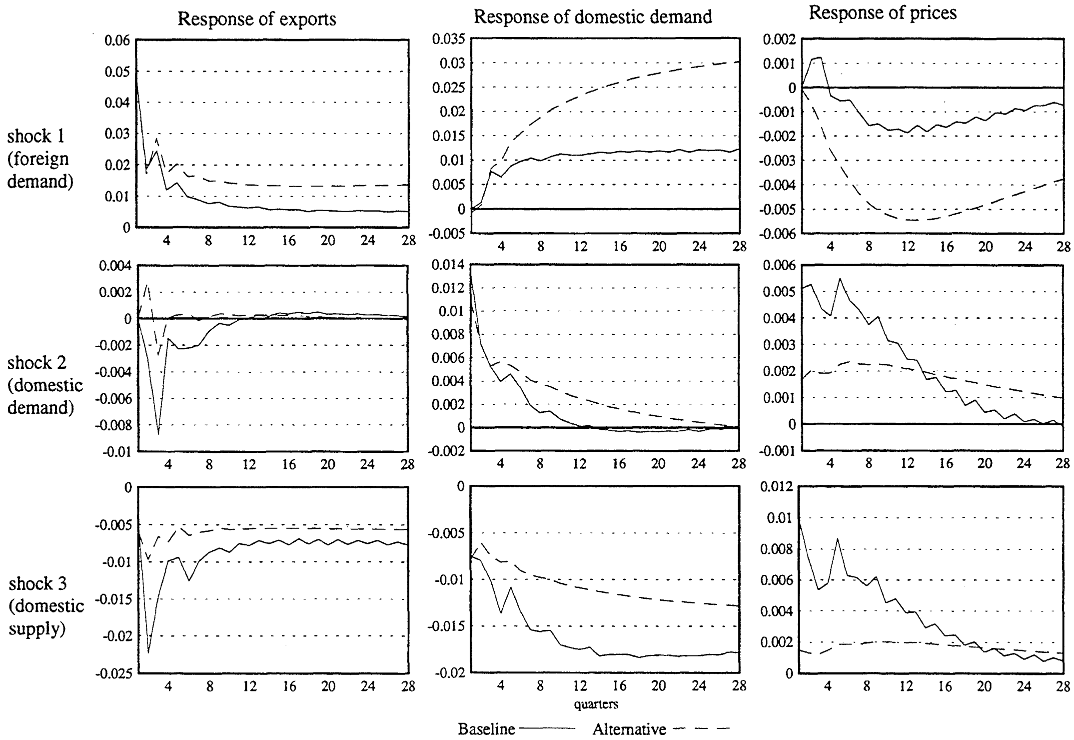
In order to test the sensitivity of the results with respect to the structural identification scheme we experimented with two alternative specifications. Specifically, we tested the effect of the last (and perhaps the most precarious) step of the identification scheme: namely, the decomposition of the contemporaneous effects matrix Φ_0 — defining the mapping from the structural errors to the reduced form residuals $u_t = \Phi_0 e_t$ — into the direct effects matrix Λ and the simultaneous system matrix Θ_0. To facilitate comparison, it is necessary to keep Φ_0 constant across the specifications; changing Φ_0 would change the structural errors and their interpretation, and therefore render any meaningful comparison impossible. Instead, choosing an alternative decomposition of the original contemporaneous effects matrix — say, $\Phi_0 = \hat{\Theta}_0^{-1}\hat{\Lambda}$ — leaves the structural errors intact. Altering this decomposition only affects the role played by the monetary equations in the transmission of the shocks to the real variables. Consequently, the impulse responses estimated for the present regime remain unaffected, while those estimated for a monetary union generally change.

There are two extreme cases of this decomposition which make natural candidates for the alternative specifications. First, we may assume that all contemporaneous effects are direct effects: ie that $\hat{\Lambda} = \Phi_0$ and $\hat{\Theta}_0 = I$. In this case, the structural form coincides with the reduced form. Alternatively, we may take all contemporaneous effects be channeled through the simultaneous system matrix Θ_0. This implies that $\hat{\Lambda} = I$ and $\hat{\Theta}_0 = \Phi_0^{-1}$. Incidentally, the latter alternative scheme turned out to produce simulation results identical to those obtained with the baseline specification. Thus, we concentrated on the first specification[13].

Figure 5 plots the median impulse responses in a monetary union for the baseline specification and the first alternative specification. In the alternative scenario the adjustment of prices is much slower than in the baseline scenario, and consequently, the real effects of shocks are much greater. The long-run

[13] Alterations in the identification scheme can be thought as consisting of the choice of a matrix F for which the new structural matrixes are defined as $\hat{\Theta}_0 = F\Theta_0$ and $\hat{\Lambda} = F\Lambda$. It can be shown that, in the present model, the results are invariant with respect to alterations in which F is lower block triangular so that the 3×2 upper right submatrix is zero. In the first alternative scheme $F = \Theta_0^{-1}$ is not lower block triangular; in the second scheme $F = \Lambda^{-1}$ is lower block triangular. Hence, results are affected in the first case but not in the second.

Figure 5 **Impulse responses under alternative specifications**

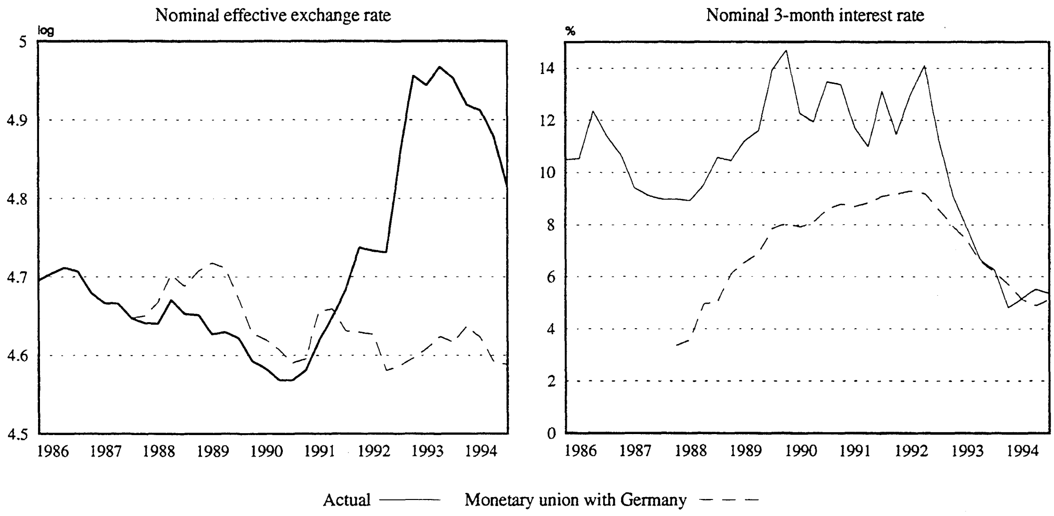


effects of foreign demand shock and domestic supply shock are roughly double their baseline values. The domestic demand shock, which was originally defined by its lack of long-run effects, in this case develops a long-run effect, albeit small compared to those of the other two real shocks. It appears that the most crucial aspect in the decomposition of the contemporaneous system is whether exchange rate changes are allowed to have within period effect on prices. If such an effect is allowed, then the resulting structural equation for prices will exhibit a high degree of flexibility; if no such contemporaneous effect is allowed, then prices appear to be quite rigid. Without monetary autonomy, price rigidity implies real exchange rate rigidity and high welfare effects of real shocks.

6 The monetary union of 1988?

In this section, the structural VAR model estimated above is used to find out what the role of monetary autonomy has been in recent Finnish economic developments. More specifically, we contrast the developments actually observed with those the model predicts would have taken place if, in the beginning of 1988, Finland had entered into a monetary union with (the Federal Republic of) Germany. We assume that in the latter case, the Bundesbank's policy would in no way be affected by this disproportional marriage, nor that it in any way showed up in the valuation of the German mark or German assets in the financial market. In effect, this means that the nominal interest rates

Figure 6 **Exchange rate and interest rate in the monetary union with Germany**



in Finland were equalized to those of Germany, and that the exchange rate of the Finnish markka vis-a-vis third countries moved together with the German mark.

The eight-year period under consideration was, in many respects, a wild time in Finnish economic history. It represents an economic roller coaster rarely found in the industrialized world: the first couple of years were characterized by rapid growth and serious overheating of the economy, which were then followed by a 13 percent crash in GDP over the next 3 years. During the period, the structures of the economy changed fundamentally. Finland got a liberalized financial market, lost its largest trading partner and experienced a five-fold increase in unemployment. Given the nature of the period, some caution is needed when interpreting the results.

Figure 6 illustrates the how such a monetary union would have affected the Finnish nominal exchange and short interest rates. The left-hand panel depicts the behavior of the trade-weighted exchange rate. The solid line is the actual exchange rate; the dashed line illustrates how this exchange rate would have evolved had the Finnish markka followed the German mark. The right-hand panel plots the corresponding paths for the Finnish and German 3-month money market interest rates. As can be seen, a monetary union with Germany would have led to a slightly weaker currency until 1991 and a considerably stronger currency from then on. The nominal interest rate would have stayed well below the realized value throughout most of the period in question. Hence, during the years of the seriously overheated economy in the late 80s, the monetary stance in Finland would have been considerably looser. During the consequent recession, the interest rate would still have been slightly lower, but the exchange rate would have been considerably stronger than the actual. On balance, monetary conditions would probably have been tighter than what was actually experienced.

Figure 7 **Simulated macroeconomic effects of the monetary union**

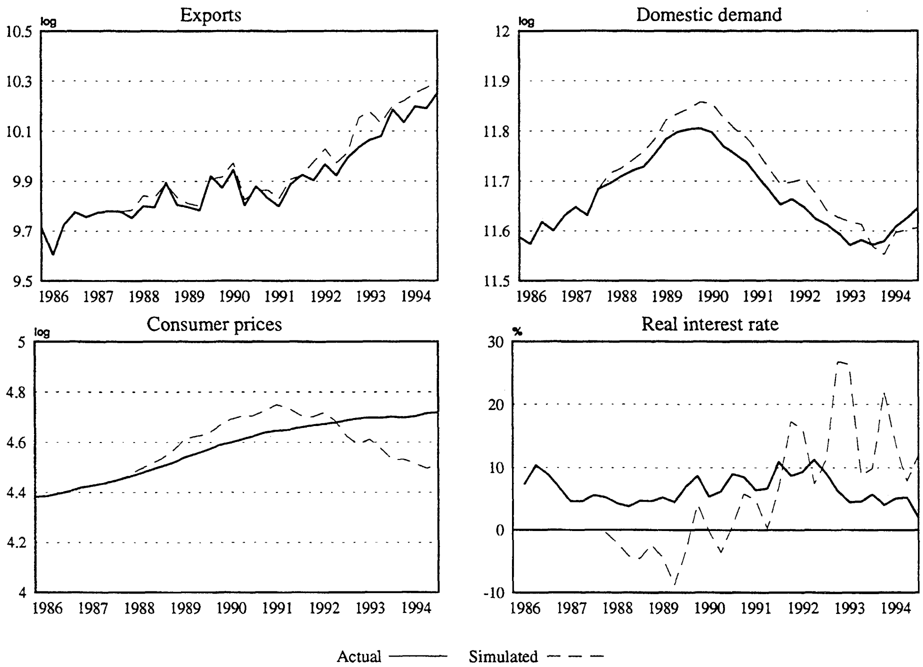


Figure 7 depicts the alternative history simulated for Finland in such a monetary union. According to these simulations, entering a monetary union would have had a minor effect on the volume of exports. In contrast, the domestic overheating of the late 1980s would have been seriously exacerbated. Low interest rates would have accelerated the growth of domestic demand which would have peaked in 1990 at a level roughly 3 % higher than what was actually experienced. Stronger growth would have added about 3 percentage points to the annual rate of inflation in late 1980s.

Starting in 1991, inflation would have turned to rapid deflation averaging more than 5 % a year. The resulting very high real interest rate would have cut domestic demand so that by the beginning of 1993, it would have reached the level actually prevailed at that time. By the end of 1994, exports would reach a level slightly higher and domestic demand slightly lower than what was experienced.

It is difficult to assess how plausible these results are. On one hand, it may be hard to believe that such a rapid deflation could have taken place. On the other hand, the Finnish economy has shown a quite remarkable capacity for nominal adjustment in the last couple of years; consumer price inflation fell below 2 % in 1993 despite a 30 % depreciation during the preceding two years. It is not altogether inconceivable to think that without such depreciation the country would have experienced a deflation.

As a whole, these simulation results fit quite nicely with those obtained earlier in this paper. The results point to a potentially destabilizing element of monetary union: When the economy is hit by a negative shock such that necessitates real exchange rate depreciation, then in the absence of exchange rate adjustment, inflation will have to slow or turn to deflation. As nominal interest rates cannot response, deflation is transmitted fully to real interest rates. Hence, during the price adjustment period, high real interest rates reinforce the downward pressure on domestic demand. This mechanism is, as most results obtained in this paper, sensitive to the estimated high price flexibility. As noted above, it is possible that a linear model, which implies the same degree of price flexibility downwards and upwards, is not a good approximation of reality. The historical relatively rapid upward reaction of domestic prices to devaluations may not be a sufficient basis for expecting equivalent downward flexibility in other circumstances.

7 Conclusions

In the first part of this paper, we review and evaluate the existing econometric work on the consequences of the European Monetary Union. Although the empirical work on the subject is abundant, it suffers from a narrow focus. Most of the research follow a highly simplistic empirical implementation of the traditional Keynesian theory of optimal currency areas in which the desirability of a currency union is measured by cross-country correlations of certain macroeconomic variables. We find the results obtained in those studies hard to interpret, and argue that — particularly when measured in a mixed exchange-rate regime as has prevailed in Europe — simple macroeconomic correlations do not convey any meaningful information about the desirability of a currency union.

In the second part we present an alternative approach to the empirical analysis of the topic. We construct a structural error-correction model to quantify the extent to which monetary autonomy has served to stabilize the real economy in Finland. This model is applied to analyze directly the consequences of Finland's possible entry into the European Monetary Union.

The results suggest that monetary autonomy has played some role in insulating the real economy from the effects of shocks. Particularly, the possibility to adjust the nominal exchange rate appears to have stabilized the real interest rate and, consequently, domestic demand. However, this role has been relatively small and, given the uncertainties involved, it is even possible that the effect has actually been negligible. Overall, we find no strong evidence to support a claim that monetary autonomy has served to significantly stabilize the Finnish economy.

At the end of the paper we run a counterfactual simulation for a scenario in which Finland enters into a monetary union with Germany at the beginning of 1988. The results suggest that such a union would have exacerbated both the overheating of the Finnish economy and the consequent slump at the beginning of the 1990s. By the end of 1994, both domestic demand and exports would have reached levels close to their actual values at that time.

The results depend on the high estimated price flexibility produced by our structural identification scheme. If prices were more rigid, the real effects of the loss of monetary autonomy would be more pronounced. Experiments with other identification schemes indicate that the estimated degree of price flexibility is, to some extent, sensitive to alterations in the structural identification. In other words, the data could be equally well explained by another model in which price flexibility is lower and the importance of monetary autonomy higher.

In general, this type of analysis requires the identification of the structural dependencies between the real and monetary sides of the economy. Since for every set of historical data there exists an infinity of structural parameterizations that fit the data equally well, this identification cannot be based on data alone; instead, economic theory and judgment must be applied. Any structural parameterization is necessarily the result of subjective choice and, as such, open to dispute. As we do not wish to claim that the parameterization applied here is necessarily the best possible, we would like to view this paper as much a methodological contribution as an attempt to predict the effects of monetary union.

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Appendix: Calculating the strucural form

The method we apply here to calculate the structural parameters is, in its basic approach, similar to that used by Gerlach et al (1995). However, since our model differs from theirs in several respects (most notably with respect to the existence of cointegration and the further decomposition of the contemporaneous effects) the approach must be tailored to suit the particular case. The idea is first to determine the structural shocks up to scale, then normalize them, and finally regress the reduced form errors on the structural shocks to obtain the structural parameters.

The identification of the structural parameters is based on the short-run relation

$$\Theta_0 u_t = \Lambda \varepsilon_t, \qquad \text{where}$$
$$\Theta_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & \theta_{25} \\ 0 & \theta_{32} & 1 & \theta_{34} & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}, \quad \Lambda = \begin{bmatrix} \lambda_{11} & 0 & \lambda_{13} & 0 & 0 \\ 0 & \lambda_{22} & \lambda_{23} & 0 & 0 \\ 0 & \lambda_{32} & \lambda_{33} & 0 & 0 \\ \lambda_{41} & \lambda_{42} & \lambda_{43} & \lambda_{44} & \lambda_{45} \\ \lambda_{51} & \lambda_{52} & \lambda_{53} & \lambda_{54} & \lambda_{55} \end{bmatrix}, \tag{8}$$

and on the long-run relation

$$B u_t = \Phi \varepsilon_t, \qquad \text{where}$$
$$\Phi = \begin{bmatrix} \phi_{11} & 0 & \phi_{13} & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & \phi_{45} \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} \end{bmatrix}. \tag{9}$$

We will denote the rows of matrix B by b_i and its elements by b_{ij} (and similarly for the other matrices).

We start by estimating the reduced form ECM and use the estimated parameter values to calculate the reduced form long-run matrix B. The two relations above imply that $B = \Phi\Lambda^{-1}\Theta_0$. Using the given representations for the right hand side matrices, the upper left element b_{11} can be solved to be equal to ϕ_{11}/λ_{11}. We will proceed as follows:

1. The first line of (9) can be written as

   $$b_1 u_t = \phi_{11} e_{1,t} + \phi_{13} e_{3,t}.$$

   Correspondingly, the first line of (8) is

   $$u_{1,t} = \lambda_{11} e_{1,t} + \lambda_{13} e_{3,t}.$$

   Multiplying the latter by $b_{11} = \phi_{11}/\lambda_{11}$ and deducting it from the former determines $e_{3,t}$ up to scale

   $$\begin{aligned} b_1 u_t - b_{11} u_{1,t} &= \phi_{11} e_{1,t} + \phi_{13} e_{3,t} - \phi_{11}/\lambda_{11}(\lambda_{11} e_{1,t} + \lambda_{13} e_{3,t}) \\ &= (\phi_{13} - \phi_{11}\lambda_{13}/\lambda_{11}) e_{3,t} \\ &\equiv \hat{e}_{3,t}. \end{aligned}$$

2. Still utilizing the first line of (8), regress $u_{1,t}$ on $\hat{e}_{3,t}$. The residual is the unscaled estimate $\hat{e}_{1,t}$ of $e_{1,t}$.

3. Solving (8) for u_t (ie premultiplying by Θ_0^{-1}) yields the coefficient $-\theta_{25}\lambda_{51}$ for $e_{1,t}$ in the equation for $u_{2,t}$ and the coefficient λ_{51} for $e_{1,t}$ in the equation for $u_{5,t}$. Hence, regressing $u_{2,t}$ and $u_{5,t}$ on $\hat{e}_{1,t}$ and dividing the coefficient from the first regression by the opposite of the coefficient from the latter regression gives us θ_{25} (since the e_i's are orthogonal, no bias is introduced by omitting other structural shocks from the regressions).

   The second line of (8) can be written as $u_{2,t} + \theta_{25}u_{5,t} = \lambda_{22}e_{2,t} + \lambda_{23}e_{3,t}$. Since the left hand side of that relation is now known we can regress it on $\hat{e}_{3,t}$. The residual is the estimate of $\hat{e}_{2,t}$.

4. Regress $u_{4,t}$ on $\hat{e}_{1,t}$, $\hat{e}_{2,t}$, and $\hat{e}_{3,t}$. The residual is the estimate of $\hat{e}_{4,t}$ (since $e_{4,t}$ and $e_{5,t}$ were identified by setting λ_{45} to zero).

5. Regress $u_{5,t}$ on $\hat{e}_{1,t}$, $\hat{e}_{2,t}$, $\hat{e}_{3,t}$, and $\hat{e}_{4,t}$. The residual is the estimate of $\hat{e}_{5,t}$.

6. Regress $u_{3,t}$ on $-u_{2,t}$, $-u_{4,t}$, $\hat{e}_{2,t}$, and $\hat{e}_{3,t}$. The first two coefficients are θ_{32} and θ_{34}. All the elements of Θ_0 are now known.

7. Calculate the structural errors by normalizing the vector $\hat{e}_t$:

$$e_t = \left(\sum_{t=1}^{T} \frac{\hat{e}_t \hat{e}_t'}{T} \right)^{-1/2} \hat{e}_t.$$

8. Regress $\Theta_0 u_t$ on e_t; the coefficient matrix is Λ. All structural parameters are now known.

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