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DENMARK

Selected Issues

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Approved by European Department

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I. Structural Reform in Europe: Cross-Country Spillovers and Adjustment[1]

A. Introduction

1. **To exploit the opportunities presented by globalization and the information technology revolution, the European Council at their March 2000 meeting in Lisbon called for a "radical transformation of the European economy" to make it more dynamic, flexible, and entrepreneurial.** Between 2000 and 2010, the Lisbon agenda calls for significant reform in European labor and product market regulation so that these economies can achieve their full potential in terms of employment and productivity growth. The package of labor market reforms introduced in 2003 in Germany is evidence of progress on the Lisbon agenda. Denmark, although further along the structural reform road in terms of labor and product market regulation than the major European economies, will undoubtedly benefit from further reform as well as experience significant spillover effects from the reforms implemented by its European neighbors. In this note, the IMF's new Global Economic Model (GEM) is used to provide some estimates of how large the benefits from reform might be. Further, the note considers what tensions, if any, many emerge in the Danish economy given its high degree of integration with the major European economies and its participation in ERM II.

2. **GEM is a large multi-country macroeconomic model derived completely from a choice-theoretic framework.[2]** Combining a multi-good structure of tradable and non-tradable goods with an optimizing foundation make GEM an extremely useful tool for examining issues of international interdependence. In addition, the model incorporates monopolistic competition in labor and goods markets. This means that wages can contain a markup over the marginal rate of substitution between consumption and leisure and prices can contain a markup over the marginal cost of production. Because the magnitudes of these markups proxy for the extent of the constraints on competition that reduce efficiencies in markets, the model is well suited for examining the macroeconomic implications of structural reform aimed at promoting competition. The conclusions drawn from GEM analysis are less susceptible to the Lucas Critique because it is a structural model incorporating rational expectations. Further, overlaying rational expectations with both real and nominal rigidities enables the model to approximate the short-run dynamic adjustment properties found in the data thereby providing valuable insights about the possible dynamic adjustment process resulting from reform.

3. **In the version of GEM used here, the world economy consists of three blocks that have been calibrated to represent Denmark, the euro area and the United States.**

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[1] Prepared by Ben Hunt.

[2] Specifically, GEM can be classified as a new open economy dynamic stochastic general equilibrium (DSGE) model at the forefront of macroeconomic model design. For a detailed description of GEM see Laxton and Pesenti (2003) and Hunt and Rebucci (2003).

The main focus of the calibration has been on the long-run equilibrium characterization of the three economies, particularly their trading relationships and the relative degrees of labor and goods market competition. Consequently, the focus of the analysis is on the medium- and long-term trends as opposed to the quarterly adjustment dynamics. Many of the model parameters that more directly affect the short-run dynamic adjustment properties are identical in all three blocks.[3] The version of GEM used for the analysis presented in this paper is outlined in the Appendix which contains a non-technical summary, information on the model's steady state calibration and the impulse responses from two standard monetary policy experiments. For a complete description of GEM's derivation, the specification of its structural equations and more detail on its dynamic adjustment properties the interested reader is directed to Laxton and Pesenti (2003) and Hunt and Rebucci (2003).

4. **GEM incorporates markups in goods and labor markets that are summary measures of the net impact of all the regulatory structure in an economy that influences competition and thus market efficiency.** In labor markets, the premium contained in the real wage that is in excess of the marginal rate of substitution between consumption and leisure depends on factors like minimum wage legislation, the generosity of unemployment insurance and welfare benefits, legislation that influences unionization and the wage bargaining process, profession licensing/qualification requirements and immigration policy. The effect of real wages containing a premium over the marginal rate of substitution is that firms will employ proportionally less labor and more capital resulting in higher unemployment and lower output. In goods markets, the premia contained in prices that are in excess of the marginal costs of production will depend on factors such as import licensing, quotas, product standards, public and private monopolies, administrative burdens and access to capital. Markups in goods markets result in prices being higher than they otherwise would be, output being lower and unemployment being higher. It is worth noting that labor and goods market markups are not necessarily independent. The existence of markups in goods markets, and thus the presence of economic rents, may induce rent seeking behavior on the part of workers leading to markups in labor markets.

5. **In summary, the analysis suggest that the potential benefits of structural reform in Denmark and the euro area aimed at reducing the markups contained in wages and prices are substantial.** Denmark, although much further along the reform road that the euro area on average, will still gain considerably because of the positive benefits that will arise from the reforms undertaken by its major trading partner. The simulation analysis suggests that the Danish government's target for a 2 percent increase in employment is possible if reform occurs in both labor and product markets. Finally, if as assumed here, more extensive reform must occur in euro area countries than in Denmark, maintaining the long-run trade balance will require adjustment in relative prices between the two areas. To achieve this

[3] A more detailed analysis of the short-run adjustment dynamics would undoubtedly be an interesting and worthwhile exercise that will hopefully be undertaken once time constraints allow.

under ERM II participation, Danish inflation must be higher than euro area inflation for a sustained period. Essentially, euro area demand for Danish goods will grow strongly and to maintain a fixed nominal exchange rate in a sustainable way, the capacity constraints in the Danish economy must be allowed to bind somewhat to generate the inflation that will equilibrate the trade balance in the medium term. Policymakers will need to be cognizant of this process and manage it carefully to avoid overshooting in relative prices and excessive volatility in real activity.

6. **The remainder of the note is structured as follows.** Section II presents some estimates of the relative efficiencies of goods and labor markets in Denmark and the euro area that are used to generate a baseline for the analysis. The estimates for Denmark and the euro area relative to the lowest estimates in the studies are used to calibrate the magnitude of the reduction in the markups that regulatory reform should aimed to achieve. However, it is worthwhile noting that the market structures in Denmark and the euro area countries that achieve these outcomes will be country specific as policymakers will craft their reform agendas to balance efficiency and social objectives in light of the unique cultures in their countries. Section III presents the GEM simulation results that estimate the impact of structural reform in the euro area and Denmark. Section IV offers some conclusions.

II. Estimates of Inefficiencies in Goods and Labor Markets

A. Goods Markets

7. **Markups exist when markets are not perfectly competitive.** Under perfect competition, profit maximization dictates that firms will produce output up to the point where the price they receive for it is just equal to its marginal cost of production. If the market produced less than this amount then there would be incentives for some firm to increase production or a new firm to enter. If the market produced more, then some firms would incur losses and they would either cut production of go out of business. However, if the regulatory environment was such that firms could restrict output without the threat of another firm entering or increasing their output, then consumers would compete for the scarce goods driving their prices up above the marginal cost of production and firms would earn economic rents. Consider the following simple price equation.

$$Price = (goods\_market\_markup) * (marginal\_cost\_of\_production) \quad (1)$$

Under perfect competition the *goods_market_markup* term above would be equal to 1. However, if firms were able to restrict output then excess demand would drive prices up and the *goods_market_markup* term would exceed 1.

8. **Some empirical estimates of the goods market markups in Denmark and the euro area are presented in Table 1 along with the lowest markup found in the study.**[4] Interestingly, the estimated markups in manufacturing in Denmark suggest that no further reform is required. The estimates suggest that manufacturing prices in the euro area, however, contain an additional 4 percent markup over marginal cost. In services, both Denmark and the euro area are estimated to have larger markups than the lowest in the study, with the additional markup in the euro area being roughly twice as large as that in Denmark.

Table 1. Estimated Markups in Goods Markets

	Manufacturing	Services 2/
Denmark	1.15	1.35
Euro Area 1/	1.19	1.42
Lowest	1.15	1.27

1/ The euro area markup is calculated as the GDP-weighted average of the estimates for France, Germany and Italy.
2/ Calculated by weighting markups across service by their value added.

B. Labor Markets

9. **Under conditions of perfect competition in the labor market, consumers will adjust their leisure-consumption bundle so that the marginal rate of substitution between consumption and leisure is equal to the real wage.** However, if the regulatory environment gives workers some monopoly power that enables them to restrict the supply of labor available to firms, real wages will rise above the marginal rate of substitution. Consider the following simple equation for the real wage.

$$\textit{Real wage} = \textit{(labor\_market\_markup)} * \textit{(the marginal rate of substitution)} \qquad (2)$$

Under conditions of perfect competition, the *labor_market_markup* term is identically equal to 1 and workers' real wage is equal the marginal rate of substitution between consumption and leisure. However, if workers have some monopoly power that enables them to restrict the labor supply, then firms must compete for scarce labor inputs, driving up the real wage above the marginal rate of substitution and the *labor_market_markup* term will be greater than 1.

[4] These are the estimates contained in Martins, Scarpetta and Pilat (1996). In this paper, the wedges between final goods prices and the marginal costs of production in a wide range of OECD countries are estimated directly using the methodology of Roeger (1995).

10. **Some empirical estimates of labor market markups are presented in Table 2.**[5] These estimates suggest that Danish labor market, while not quite the most competitive, is more competitive than those in euro area countries on average. These estimates appear to be consistent with the very high labor market participation rates found in Denmark.

Table 2. Estimated Markups in Labor Markets

	Economy wide
Denmark	1.20
Euro area	1.30
Lowest	1.16

III. The Impact of Reform

11. **In this section we consider the long-run and medium-term impact of reforms occurring in Denmark and the euro area that result in goods and labor market markups in those countries converging to the lowest levels found in the studies.** To implement this experiment, the parameters in the Denmark and euro area blocks that determine the markups are gradually reduced over roughly a ten year period until they converge to the lowest values. For the euro area this implies that the markup in the labor market falls from 1.30 to 1.16. In manufacturing the markup falls from 1.19 to 1.15 and in services from 1.42 to 1.27. In Denmark this results in the labor market markup falling from 1.20 to 1.16 and the price markup in services declining from 1.35 to 1.27. Again it is worth noting that each country's long-run market structures must reflect the balance of efficiency and social objectives that optimize social welfare given each country's unique preferences.

A. Simultaneous Reform in Denmark and the Euro Area

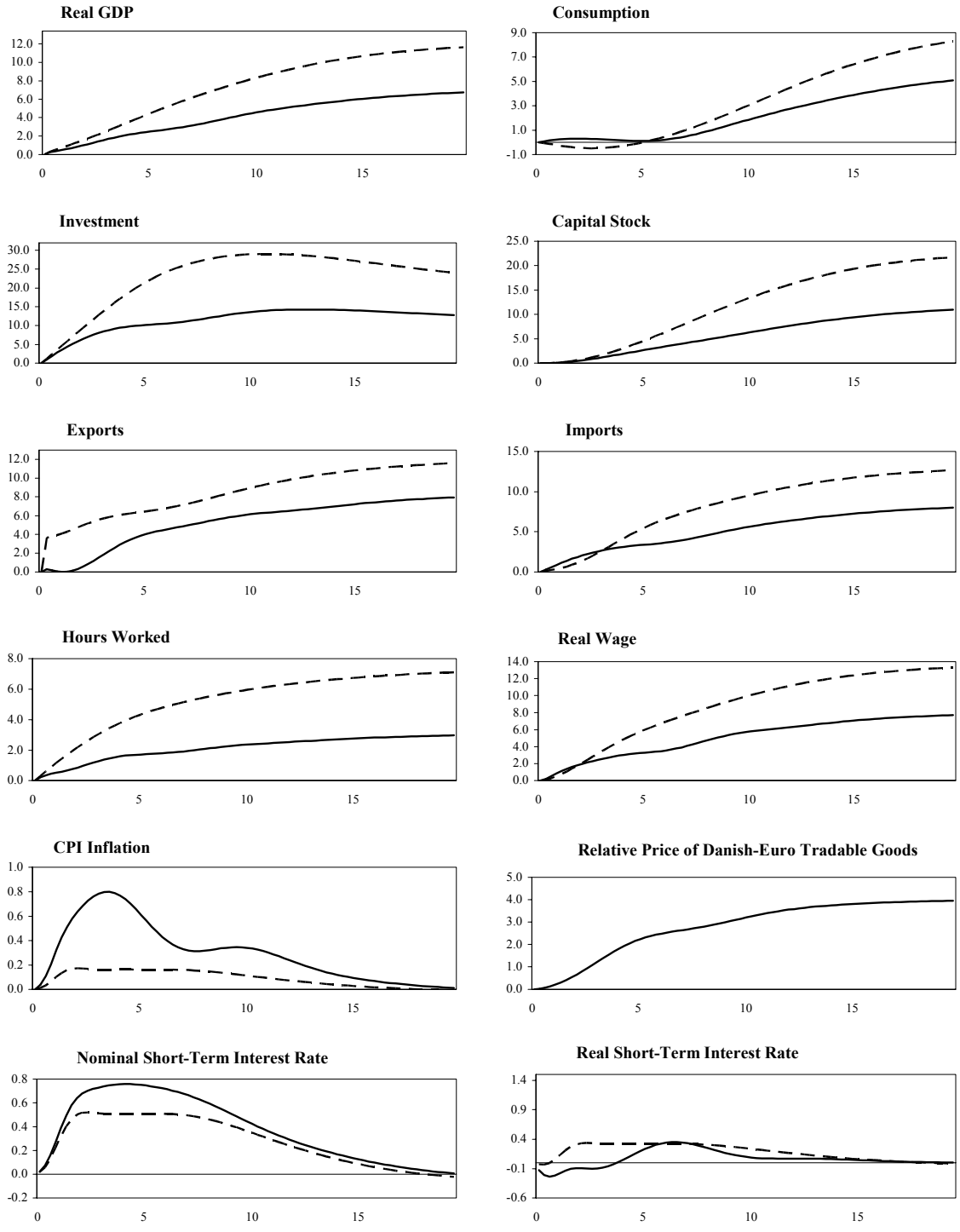
12. **The dynamic adjustment paths for several key macroeconomic variables in Denmark and the euro area are presented in Figure 1.** The results are presented in percent or percentage point deviation from a baseline path in which no structural reform occurs. The solid lines trace out the response in Denmark and the dashed lines trace out the response in the euro area. Table 3 presents the results for

Table 3. Impact of Simultaneous Reform in Denmark and the Euro Area (Percent deviation from baseline)

	5 Years	10 Years	Long Run
Denmark			
GDP	2.50	4.58	6.89
Hours worked	1.72	2.36	3.12
Capital stock	2.73	6.32	11.16
Euro Area			
GDP	4.48	8.34	11.76
Hours worked	4.34	5.95	7.36
Capital stock	4.68	13.36	21.67

[5] These estimates are based on empirical evidence in Jean and Nicoletti (2002). The markups are derived by comparing average economy wide wages to those in three sectors that are believed to have little if any markup owing to their highly competitive nature: textiles, worn apparel and leather. The labor market markups for the European economies are further adjusted as outlined in Bayoumi, Laxton and Pesenti (2003) for the bias introduced by the degree of public ownership.

Figure 1: Impact of Simultaneous Reform in Denmark and the Euro Area
(Percent or Percentage Point Deviations From Baseline)



Denmark = solid lines, Euro Area = dashed lines, x-axis in number of years

real GDP, hours worked and the capital stock after 5 years, 10 years and once all the adjustment to the reforms has been completed.

13. **The model simulation results suggest that once all the adjustment to reform is complete, Denmark's GDP will increase by almost 7 percent and euro area GDP will increase by roughly 12 percent.** The increase in GDP comes from two sources. The first is an increase in hours worked of roughly 3 percent in Denmark and 7½ percent in the euroTable 3 presents the results for real area. The second is an increase in the capital stock of 11 percent in Denmark and 22 percent in the euro area. Although the process occurs simultaneously, one can think of the reforms as having the following dynamic. First, changes in product market regulations spur competition driving down prices. This causes demand for final goods to increase leading firms to increase output by employing more capital and labor. Additional labor is attracted by increasing the real wage. The impact of regulatory reform in the labor market is to increase the supply of labor that, all else equal, firms can be encouraged to employ only through reductions in the real wage. However, the impact of product market reform dominates in both Denmark and the euro area and the net effect on the real wage is positive. The real wage rises by roughly 8 percent in Denmark and 14 percent in the euro area.

14. **After five years, approximately ⅓ of the increase in GDP is realized with 2/3 being realized after 10 years.** Initially the increase in hours worked contributes more to the increase in GDP than does the increase in the capital stock. After five years roughly 60 percent of the increase in hours worked has occurred with almost 80 percent complete after ten years. Because of the real costs incurred in adjusting the capital stock, only 20 percent of the increase in capital has occurred after five years with 60 percent of the increase complete after 10 years.

15. **One interesting aspect of the dynamic adjustment path is that the increases in the capital stock in both Denmark and the euro area are financed primarily by domestic savings.** Over the first five years of reform, consumption remains very close to the baseline path and the increase in output is used to build the capital stock as investment booms. Even after ten years, consumption has increased by only about ⅓ of its long-run increase. If consumers are less patient than these simulations suggest, then either the adjustment process will be slower, as households compete with firms for scarce resources delaying the accumulation of capital and the arrival of the associated benefits, or current accounts will go into deficit as resources are imported from abroad to be consumed and/or used to build the capital stock.

16. **Another interesting feature of the dynamic adjustment process is that a fairly significant and persistent inflation differential opens up between Denmark and the euro area over the first five years of the reform process.** This inflation differential arises because of Denmark's participation in ERM II and the different extent of the reform that is undertaken. Because the euro area undertakes more extensive reform resulting in a larger increase in real economic activity, maintaining its long-run trade balance given preferences for Danish goods requires that prices in the two economies adjust. Consequently, an inflation

differential must open up to so that Danish goods become relatively more expensive in the euro area, moderating demand and maintaining the trade balance in the long run. Essentially, strong euro area demand for Danish goods increases their prices. This result has a broader implication for the euro area as well. Given the different degrees of reform that must be undertaken across euro area countries, the experience of fairly significant inflation differentials since the introduction of the euro may continue for some time.[6]

B. The Impact of Own Reform Versus Spillovers in Denmark

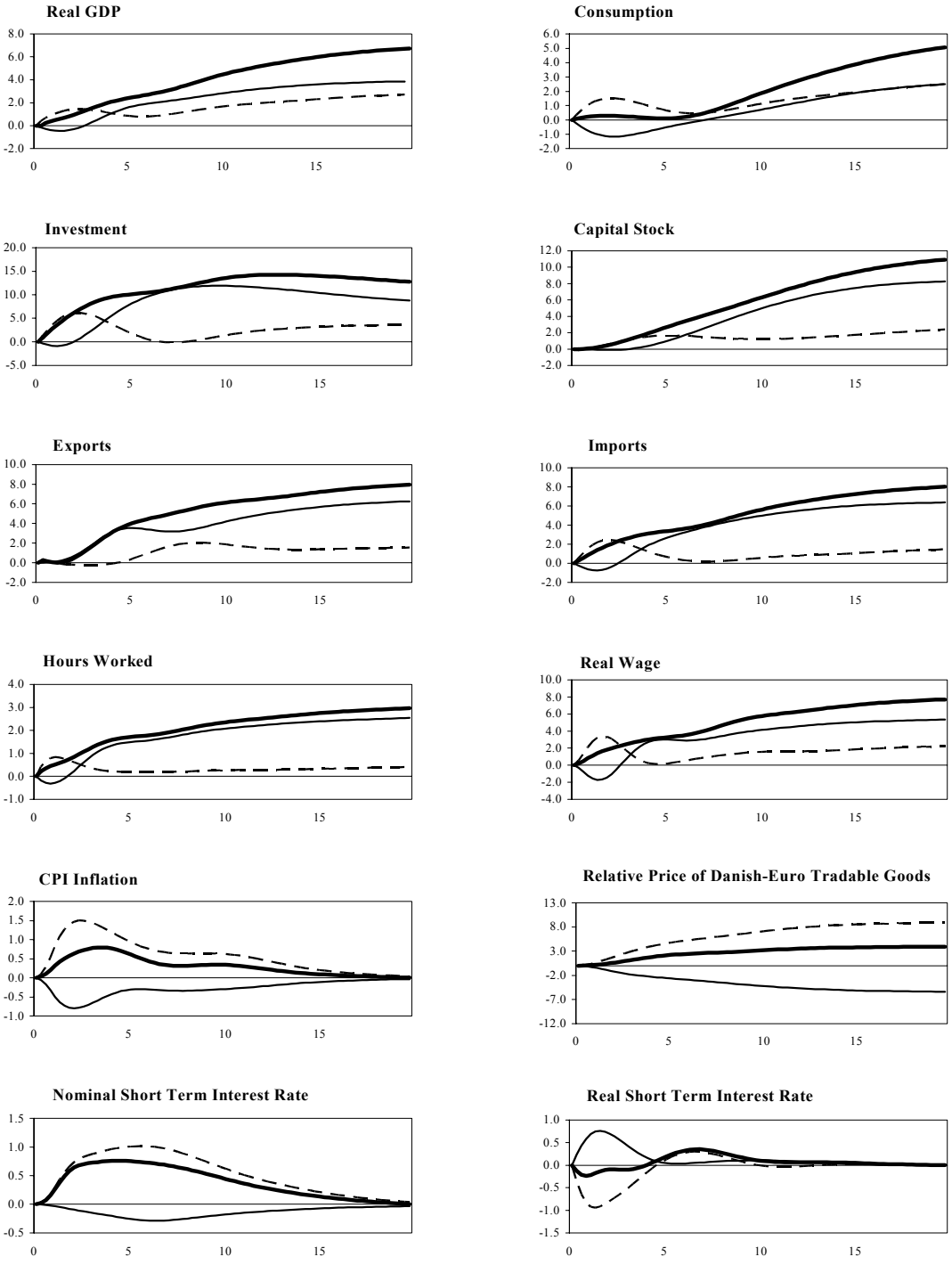
17. **Given that the levels of the initial markups in Denmark are estimated to be considerably lower than those in the euro area, one surprising aspect of these results is the large impact in Denmark.** The extent of labor market reform is more than three times larger in the euro area. Euro area goods market reform in the service sector is twice that required in Denmark and the euro area must also increase competition in manufacturing which is not required in Denmark. However, real GDP in Denmark increases by more than half of the percent increase in GDP in the euro area. The decomposition of the impact of the reform in Denmark presented in Table 4 and Figure 2 illustrates that Denmark receives large benefits from the reform undertaken by euro area countries. In Figure 2, the solid thick line traces the total impact of reform in Denmark, the thin solid line traces out the impact of own reform in Denmark and the dashed line the impact in Denmark of reform in the euro area.

Table 4. Decomposition of the Impact in Denmark of Simultaneous Reform (Percent deviation from baseline)

	5 Years	10 Years	Long Run
GDP			
Total	2.50	4.58	6.89
Own reform	1.62	2.83	3.90
Spillovers	0.84	1.67	2.85
Hours worked			
Total	1.72	2.36	3.12
Own reform	1.50	2.08	2.64
Spillovers	0.20	0.27	0.45
Capital stock			
Total	2.73	6.32	11.16
Own reform	1.04	4.99	8.13
Spillovers	1.67	1.20	2.74

[6] See Honohon and Lane (2002) for a detailed analysis of the dispersion in euro area inflation rates.

Figure 2: Decomposition of the Impact in Denmark of Simultaneous Reform
(Percent or Percentage Point Deviation from Baseline)



All reform = solid thick line, Denmark reform = solid thin line, euro area = dashed line, x-axis in years.

18. **In the long run, real GDP growth in Denmark increases by roughly 4 percent from own reforms and 3 percent from euro area reforms.** Almost half of the impact on real GDP comes from spillover effects that work through trade. As wealth increases in the euro area, demand for Danish exports increases. To maintain the equilibrium trade balance in the long run, the prices of Danish tradable goods must rise relative to the prices of euro area tradable goods making imports to Denmark cheaper and Danish exports more valuable resulting in a positive wealth shock for Danes. This leads to increased domestic demand as well and firms respond by increasing capital and labor driving real Danish wages up, further increasing wealth. Roughly 25 percent of the increase in the Danish capital stock comes from spillover effects. The labor market impact, however, is smaller with only 15 percent of the increase in hours worked due to spillover effects.

19. **It is worth noting that after 10 years, hours worked increase by just over 2 percent as a result of reforms undertaken in Denmark.** This is close to the Danish government's estimate of the increase in structural employment that is required by 2010 to keep fiscal policy on a sustainable path given the pressures arising from an ageing population.[7]

20. **When the euro are reforms alone, the inflation differential is much larger.** If Denmark does not implement reforms while the euro area does, inflation in Denmark is 1.3 percentage points above that in the euro area after two years and this differential only narrows to 0.8 percentage points after five years and 0.5 percentage points after 10 years. However, when Denmark reforms at the same time as the euro area, then the maximum inflation differential is roughly 0.5 percentage points over the whole transition path. This occurs because own reforms put downward pressure on inflation directly and the increase in demand for euro area goods resulting from the increase in wealth in Denmark implies that less relative price adjustment is required to maintain the trade balance in the long run. This suggests that managing the process of relative price adjustment under ERM II participation will be considerably less challenging if reforms in Denmark keep pace with labor and product market reforms implemented in the euro area.

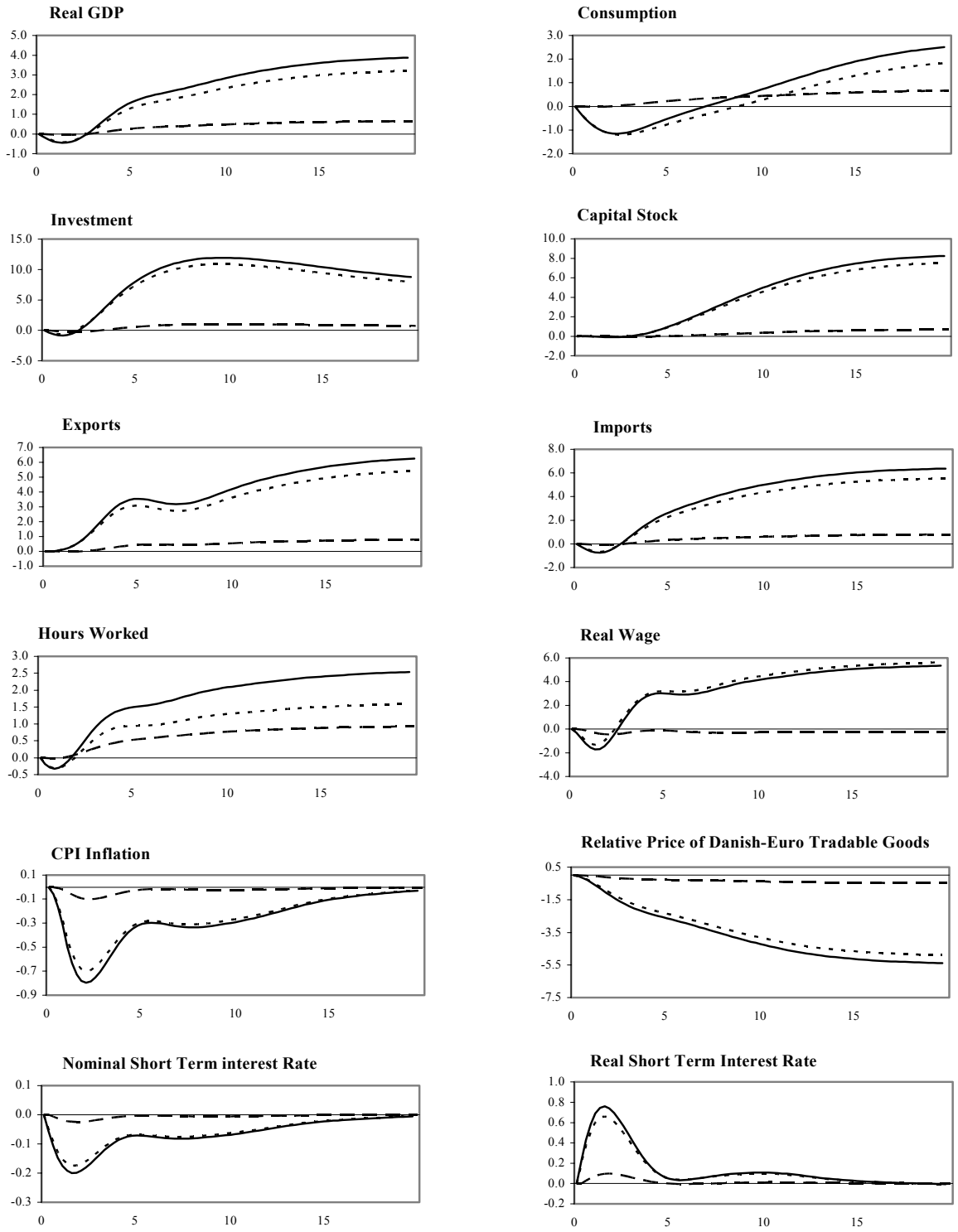
C. Impact of Goods Market versus Labor Market Reforms in Denmark

21. **Although markups in product and labor markets are not necessarily independent, it is interesting to look at the impact of these reforms individually.**[8] Figure 3 and Table 5 present the results from decomposing the effects of own reform in Denmark into those arising from labor market reforms and those arising from goods market reforms. The decomposition illustrates that the positive impacts on GDP, the capital stock

[7] See the Danish Ministry of Finance's 2003 Convergence Report.

[8] Markups in product and labor markets are likely to be interdependent because the existence of large product market markups may induce rent seeking behavior on the part of wage earners leading to labor market markups.

Figure 3: The Impact of Labor and Product Market Reforms in Denmark
(Percent or Percentage Point Deviation from Baseline)



Product and labor market = solid, product market only = dotted, labor market only = dashed, x-axis in years.

and the real wage largely arise from goods market reform. Even for hours worked, more than half of the positive impact comes from goods market reform. This result suggests that reforms in both labor and goods markets will be required for Denmark to achieve its targeted increase in employment by 2010. Further, labor market reforms on their own result in a fall in real wages because, all else equal, firms will be unwilling to hire the additional labor supply unless the real cost of labor declines. Simultaneously pursuing both goods and labor market reform will make the reform more popular with households since the net effect is an increase in real wages.[9]

Table 5. Impact of Labor and Goods Market Reforms in Denmark
(Percent deviation from baseline)

	5 Years	10 Years	Long run
GDP			
Total	1.62	2.83	3.90
Goods market	1.33	2.33	3.20
Labor market	0.30	0.49	0.68
Hours worked			
Total	1.50	2.08	2.64
Goods market	0.94	1.29	1.66
Labor market	0.55	0.78	0.97
Capital stock			
Total	1.04	4.99	8.13
Goods market	1.00	4.59	7.40
Labor market	0.03	0.38	0.69
Real wages			
Total	3.00	4.00	5.40
Goods market	3.14	4.31	5.70
Labor market	-0.12	-0.28	-0.27

D. Sensitivity and Robustness

22. **Although the estimates above provide a rough benchmark of the impact of structural reform in Denmark and the euro area, they should be thought of as an interesting starting point for discussion.** Considerable work still remains. These results are highly dependant on the calibration of the model. The calibration used here is quite simple and preliminary. In terms of the long-run impact, the calibration of many of the elasticities of substitution such as those between capital and labor, between labor and leisure, and between home and foreign produced goods will have a significant impact on both the effects of own reform and the magnitude of spillovers.[10] In terms of the dynamic adjustment paths, both the

[9] This result is also noted in Blanchard and Giavazzi (2003).

[10] See Bayoumi, Laxton and Pesenti (2003) for some sensitivity analysis of the impact of several key elasticities of substitution.

nominal and real frictions in the economy will determine how quickly the benefits from reform arrive and what tensions may emerge along the adjustment path. Looking ahead, it will be useful to generate a more careful calibration of the model to increase the degree of confidence in the estimates. Additionally, it will be desirable to ensure that the estimates are robust by conducting some careful sensitivity analysis around critical parameters for which there is a high degree of uncertainty about the appropriate value.

23. **Considering the implications of uncertainty about the pace of structural reform implementation will also be important.** The simulations examined here assume that private agents believe that the pace of structural reform will be maintained so that markups are reduced by the magnitudes considered over roughly a ten year horizon. However, if private agents only gradually learn about policymakers' commitment to the reform agenda then the benefits to reform may be slower to arrive than suggested here.

24. **The estimates of the magnitudes of the reform that should be implemented also embody a great deal of uncertainty.** In addition to the fact that these must be estimated from the data using several assumptions, the study from which the estimates of the goods market markups are taken is almost ten years old and likely outdated. Better estimates of the magnitudes of required reform would clearly enhance the credibility of the simulation analysis.

25. **The structure of GEM means that it cannot incorporate demographic issues that may have a significant impact on the macroeconomic spillovers to Denmark from euro area reform**. For example, there will likely be a need to increase saving in many euro area countries to fund the retirement of their aging populations. Because GEM is based on a representative agent framework, such effects cannot be accounted for in simulation analysis of the cross-country spillovers associated with structural reform. Consequently, the results presented may overstate the magnitude of the spillover effects if households in euro area countries increase their savings rates as the reform process unfolds.

26. **There is one critical sense in which the estimates presented in this note should be thought of as a lower bound of the impact of structural reform on economic activity.** The simulation analysis presented abstracts from productivity growth, the central driver of economic progress. Evidence presented in Nicoletti and Scarpetta (2003) indicates that more competitive labor and product markets are associated with faster productivity growth. It appears that increasing competitive pressures increases the incentives for both developing and adopting new technologies. Consequently, it can be argued that productivity growth will likely increase above what it would otherwise have been, resulting in larger benefits from reform than those estimated here.

IV. CONCLUSIONS

27. **In this note, the IMF's new macroeconomic model, GEM, has been used to provide estimates of the impact of successfully implementing the European Council's ambitious Lisbon reform agenda.** Although the results should be interpreted carefully

because the calibration of the model is quite preliminary, several interesting results emerged. First, if structural reform in both Denmark and the euro area successfully increases the efficiency in their labor and goods markets by the magnitudes considered, significant increases in real economic activity will be achieved. Although the empirical estimates of market inefficiency suggest that Denmark may have far less to gain than the euro area, the results imply that the gains in Denmark are in fact significant because of positive spillovers from the reform undertaken in the euro area. The results suggest that the Danish government's target of a 2 percent increase in structural employment by 2010 is achievable; however, labor market reforms alone may not be sufficient and the reform agenda should be focused on product markets as well. Not only will further product market reforms help achieve the employment objective, but their positive impact on real wages will make labor market reform more politically viable.

28. **Because of Denmark's participation in ERM II, any relative price adjustment required to maintain long-run trade balances must be achieved via an inflation differential with the euro area.** The results indicate that should reform in Denmark not keep pace with reforms in euro area countries, the required inflation differential could be large as well as persistent. Consequently, to minimize the magnitude of the relative price adjustment and thereby the required inflation differential, the pace of structural reform in Denmark should match that in the euro area. This is important because managing the macroeconomic cycle is a challenging task due to inherent uncertainties and it is reasonable to assume that the smaller is the required relative price adjustment, the lower will be the probability of overshooting in relative prices and excess volatility in real activity. This inflation-differential result also has implications for the euro area. Since the introduction of the euro, inflation differentials across euro area countries have, if anything, increased.[11] Given the fact that the various euro area countries require different levels of reform that will likely be pursued with different degrees of vigor, significant inflation differentials across euro area countries may persist for a considerable time.

[11] See Honohon and Lane (2002) for a detailed analysis of the dispersion in euro area inflation rates.

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Non-Technical Description of the Global Economic Model (GEM) Overview

GEM is a large multi-country macroeconomic model derived completely from optimizing foundations. The version of GEM used here, characterizes the behavior of three countries/blocks: Denmark, the euro area and the United States. In each country there are households, firms, and a government. Households maximize utility derived from the consumption of goods and leisure. Firms combine capital and labor to maximize the net income from the production of non-tradable and tradable intermediate goods. Firms also produce the final non-tradable good. Governments consume goods financed through non-distortionary taxes and adjust short-term nominal interest rates to provide nominal anchors.

Households

Households are infinitely lived, consume the non-tradable final good, and are the monopolistic suppliers of differentiated labor inputs to all domestic firms. Households exhibit habit persistence in their consumption behavior contributing to real rigidities in economic adjustment. Monopoly power in labor supply implies that the wages households receive contain a markup over the marginal rate of substitution between consumption and leisure. Because wage contracts are subject to adjustment costs, aggregate nominal rigidities arise through the wage bargaining process.

Households own all domestic firms and the domestic capital stock, which they rent to domestic firms. The market for capital is competitive. Capital accumulation is subject to adjustment costs that also contribute to gradual economic adjustment. Labor and capital are immobile internationally. Households only trade short-term nominal bonds internationally. These bonds are denominated in United States dollars and issued in zero net supply worldwide. There are intermediation costs for households entering the international bond market.

Firms

Firms produce three types of goods: non-tradable final goods, non-tradable intermediate goods, and tradable intermediate goods. Firms also provide financial intermediation services enabling households to trade in bonds. Intermediate goods are assumed to be differentiated, giving rise to the market power that enables firms to charge a markup over the marginal cost of production.

The final good is produced by perfectly competitive firms that use non-tradable and tradable intermediate goods (domestic and/or imported) as inputs. The final good can be consumed by domestic households or the government, or used for investment. The structure of final good production reflects the preferences of households and firms over all intermediate goods and, consequently, international trade is driven by the interaction of preferences and relative prices.

Intermediate goods are produced by firms under conditions of monopolistic competition. Consequently, prices contain a markup over marginal cost. Firms in the intermediate goods sectors combine capital and labor under Cobb Douglas technology.[1] Prices of intermediate goods are subject to adjustment costs that, along with slowly adjusting wages, give rise to the gradual adjustment of prices in response to economic disturbances. Intermediate non-tradable goods are used directly in the production of non-tradable final goods. Tradable intermediate goods are used either in the production of domestic non-tradable final goods or in the production of foreign non-tradable final goods.

Government

Government spending falls exclusively on final non-tradable goods. Government spending is financed through a non-distorting tax. The government controls the national short-term nominal interest rate with the objective of providing a nominal anchor for the economy. The nominal anchors in the United States and the euro area are inflation rates. For Denmark, the nominal anchor is stability in the nominal exchange rate between the Danish krone and the euro.

Parameterization

Currently, parameter values for GEM are derived through calibration.[2] Specific parameter values are determined by balancing several factors: empirical estimates available in the literature, the desired steady-state characterization of the economies, and the model's dynamic adjustment properties. In the calibration of the version of GEM used here, the focus has been primarily on the steady-state characterization of the economies, although some attention was also given to achieving some key dynamic adjustment properties. Appendix Table 1 presents the key steady-state characteristics achieved in calibration.[3] To provide a flavor for the model's dynamic adjustment properties, the model's impulse response to a one percentage point decline in the target rate of inflation is presented in Figure 1 and the model's response to a temporary increase in the short-term nominal interest rate is presented in Figure 2.

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[1] The model's production technology is actually the more general CES. For this application the elasticity of substitution between labor and capital has been set to unity yielding the special case of Cobb Douglas production.

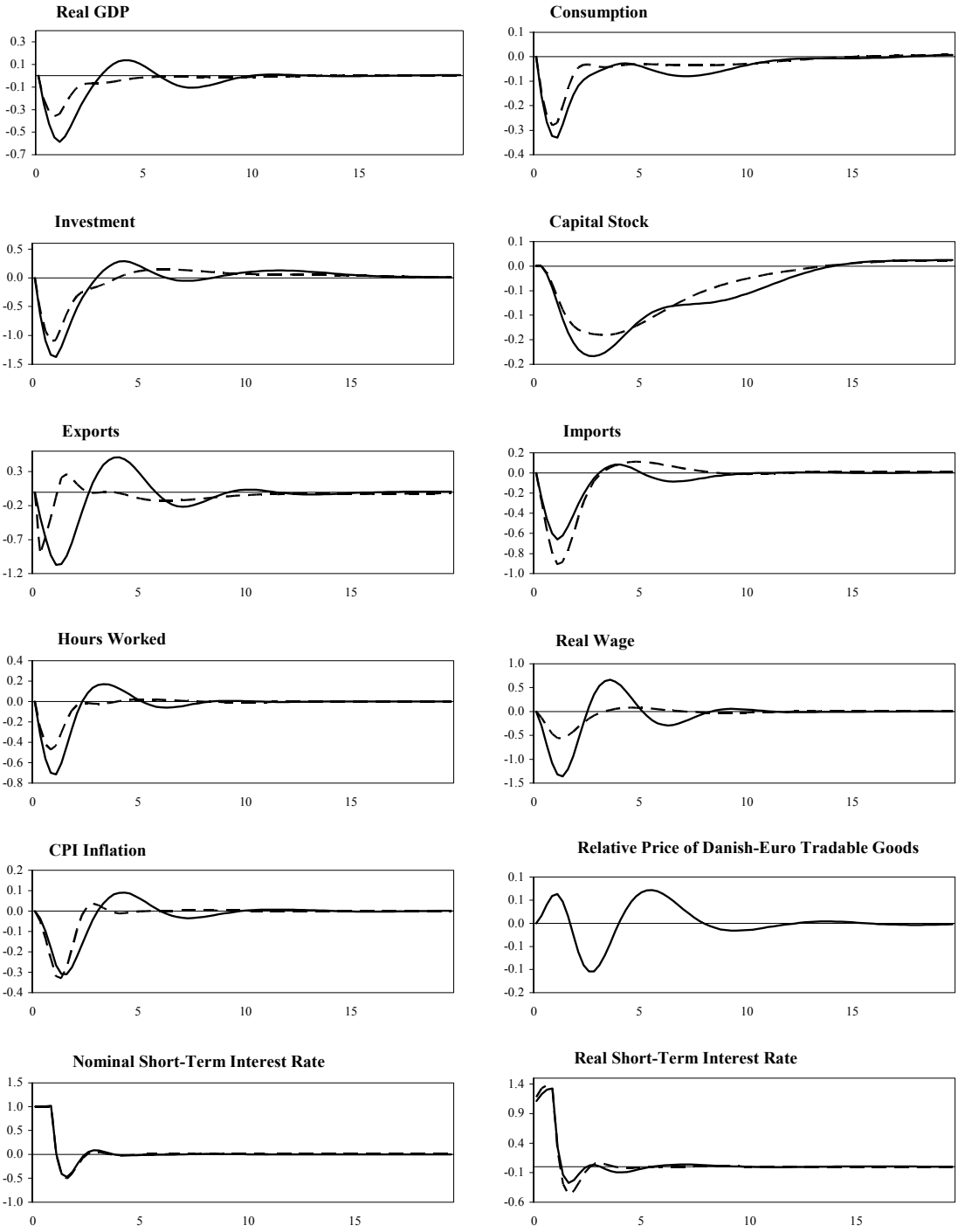
[2] Work is underway applying the Bayesian estimation technique employed in Smets and Wouters (2002) and outlined in Schorfheide (2002) to small versions of GEM to enhance the data coherence of the model's parameter values.

[3] Because the details of the model's structural equations are not presented in this note neither are the parameter values; however, all details are available from the author.

Table 1. Denmark: Calibration of the Steady-State

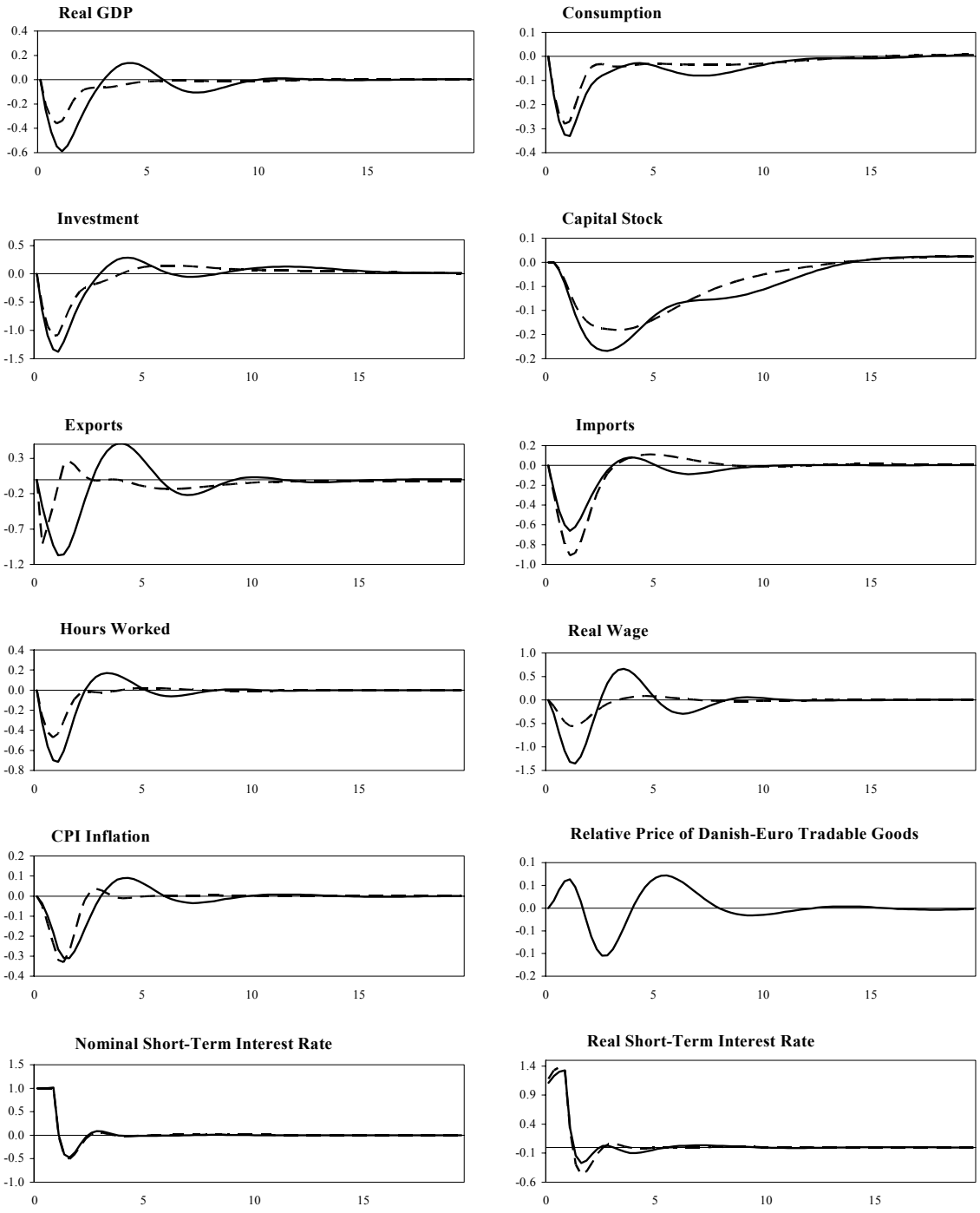
	Denmark	Euro Area	US
Size (sum to unity)	0.0083	0.4958	0.4959
Index of GDP per capita	3.89	4.01	5.29
Real exchange rate with US	0.79	0.76	n.a.
Private consumption as a share of GDP	0.58	0.58	0.66
Public consumption as a share of GDP	0.20	0.20	0.14
Investment as a share of GDP	0.22	0.22	0.20
Exports to Denmark as a share of GDP	n.a.	0.0040	0.0003
Exports to Euro Area as a share of GDP	0.26	n.a.	0.03
Exports to US as a share of GDP	0.02	0.03	n.a.
Non-tradables as a share of GDP	0.67	0.69	0.74

Figure 1: One Percentage Point Decline in the Euro Area Target Rate of Inflation
(Percent or Percentage Point Deviation from Baseline)



Denmark = solid lines, Euro Area = dashed lines, x-axis in number of years

Figure 2: One Percentage Point Increase in the Euro Area Nominal Short-Term Interest Rate
(Percent or Percentage Point Deviation from Baseline)



Denmark = solid lines, Euro Area = dashed lines, x-axis in number of years