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THE FINNISH GREAT DEPRESSION: FROM RUSSIA WITH LOVE*

Yuriy Gorodnichenko
UC Berkeley
and NBER

Enrique G. Mendoza
University of Maryland
and NBER

Linda L. Tesar
University of Michigan
and NBER

Current version: December 2008

Abstract

During the period 1991-93, Finland experienced the deepest economic downturn in an industrialized country since the 1930s. We argue that the culprit behind this Great Depression was the collapse of Finnish trade with the Soviet Union, because it induced a costly restructuring of the manufacturing sector and a sudden, large increase in the cost of energy. We develop and calibrate a multi-sector dynamic general equilibrium model with wage rigidities and labor market frictions. We show that the collapse of Soviet-Finnish trade can explain key features of Finland's Great Depression. We also show that Finland's Great Depression mirrors the macroeconomic dynamics of the transition economies of Eastern Europe. These economies experienced a similar trade collapse. However, as a western democracy with developed capital markets and institutions, Finland faced none of the large institutional adjustments that other transition economies experienced. Thus, by studying the Finnish experience we isolate the adjustment costs due solely to the collapse of Soviet trade, and we find that these costs go a long way into explaining the performance of transition economies.

JEL: E32, F41, P2.

Keywords: business cycles, depression, trade, Soviet, reallocation, multi-sector model.

***** The authors would like to thank participants of seminars at the University of Michigan, the UC Davis, UC Berkeley, UCLA, Wharton, "Macroeconomics across Time and Space" at the Federal Reserve Bank of Philadelphia, Western Michigan University, Society for Economic Dynamics, Olivier Coibion, Pierre-Olivier Gourinchas, Seppo Honkapohja, Wolfgang Keller, Lee Ohanian, Kei-Mu Yi, Christina Romer, Jeff Smith, and Jing Zhang.

I Introduction

Depressions have long been one of the central puzzles in macroeconomics. The massive costs as well as disagreement on sources and propagation of depressions fueled continuous interest in explaining these colossal events. We examine one of the modern day depressions, the Finnish Great Depression in the early 1990s, and shed new light on understanding other major depressions and mechanisms behind significant downturns in economic activity. The Finnish Great Depression is also particularly useful for understanding the reaction of a small open developed economy to trade shocks.

During the period 1991-93, Finland experienced the deepest economic slump in an industrialized country since the 1930s. As illustrated in Figure 1 (Panel A), between 1990 and 1993 real GDP declined 13 percent, real consumption declined 7 percent and investment fell to 45 percent of its 1990 level. Over the same period, Finland experienced a quadrupling of unemployment from slightly under 4 percent to a peak of 18.5 percent and the stock market lost 60 percent of its value.

We focus on a particular explanation of the Finnish Great Depression. We argue that the collapse of trade with the Soviet Union played a major role in causing the Depression, because it caused a costly restructuring of the manufacturing sector and a sudden, significant increase in the cost of energy. The barter-type arrangement between the USSR and Finland skewed Finnish manufacturing production and investment toward particular industries, and effectively allowed Finland to export non-competitive products in exchange for energy imports at an overvalued exchange rate. The demise of the USSR provides an exceptionally unique natural experiment when we know the timing, nature and size of the exogenous shock to the Finnish economy. Furthermore, unlike previous analyses of earlier depressions or downturns in developing economies, we have access to high quality economic data at different levels of aggregation and frequency.

We develop a multi-sector dynamic general equilibrium model that accounts for the key features of the Finnish Great Depression as the economy's responds to the collapse of trade with the Soviet Union. The calibrated model generates large declines in aggregate output, consumption and employment, and replicates the dynamics of the sector devoted to Soviet trade, the non-Soviet sector of tradable goods, and the nontradables sector. The deep, persistent recession follows from eliminating energy subsidy and specialized trade with a major trading partner. We find that a major chunk of the output drop in Finland can be explained by the collapse of the Soviet trade, which was largely a demand side shock. Our simulations suggest that downward wage rigidity observed in Finland played the key role in the amplification of the downturn. We validate the model using the “out-of-sample forecast” for the oil price hike in the 1970s and find the model performs well in terms of reproducing the dynamics of macroeconomic variables in this episode. We also use the experience of the Swedish economy, which went through a similar economic downturn in the early 1990s and is similar in many respects to the Finnish economy but did not extensively trade with the Soviet Union, to assess whether our quantitative predictions are broadly in line with this additional natural experiment when one country (Finland) was treated with the Soviet shock and the other country (Sweden) was not. Our findings from this comparison support our estimates from the model.

The impact of the trade shock on Finland is interesting in its own right, but it is especially compelling in light of the similar experiences of the Eastern European transition economies (TEs). Panel B in Figure 1 plots real GDP in the Czech Republic, Hungary, Poland, Slovenia, Slovakia, Bulgaria and Finland. The figure captures the familiar “U-shaped” path for output characteristic of TEs (Blanchard and Kremer 1997, Roland and Verdier 1999). With the exception of Poland, output declined between 1990 and 1993 in all TEs, and the magnitude of the cumulated output drop ranged from roughly 7 to 21 percent of the level of GDP in 1990. The most remarkable feature of the figure is that the adjustment path for Finnish GDP in the post-1990 period is virtually identical to those observed in the TEs.[1] Finland experienced the full force of the Soviet trade shock, but as a western democracy with developed capital markets and institutions, faced none of the institutional adjustments experienced in the TEs. Thus, by studying the Finnish experience we isolate the adjustment costs due solely to the collapse of trade from the other burdens of adjustment borne by TEs.

This analysis is of fundamental importance for understanding the macroeconomic performance of TEs. To the best of our knowledge, we provide the first quantitative assessment

[1] A number of papers have explored the possible impact of trade on output in transition economies. Shortly after the dismantling of the Soviet Union, Rodrik (1994) estimated that the collapse of trade with the USSR could account for a 7 to 8 percent decline in GDP in Hungary and Czechoslovakia and a 3.5 percent decline in Poland. At the time these papers were written, it was too early to characterize the transition path and U-shaped pattern of output resulting from the loss of trade, but Rodrik's work suggested that trade was a key factor in understanding the dramatic decline in output in 1990 and 1991. In Table E1, we use Rodrik’s method to compute the static cost of the Soviet trade collapse for Finland. The size of the shock is comparable to the Soviet trade shocks experienced by Eastern European transition countries.

of the significance of the trade shocks to explaining the downturn in these economies. Our results suggest that a significant part of the depressions in TEs could be due to severing trade links with and removing energy subsidy from the Soviet Union. Hence, to the extent the trade shock combined with standard macroeconomic reallocation costs and frictions accounts for a lump of the depressions in TEs, the role of other factors such as institutional transformations is significantly smaller than thought before.

The crisis in Finland has been examined in a number of previous studies. One view is that the origins of the Finnish depression were largely financial, working through the banking sector and ultimately triggering an exchange rate crisis (Honkapohja and Koskela 1999, Honkapohja et al 1996). Under this scenario, financial liberalization during the 1980s resulted in an over-expansion of credit, an over-valued stock market, inflated real estate values and a large stock of debt. A downturn in the economy in the early 1990s due to the loss of the Soviet export market and a slowdown in European growth triggered both a speculative attack on the currency and a credit crunch. Clearly these factors played a role but they are also more easily interpreted as symptoms rather than causes of the depression. Indeed, troubles in the financial sector followed the collapse of the Soviet trade rather than preceded it.[2] In any case, our analysis should not be interpreted as disregarding the importance of the financial frictions. We believe that the financial side of the economy played an important role; however, the focus of this paper is to examine how far a pure trade shock could go in explaining the Finnish Great Depression in a standard multi-sector business cycle model.

In the next section of the paper we describe important features of Finland's trading relationship with the USSR that are central to our argument. In Section III, we develop the dynamic model of the Finnish economy. In Section IV the model is calibrated using Finnish data before the collapse of Soviet trade. Then we hit the model economy with the shocks caused by the collapse of the Soviet Union, as once-and-for-all unanticipated shocks in a deterministic environment, and compare the model’s dynamics with the dynamics observed in the data. In section V, we compare our trade theory of the Finnish recession with alternative explanations proposed in the literature. In section VI, we compare the Finnish experience with the experience

[2] Real domestic credit, which had increased at a steady pace since the late 1970s, began to fall in 1992:1 and the exchange experienced a first initial depreciation in 1991:4, with a full currency collapse in 1993:1. Real GDP began contracting in the last quarter of 1990.

of TEs, and discuss how our conclusion for Finland can be extended to former Soviet bloc countries. We make concluding remarks in Section VII.

II Finnish-Soviet Trade

Finland and the USSR had a series of five-year highly regulated trade agreements, similar to the agreements between the USSR and its East European allies. These agreements established the volume and composition of trade between the two countries, and by the late 1980s they had evolved into a barter of Finnish manufactures for Soviet crude oil. In principle, trade was to be balanced annually, though arrangements were periodically made to allow for temporary imbalances.[3] These trade imbalances were subject of annual interim negotiations and were usually cleared on the Finnish side through supplemental exports above the agreed quotas or on the Soviet side by additional petroleum exports.

By 1975, the USSR was Finland's most important trading partner. Panel C in Figure 1 plots Soviet and non-Soviet exports over the 1975-2003 period. During the early to mid-1980s, the USSR accounted for 20-25 percent of Finnish trade flows. Thereafter, the volume of trade with the Soviet Union began to gradually decline until the collapse of the trade agreement. Part of the decline during the 1980s was an endogenous contraction, resulting from falling oil prices. The decline was also a consequence of the reforms under Perestroika, which attempted to decentralize Soviet decision making but made it difficult for Finnish authorities to identify those with real authority on the Soviet end of the bargain. The trade regime fully collapsed and all contracts with the Soviet Union were cancelled on December 18, 1990.

Roughly 80 percent of Finnish imports from the USSR in the early 1980s were in the form of mineral fuels and crude materials (Panel D, Figure 1). More than 90 percent of imported oil and 100 percent of imported natural gas came from the USSR. Under the terms of the bilateral agreement, the value of crude oil exports to Finland was determined by the dollar price of crude oil on the world market and then converted to rubles using the official ruble/dollar exchange rate. From the Finnish perspective, the volume of bilateral trade was thus a function of Finnish oil import demand given the world price of oil. During the oil crises of the 1970s, the oil-for-manufactures structure of trade provided Finland with a buffer against the cyclical

[3] See Mottola, Bykov and Korolev (1983) and Oblath and Pete (1990) for a more complete discussion of the history of trade relations between the USSR and Finland and the bilateral clearing system.

fluctuations experienced in most other industrialized countries. As oil prices rose, Finland was able to expand employment and production in those sectors exporting to the USSR to finance the higher cost of energy imports.

On the export side, the five-year trade agreements established explicit quotas for the export of manufactures to the USSR. While the total volume of exports was established by the bilateral trade agreement, the specific quantities and unit prices of the items to be exported was established through direct negotiations. Typically, trade associations conducted the negotiations, applied for export licenses from the Finnish government, and distributed the rights to export among their members. A key condition of the export license was an 80 percent domestic content restriction. The majority of exports to the USSR took the form of manufactured goods and machinery and transport equipment, which included the production of ships.

It was widely perceived that exporting to the USSR was a lucrative business for Finnish firms. Pre-commitment to the five-year contracts eliminated exchange rate and business cycle risk for firms. Surveys of managers and industry experts indicated that Soviet trade was a low risk, low cost, and long-term business. In a survey of the structural effects of Soviet trade on the Finnish economy, Kajaste (1992, p. 29) concludes that "[Soviet] exports seem to have been exceptionally profitable." More formally, Kajaste (1992) uses unit prices of Soviet and non-Soviet exports to and estimates that the prices of exports to the Soviet Union were at least 9.5 percent higher than those for exports to western markets. We find an even larger 36 percent markup when we replicate Kajaste's analysis using more recent trade data at 5-digit-level of disaggregation for 1990. These markup suggests that if a Finnish industry redirected its Soviet trade to other countries, its goods would be competitive only if sold at a 10 to 36 percent discount.[4]

[4] There are several reasons why the USSR was willing to overpay for Finnish goods. First, neutral Finland was the key source of modern Western know-how for the Soviet Union. For example, Finland supplied products with sensitive technologies such as deep-sea submersible, nuclear icebreakers, telecommunications equipment (Nokia), etc. Other countries had much tighter export controls against the Soviet bloc, with particular focus on blocking the transfer of technology. Second, the Soviet Union used the Finnish-Soviet trade as a lab for testing various forms of capitalist and socialist cooperation. Political leaders in Finland and the USSR viewed trade as a guarantee of peaceful co-existence. For example, Urho Kekkonen, the Finnish prime minister and president for three decades, wrote in 1974, "…our whole stable foreign policy course demands that we do keep the Soviet markets." Third, the Soviet subsidy was aimed at maintaining political status quo in Finland where left parties played an important role. A former leader of Soviet intelligence in Finland once wrote, "One can go to any lengths in thinking, whether Kekkonen was a Soviet 'agent of influence', but hardly anybody denies that the Finns had a president who pumped enormous amounts of economic benefit from Soviet leaders against short-term political concessions … and thus Finnish standards of living increased" (cited in Sutela 2007).

Finnish exports to the USSR were typically specialized for the Soviet market and did not compete directly with products traded in western markets. To assess the degree of specialization of the goods destined for the USSR, Kajaste (1992) computes the share of Soviet exports at 4-digit level of CCCN classification and finds strong concentration of trade. Once a good was exported to the East, more than 80 percent of all exports of this good went to socialist countries. At the more detailed 7-digit level, Kajaste (1992) identifies 133 items with a Soviet export share exceeding 90 percent. These items constituted approximately 40 percent of exports to the USSR. Kajaste (1992) reports that because of the highly specialized nature of goods traded with the CMEA bloc, the collapse of trade with the Eastern markets was compensated only to a very limited extent by redirecting trade to the West. The extent of specialization was such that firms' capacity developed for trading with the USSR became more or less obsolete overnight.[5][6]

Table 1 shows exports to the USSR by sector, as a share of sectoral exports and as a share of sectoral value added. The table focuses on the year 1988, before the uncertainties of Perestroika began to disrupt trade contracts. Among the sectors with heaviest Soviet-trade exposure were textiles, textile products, leather and footwear, with Soviet exports accounting for 29 percent of exports and 34 percent of value added. Machinery and equipment also had significant Soviet exposure at both the aggregate and disaggregated level. The sector with the heaviest exposure was transport equipment, and this exposure is further concentrated in shipbuilding (85 percent of exports designated for the USSR and 225 percent of value added) and railroad equipment (86 percent of exports to USSR and 103 percent of value added). A message of Table 1 is that while some manufacturing sectors were particularly specialized in goods destined for Soviet market, no sector was fully isolated from the loss of Soviet trade.

The collapse of Soviet trade was largely unanticipated. It was clear that the Soviet Union was under distress in the late 1980s, and that some Finnish companies faced difficulty in their

[5] The fact that Finnish exports to the USSR could have had a limited success in the West was clearly understood at the time. Urho Kekkonen, President of the Republic and a very active promoter of trade and economic cooperation with the Soviet Union, wrote in a private letter on 20 November 1972: "We must of necessity maintain a relatively large trade with the West, but of much importance is the fact that we are able to sell to the Soviet market in the main such goods that would be very difficult to market into the West." Cited in Sutela (2005).

[6] Another important aspect of trade with the USSR was industry concentration. Only 600 or so firms exported to the USSR in the 1970s, while more than 3,000 firms exported to Sweden (Sutela 1991). In 1989 the total number of Finnish exporters to the USSR was 1,688. The five largest exporters accounted for 39.9 percent of all exports, the fifty largest for 78.7 percent, 116 largest for 90 percent (Sutela 2005). This concentration of the Finnish-Soviet trade resembles trade within Council of Mutual Economic Assistance. Given this concentration, economies of scale were often cited as an important source of profitability in the Finnish-Soviet trade. The scale of production also often implies that firms are likely to be multi-product.

trade dealings with the Soviets. However, news articles and policy analyses from the period suggest that Finnish government officials and firms remained optimistic about the future of trade with the USSR.[7]

The collapse was quick and deep. Imports of oil from the USSR fell from 8.2 million tons in 1989 to 1.3 million tons in 1992. Exports tumbled down by 84 percent over the same period. Panel D in Figure 1 shows the exports of four industries that sent a significant share of their exports to the USSR (Cable and wire with the 1990 Soviet share of total exports of 30 percent; Railroad equipments with 96 percent; Shipbuilding with 74 percent; and Footwear with 43 percent).[8] In general, the loss of Soviet exports caused total exports to fall, suggesting that the goods were not redirected to other counties after the collapse of Soviet trade. After the collapse of trade with the USSR in December of 1990, entire industries had to be reorganized through the early 1990s. Even for industries that had some export recovery (e.g., shipbuilding), the loss of the Soviet market was painful as it involved major transformations in product lines. The strategy of "icebreakers for the communists, luxury liners for the capitalists" meant that production facilities specialized for Soviet production had to be shut down.[9]

To fully understand the reaction of the Finnish economy to the collapse of the Soviet trade, one must carefully examine the Finnish labor market which is characterized by almost complete unionization. In 1993, approximately 85 percent of workers belonged to unions and almost 95 percent of workers were covered by collective agreements (Böckerman and Uusitalo, 2006). Since most employers are organized in federations, the wage bargaining normally starts at

[7] For example, in July 1990 the Wall Street Journal reported that Finnish Premier Harri Holkeri was surprised by the announcement that the Soviet Union would end the bilateral agreement in December, earlier than was originally planned. A representative of the central bank suggested that it was still possible that the system would be reformed, and not fully dismantled. The private sector was equally surprised by the collapse of the Soviet trade. For example, Nokia remained confident that sales to the Soviet Union would continue at their mid-1980 levels. Nokia's sales to the USSR came in at just 2 million markka instead of projected 121 million markka. More broadly, Jonung (2008) argues that professional forecasters failed to predict the timing and later the depth of the coming recession.

[8] The shares of Soviet exports in total exports for reported industries were 30 percent for cable and wire, 96 percent for railroad equipments, 74 percent for shipbuilding, and 43 percent for footwear.

[9] Sutela (1991) provides a case study of the shipbuilding industry in Finland. Finnish shipbuilders had supplied the Soviet Union since 1940s. The major companies were Valmet (state-owned), Repola, Wartsila, and Hollming. Hollming was the only one of these firms specialized in shipbuilding. The other companies were large corporations with a broad nomenclature of products. Historically shipyards fared well in terms of profits and accumulated a unique know-how in the industry. For example, most icebreakers operating in the world were produced in Finland. With the collapse of the Soviet Union, the shipyards were in deep trouble. Policymakers and business circles were openly discussing whether the Soviets would allow these companies to go bankrupt. Valmet's shipbuilding operations were sold to Wartsila, which knowingly took orders for loss-making luxury cruises (another field of specialization) for the Caribbean, underestimated domestic cost increases and declared its shipbuilding branch insolvent. The new company established upon the ruins of Wartsila-Marine was later sold to a Norwegian company.

the national level. If a federation or union rejects the nation-wide agreement, it can negotiate its own terms. Collective agreements stipulate the wages for different levels of job complexity, education, etc. in a given industry. Typically, agreements allow upward wage drift if firms perform well. Although the government does not have a formal role in the bargaining process, the government usually intermediates negotiations.[10] Not surprisingly, Finland is often classified as a country with highly centralized wage setting (e.g., Botero et al 2004).

Unions did not agree to cut nominal wages in 1992-1993, which were the peak years of the depression.[11] Instead, wages were frozen at the 1991 level. Figure 3 reports the distribution of wage changes over 1990-1994 for individual workers. There is a clear spike at zero percent change for most types of workers in 1992 and 1993.[12] Strikingly, the fraction of workers with no wage change reached 75 percent. Thus, the national agreement was binding for a broad array of firms and workers. Given that inflation was quite moderate in the 1990s, real wages fell only to a limited extent. These findings are consistent with Dickens et al (2007) who cite Finland as the country with one of the greatest downward wage rigidities.

As we will report later, the dynamics of wages at the macro level are similar to the dynamics of wages at the micro level. Specifically, wages at the aggregate level had a very weak downward adjustment during the Finnish Great Depression. Our micro level evidence strongly suggests that very sluggish adjustment of wages at the aggregate level reflects genuine wage rigidity rather than compositional changes in employment. We conclude that wage stickiness was a prominent feature of the Finnish labor market during the depression.

III Model

In this section we develop a model of the Finnish economy that captures the key features of the trading relationship between the Soviet Union and Finland as well as the Finnish labor market. These features include the volume of trade, the composition of trade (barter of manufactures for oil), overvalued terms of trade, low elasticity of substitution between goods destined for the Soviet market and western markets, and rigid labor markets.

[10] See Snellman (2005) for a more detailed description of the wage bargaining process in Finland.
[11] Table E2 provides a summary of wage agreements in the 1990s.
[12] There is more variability in wage changes for manual workers. We should note that the distribution of wage changes for manual workers in 1992-1993 is similar to the distribution of wages changes in other year. In part, this distribution reflects the fact that earnings of manual workers are more variable due to changes in hours worked. Changes in wage rates are much more downward rigid (see Snellman, 2004).

We model the Finnish economy as a small open economy with three sectors. Sector 1 (non-Soviet sector) produces a traded good consumed at home and sold abroad in western markets. Sector 2 (Soviet sector) produces a good that can be consumed at home or sold exclusively to the Soviet Union. Sector 3 (services) produces non-tradable goods.

Households

The representative household chooses a lifetime plan for consumption and leisure to maximize utility $U \equiv \sum_{t=0}^{\infty} \beta^t U(G_t, L_{1t}, L_{2t}, L_{3t})$, where G is a CES consumption aggregator over four consumption goods: C_{1t}, consumption the good produced by sector 1, C_{2t}, consumption of the good produced by the sector with Soviet exposure, C_{3t}, consumption of services and C_{4t}, a good imported from the western markets, L_{it} for i=1,2,3 is labor supplied to each sector.[13] We assume that the consumption aggregator is given by $G_t = \{\zeta_1 \overline{C}_{1t}^{\rho_C} + \zeta_2 \overline{C}_{2t}^{\rho_C} + \zeta_3 \overline{C}_{3t}^{\rho_C} + \zeta_4 \overline{C}_{4t}^{\rho_C}\}^{1/\rho_C}$ where $1/(1-\rho_C)$ is the elasticity of substitution in consumption, ζ_j are weights in the consumption aggregator. In a more general specification we allow for habit formation in consumption.

To eliminate wealth effects on labor supply, we follow Greenwood, Hercowitz and Huffman (1988) and assume $U(G_t, L_{1t}, L_{2t}, L_{3t}) = \frac{1}{1-\sigma}\left(G_t - \frac{\chi_1}{\eta_1+1} L_{1t}^{\eta_1+1} - \frac{\chi_2}{\eta_2+1} L_{2t}^{\eta_2+1} - \frac{\chi_3}{\eta_3+1} L_{3t}^{\eta_3+1}\right)^{(1-\sigma)}$ where σ is the elasticity of intertemporal substitution, $1/\eta_j$ is the Frisch elasticity of labor supply in sector j and χ_j is the scale of disutility from working in sector j. In the benchmark version of the model we assume that labor is sector specific and hence wages are not generally equalized across sectors. Aggregate labor supply is $L_t = L_{1t} + L_{2t} + L_{3t}$. In robustness exercises we examine the case of a high elasticity of substitution between labor services allocated to different sectors.[14]

Households face the following budget constraint:

$$w_{1t} L_{1t} + w_{2t} L_{2t} + w_{2t} L_{2t} + B_{t+1} - R_t B_t - C_{1t} - p_{2t} C_{2t} - p_{3t} C_{3t} - p_{4t} C_{4t} = 0, \qquad (1)$$

[13] The fourth consumption good plays no role in the dynamics but allows us to calibrate the model to reflect positive imports from Western markets.

[14] We had a modeling choice between having sector specific labor supply and having decreasing returns to scale in production. These two options ensure that the production possibility frontier is concave and hence the model economy does not fully specialize (see Baxter (1992) for more details on linearity/concavity of the production possibility frontier for economies where inputs can be accumulated). It was common in Finland that different units of firms produced goods for different markets (i.e., Soviet, non-Soviet, non-tradable). In our analysis we study the effects of the Finnish-Soviet trade collapse using synthetic sectors (i.e., Soviet, non-Soviet, non-tradable) constructed from disaggregate industry level data. Hence, we prefer sector specific labor supply because it allows straightforward aggregation of firms producing different goods (i.e., Soviet, non-Soviet, non-tradable) into sectors.

where w_j is the wage rate in sector j = 1,2,3, B_t is a one-period discount bond traded on international markets at the gross world interest rate of R.[15]

Production

Firms in all three sectors use inputs of capital (K), labor and energy (E) to produce final output. The problem faced by a representative firm in each industry is to choose factor inputs to maximize profits. In sector j = 1,2,3, a representative firm solves the following problem:

$$\sum_{t=0}^{\infty}\frac{1}{\prod_{s=0}^{t}R_s}\left(p_{jt}Q_{jt}-p_t^E E_{jt}-w_{jt}L_{jt}-p_{jt}(K_{jt}-(1-\delta)K_{j,t-1})-p_{jt}\frac{\phi_j}{2}(\frac{K_{jt}}{K_{jt-1}}-1)^2 K_{jt-1}\right), \quad (2)$$

where δ is the rate of depreciation of the capital stock, ϕ is a capital adjustment cost coefficient,, I is investment, and p_j is the price of goods in sector j (we take good 1 as numeraire so p_{1t} = 1) and p^E is the price of energy. In a more general specification we allow for adjustment costs in investment and labor.

Production functions are given by $Q_{jt}=\min\{a_{jE}E_{jt},(\alpha_{jK}K_{j,t-1}^{\rho_P}+\alpha_{jL}L_{jt}^{\rho_P})^{\gamma_j/\rho_P}\}$, for j=1,2,3, where a_{jE} is the energy requirement in sector j, $1/(1-\rho_P)$ is the elasticity of substitution between capital and labor, α_{jK} and α_{jL} are weights in the capital-labor aggregator, and γ_j is returns to scale in sector j. We assume that energy input and value added are perfect complements to capture the fact that the ability of firms to substitute energy is very small in the short run. At an optimum, no input is wasted so $a_{jE}E_{jt}=Q_{jt}$. For convenience define value added as $Y_{jt}\equiv p_{jt}Q_{jt}-p_t^E E_{jt}=(p_{jt}-\frac{p_t^E}{a_{jE}})Q_{jt}$ and the corresponding value added function as $F_j(K_{j,t-1},L_{jt},p_{jt},p_t^E)\equiv Y_{jt}$. Note that for simplicity the three sectors do not have direct linkages via input-output relationships.

Market clearing conditions

In each sector, output is consumed, invested or exported:

$$Q_{1t}-C_{1t}-I_{1t}-X_{1t}=0, \quad (3)$$

[15] In some specifications of the numerical simulations we allow for returns to scale to be less than one, where economic profits from sector j (paid to households) are $\pi_{jt}=Y_{jt}-w_{jt}L_{jt}-(\delta+R)p_{jt}K_{jt-1}$. Profits in that case are rebated to the household.

where X_1 is the net export of the non-Soviet good. In the non-Soviet sector, output is consumed by domestic consumers, invested in sector 1 or exported to western markets in exchange for energy imports, M^*, at world prices p^* and good C_4:

$$TB_t = X_{1t} - p_t^* M_t^* - p_{4t} C_{4t} = B_{t+1} - R_t B_t. \qquad (4)$$

In the Soviet sector, a fraction of output is consumed by domestic consumers, invested in sector 2, or sold to the Soviet market in exchange for energy:

$$Q_{2t} - C_{2t} - I_{2t} - X_{2t} = 0, \qquad (5)$$

where X_{2t} is the export to the USSR. To capture the clearing system in the Finnish-Soviet trade, we assume that the trade with the Soviet Union is balanced at all times:

$$p_{2t} X_{2t} - p_t^S M_t^S = 0, \qquad (6)$$

where p_t^S is the price of oil from the Soviet union. M_t^S is imports of energy from the USSR. Values of p_t^S and M_t^S are fixed, set by the five-year agreements between Finland and the USSR.

We assume that Finland produces no energy domestically and energy is not storable so that import of energy is equal to consumption of energy:

$$M_t^* + M_t^S - (E_{1t} + E_{2t} + E_{3t}) = 0. \qquad (7)$$

Wage determination

To close the model, we need to specify how reservation wages are related to wages faced by firms. To capture slow adjustment of wages, we assume that real wages evolve as follows:

$$w_{1t} = \theta_1 w_{1,t-1} + (1-\theta_1) w_{1t}^D, \qquad (8)$$

$$w_{2t} = \theta_2 w_{2,t-1} + (1-\theta_2) w_{2t}^D, \qquad (9)$$

$$w_{3t} = \theta_3 w_{3,t-1} + (1-\theta_3) w_{3t}^D, \qquad (10)$$

where the parameter θ governs the degree of wage stickiness, w^D is the reservation wage given by the household labor supply. A possible interpretation of these dynamics is that trade unions take the wage in the previous period as a starting point in bargaining ("status quo" wages) and gradually change the wage to increase the employment of union workers. Specifically, $\theta = 1$ corresponds to complete real wage rigidity, while $\theta = 0$ corresponds to complete real wage flexibility. Regardless of θ, $w_j^D = w_j$ in the pre-Soviet-collapse steady state.

IV Quantitative Analysis

Data

One of the challenges in mapping the model to the data is that the pervasiveness of Soviet exports throughout the manufacturing sector makes it difficult to separate out a "Soviet" sector from a "non-Soviet" sector. In the model, the trade shock will be concentrated in sectors with heaviest exposure to Soviet trade. In the data, the "Soviet-exposed" sector will be defined as a weighted index of industrial sectors. We define ω_{it}^{X} as the share of exports of industry *i* at time *t* to the Soviet Union in total exports of industry *i*. Let Q_{it} be value added (or any other the variable of interest) in industry *i* at time *t*. Then we compute value added in the Soviet-exposed sector as $Q_t^S = \sum_i \omega_{it}^X Q_{it}$ and correspondingly the non-Soviet-exposed sector is $Q_t^{NS} = \sum_i (1-\omega_{it}^X) Q_{it}$. We treat services as a separate sector producing non-tradable goods. We allow the weights, ω_{it}^{X} , to change over the 1989-1992 period. The relative size of the Soviet sector will therefore decline automatically as trade with the USSR collapses.

We provide details on data sources and construction of sectors in the data Appendix B. We take 1989 as the "pre-collapse" benchmark year. Based on this definition, Table 2 shows the share of the Soviet sector in total value added, capital/labor ratios, employment and output shares as well as other descriptive statistics in the base year.

Calibration

The model is calibrated at a quarterly frequency. The quarterly deprecation rate of capital is the same across sectors and equal to $\delta = 0.025$ (i.e., approximately 10 percent at the annual frequency). The discount factor is $\beta = 0.99$ so that the real rate or return is 4 percent per annum, assuming the standard stationarity condition that equates the rate of interest with the rate of time preference. We also calibrate the intertemporal elasticity of substitution as $\sigma = 2$, the standard value in the RBC literature.

Micro level studies favor very large values for η, so that the labor supply elasticity $1/\eta$ is small. On the other hand, macro level models need relatively large labor supply elasticity to generate large movements in labor. Recently, Hall (2007) provided empirical evidence indicating that the elasticity is about 0.91 in the United States. In line with this evidence, we set $\eta = 1$.

We assume unit elasticity of substitution in consumption, i.e., $\rho_C = 0$. Given this assumption, consumption shares can be computed from the input-output matrices which provide us with the information on consumption expenditures by sector. We find that $\zeta_1 = 0.04; \zeta_2 = 0.15; \zeta_3 = 0.54; \zeta_4 = 0.27$.

Our baseline calibration assumes that the production function is Cobb-Douglas (i.e., $\rho_P = 0$). In this case, we can read the α_{jL} from the labor shares in sector *j*. In 1989, shares of labor compensation in value added were $\alpha_{1L} = 0.57$, $\alpha_{2L} = 0.63$ and $\alpha_{3L} = 0.63$ for the non-Soviet, Soviet, and service sectors respectively. Empirical studies tend to find that the elasticity of substitution between capital and labor is smaller than one. Thus, we also experiment with $\rho_P = -1$, which implies 0.5 elasticity of substitution between capital and labor.

In our baseline calibration, we assume that the production functions in all sectors have constant returns to scale. Rotemberg and Woodford (1995) and Basu and Fernald (1997) argue that the share of economic profits in the US economy is about 3 percent, which implies that returns to scale are approximately 0.97. Given that Finland has more concentrated industries, the share of economic profit should be larger. In alternative calibrations, we consider returns to scale equal to 0.95.

We define units of oil in such a way that the unit price of oil before the collapse of the Soviet Union is equal to one (i.e., the price of the numeraire). Because energy and value added are Leontieff complements, the energy requirement in the non-Soviet sector is given by $a_1 = Q_1 / E_1 = p_1 Q_1 / p^E E_1$. Since we know the cost structure (specifically expenditures on energy), we can compute energy requirement for the non-Soviet sector as the ratio of cost (value added plus energy expenditures) to energy expenditures. For the non-Soviet sector this ratio is equal to 21.56. For other sectors, we cannot make this calculation directly because it depends on prices determined in equilibrium. We can impute the relative prices using cost shares for labor, capital labor ratios and relative wages and then compute energy intensity for the Soviet and service sectors: $a_2 = 37.84$ and $a_2 = 47.51$. These parameter values imply that the share of Soviet exports in total exports is approximately 18 percent, which is consistent with observed share in the data.

Using information on employment shares and relative wages, we can calculate ratios $\chi_2/\chi_1 = 4.127$ and $\chi_3/\chi_1 = 0.324$. Because utility is Cobb-Douglas and we need only total expenditures on imported good C_4, we set $p_4 = 1$ without loss of generality. Since χ_1 regulates only the scale of the economy, we set without loss of generality $\chi_1 = 0.4$. Since more than 90 percent of energy was imported from the USSR we assume that in the pre-Soviet-collapse period no energy was imported from other countries. We assume small to moderate adjustment costs in capital stock $(\phi_1 = \phi_2 = \phi_3 = 1)$. We provide more details on calibration in Appendix.

As we have discussed above, wages in Finland are downward rigid and wage adjustment in the early 1990s was very slow. Indeed, we do not observe large movements in real or nominal wages in Finland over the 1990s (see Appendix Figure 3). In light of these facts, we set $\theta_1 = \theta_2 = \theta_3 = 0.99$, which corresponds to the maximum annual decline of real wages equal to 4% and approximately matches the 1-2% decline of real wages during the depression. By setting this high value of wage rigidity we want to capture downward wage rigidity in this particular historical episode since we anticipate that wages in our model will have to fall in response to shocks.

Simulating the Effects of the Soviet Trade Collapse: Benchmark results

We study the response of the Finnish economy to the collapse of trade with the Soviet Union, modeled as a once-and-for-all unanticipated event in a deterministic environment. As we explained, this event produced two shocks for Finland. First, Finland lost one of its major export markets, and because of the specialized trade with the USSR Finnish firms could not easily redirect trade to other countries. We model this shock as a permanent drop in X_{2t} to zero. This also implied, however, that "cheap" Soviet oil imports M_t^S vanished as well. Hence, the second shock was the end of the Soviet Union's provision of subsidized energy for Finland. Our discussion in Section II suggests that this subsidy was at least 10 percent of the world oil price. Thus we assume that the second shock was equivalent to an increase in the oil price from $p^E = 1$ to $p^E = 1.1$. We hit our model economy with these shocks as of the initial date t=0 and compute the resulting transitional dynamics.[16]

[16] Following Mendoza and Tesar (1998), we used shooting and linearization around the post-Soviet-collapse steady state to adjust transitional dynamics for steady state changes in the net foreign asset position.

Figure 4 plots actual and simulated responses for key macroeconomic variables measured as percent deviations from the pre-collapse steady state.[17] The model can capture the dynamics of output well in terms of magnitude. The model predicts an output decline of 20 percent nearly identical to that observed in the data, albeit the trough is reached in 1991 in the model versus 1992 in the data. Very similar results are also obtained for consumption and employment. Both decline about as much as in the data (about 24 percent), but both reach their troughs a year earlier than in the data. The model also approximates well the observed dynamics of wages. In contrast with the data, however, the model predicts a recovery in consumption to 10 percent below the trend by 1997 while consumption in the data does not seem to recover and stays 20-22 percent permanently below trend. The model also predicts a moderate recovery in employment that is somewhat stronger than what is observed in the data. Consistent with the data, the model predicts an increase in the net export-GDP ratio. However, the increase in the ratio is gradual in the data while in the model it peaks in 1991.

The model predicts a 26 percent decline in investment over 1991-1993 and a recovery to about 12 percent below the trend in the long run. In contrast, investment in the data falls by 65 percent below the trend and although it slightly recovers by 1997 it stays permanently 40 percent below trend. One may expect, however, that if utilization of capital requires energy as in Finn (2000), the relative price of capital is going to be higher in the post-Soviet-collapse period and hence the decline in investment could be larger and more persistent.

Figure 5 show the model and data responses for value added, investment, employment and wages at the sectoral level. Generally, the model captures well the qualitative features of the dynamics in the Soviet and service sectors, but quantitatively there are non-trivial differences. The model predicts permanent declines in value added, employment, investment and wages in the Soviet sector, but the model underestimates the drop in value added in the early years of the transition, and overestimates the declines in employment, investment and wages. In the services sector, the model does well at matching the initial declines of all four macro aggregates, but it cannot match the highly persistent declines observed in the data. The predictions of the model for the non-Soviet sector are generally a poor match of the observed dynamics, except for the initial

[17] Note that since we fit trends to each series in the data individually, we can have a discrepancy in the dynamics of output and inputs. In other words, we do not force variable to grow at the same rate as predicted by the standard business cycle models. Although this restriction may be useful in long time series, in short samples like ours this restriction could be too demanding. This explains why, for example, output and employment in the data fall by similar amounts.

decline in value added. In particular, the model understates the magnitudes of the declines in value added, employment, investment and wages in the non-Soviet sector.

In summary, the model performs well at matching aggregate dynamics, but is less successful at explaining some sectoral dynamics. It may seem surprising that the collapse of Soviet trade, which accounted for only about 5 percent of total employment and value added, can produce a significant contraction of output at the aggregate level in the model (almost 20 percent in 1991). The key to understanding this result is the combined effect of wage rigidity and the role of nontradables. Consider first a two-sector model, with only the Soviet and non-Soviet sectors. In this economy, the collapse of trade with the Soviets would put pressure on factors to shift from the Soviet to non-Soviet sector. This happens for two reasons: first, because the relative price of the Soviet-goods falls, and second, all of Finland's energy needs now have to be financed by exports of the non-Soviet good. If factors are perfectly immobile, the maximum output effect is a fall of about 5 percent. To the extent that factors can adjust, the decline in output will be smaller.

What happens when there are nontraded goods in the economy? The trade collapse causes the relative price of oil to rise, increasing production costs in both the non-Soviet and nontraded goods sectors. In addition, the collapse of demand in the Soviet sector reduces income and hence the demand for all other goods. These two effects together lead to a decline in relative price of nontraded goods and output. Rigid wages amplify the contraction in demand in the short run. As consumers purchase fewer goods, firms demand less labor which entails further contraction of demand and the spiral continues. In summary, a combination of higher costs of producing goods as well as a fall in demand magnified by rigid wages leads to large short-run multipliers on the initial shocks. Consistent with this argument, the relative prices of Soviet and non-tradable goods fell by 17.4 and 13.3 percent respectively below the trend between 1990 and 1995. The model predicts 18 and 5 percent decline after four years for prices of Soviet and non-tradable goods respectively.

To assess the separate contribution of oil price and trade shocks, we perturb the economy with one shock at a time and plot the resulting transitional dynamics of aggregate variables (see Figure 4). The economy's response to an oil price shock is much smaller than to the trade shock. In addition, the response to the oil price shock tends to produce an *expansion* of the Soviet sector, because larger exports to the USSR increase the amount of oil that can be imported and thus help offset the effect of the higher price of energy (Figure 5). This is consistent with the Finnish experience in late 1970s and early 1980s when oil prices increased. By contrast, the trade shock leads to an expansion in the non-Soviet sector. In general, the oil and pure trade shocks push the Soviet and non-Soviet sectors in different directions, but the two shocks are contractionary for the services sector.

Sensitivity Analysis

In this subsection we vary parameter values to study the sensitivity of our results to alternative calibrations. First we modify the model to introduce habit formation in preferences and add quadratic labor and investment adjustment costs (in addition to quadratic capital adjustment costs). Both habit formation and labor and investment adjustment costs make the responses of macroeconomic aggregates smoother, but neither adjustment costs nor habit formation are crucial for the qualitative results (Figure D1). However, adding these features improves the model's ability to match the timing of troughs.[18]

Next we study the implications of altering parameters of the production technology, the consumption aggregator and labor supply. Our qualitative results are not sensitive to changes in the production function parameters (Figure D2). Decreasing the elasticity of substitution between capital and labor from one to 0.5 amplifies the responses of all variables, and investment in particular.[19] The quantitative results change little when we decrease returns to scale from 1 to 0.95. Likewise, we find that altering the elasticity of substitution in consumption across goods and over time does not change our main results (Figure D3). We also find that as long as labor supply is upward sloping and convex, we obtain the similar quantitative results.

Finally we study the implications of altering the degree of wage stickiness. In contrast with the other parts of the robustness analysis, we found that wage stickiness plays a very important role. In particular, the key parameter governing the response of the macroeconomic variables to the collapse of the Soviet-Finnish trade is the persistence of real wages (Figure 6). In

[18] We assume small to moderate quadratic adjustment costs in labor ($\lambda_1=\lambda_2=\lambda_3=1$). Christiano, Eichenbaum and Evans (2005) report that investment adjustment costs are necessary to explain the response of macroeconomics aggregates to supply side shocks. We follow these authors and introduce a small quadratic cost to changing the flow of investment: $\psi_1=\psi_2=\psi_3=0.5$. This small cost helps to generate a smoother contemporaneous response of investment to shocks. Numerous studies find a significant habit in consumption. A typical range is between 0.7 and unity. We take an intermediate value of habit persistence and set $h_1= h_2=h_3=0.8$.

[19] In the richer model with habit formation and additional adjustment costs in the flow of investment and labor higher elasticity has smaller effects on the impulse responses.

the case with fully flexible wages, the recession is short and shallow. For example, output, employment, investment and consumption fall only by 2-5 percent and there are hardly any dynamics after the first year. Thus, the response of investment, output, consumption and employment is small when compared to the response of these variables in the data. On the other hand, the response of real wages is overstated. In the data, wages declined gradually, while the model with fully flexible wages predicts an immediate 7.5 percent decline. At the sectoral dimension, fully flexible wages fail to capture the contraction across sectors. In particular, the non-Soviet sector expands in response to the collapse of the Soviet-Finnish trade: as resources are released from the Soviet sector they flow into the relatively more productive non-Soviet sector. In contrast, when wages are rigid, the oil shock reduces the marginal product of labor and firms would like to hire less labor at the current wages or to keep employment fixed but cut wages. If wages are rigid, the adjustment occurs via quantities and the model can capture sizable permanent decreases in output, consumption, investment and labor. The recession is considerably deeper when wages are inflexible. In summary, our qualitative and, to a large extent, quantitative results depend only on adjustment of real wages being sufficiently slow and in this respect our findings echo the results in Cole and Ohanian (2004). As reported in Section II, however, there is evidence in the data from Finland suggesting that this was indeed the case.

Oil shock in 1974

Given the good performance of the model in explaining the recession in the 1990s, one might be interested in how the model fares in accounting for the macroeconomic dynamics after the oil price shock in 1974. Like with the collapse of Soviet trade, this shock produce a large increase in energy costs, unlike the Soviet trade collapse, it did not cause a major dislocation in Finland's economic structure and sectoral factor allocations. In particular, during this episode Finland continued to import subsidized energy from the USSR in exchange for specialized exports. Hence, if in this experiment the model dynamics are still consistent with those observed in the data, we gain more confident about the conclusions derived in the previous subsection. In this exercise, we keep the model calibrated as before. The only modifications we make are to the speed of wage adjustment, which we set to $\theta_1 = \theta_2 = \theta_3 = 0.9$ (Finland was less unionized in the early 1970s), and energy intensity, which we set a 25 percent higher (the Finnish economy was more energy intensive in 1970s than in early 1990s).[20]

Although most economies experienced the oil shock early in 1974, the shock to the Finnish economy was somewhat delayed because the oil price in the Finnish-Soviet trade was a moving average of the world price. Hence, we assume that the shock to the world price occurs in the first quarter of 1974 and it hits the Finnish economy in the last quarter of 1974. To calibrate the size of the shock, we compute the unit price of imported oil in 1973 and 1974 and find that the (log) change in the price was 109 percent.

Figure 7 plots the model's transitional dynamics in response to the oil price shock and the dynamics of actual output, consumption and investment. Again, we detrend the data to remove secular movements in macroeconomic variables. The model broadly matches the response of the Finnish economy. Although we do not have reliable sectoral data before 1975 to construct counterfactual movements in the data in the absence of the shock, we know from Figure 5 that exports to the USSR expanded in response to the oil sector. We also know that output in the Soviet sector expanded relative to output in the non-Soviet sector. The sectoral responses in the model (not reported) capture these facts as well.

Sweden vs. Finland

An alternative way to assess the importance of the collapse in the Soviet-Finnish trade in accounting for the Finnish recession as well as to validate our simulations is to compare the output dynamics in Sweden and Finland. Both countries had similar institutions (including regulated labor markets with high downward wage rigidity, see Botero et al (2004) and Dickens et al (2007) for detailed comparisons) and experienced a similar and almost simultaneous sequence of events (including currency and financial crises) and policy responses in the late 1980s and early 1990s with the only major difference being that Sweden had miniscule trade with USSR.[21] In a sense, Sweden could be used as a counterfactual for what could have happened to Finland if it did not trade so much with the USSR. Hence, we can utilize this natural experiment to evaluate the predictions from our model.

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[20] The ratio of energy consumption (in millions to TOE) to GDP (in constant 2000 prices) in 1973 was 25% larger than the same ratio in 1989.

[21] Comparing the developments in Sweden and Finland between 1985 and 2000, Jonung, Kiander and Vartia (2008) say that the two countries behaved as if they were "economic twins."

Figure 8 plots the time series of percent deviations of output from linear time trend (estimated on 1970-1990 data) for Finland and Sweden. At the trough of the recession the output drop in Finland was about 15 percent deeper than in Sweden. If we take this difference as a measure of the contribution of the Soviet trade collapse to the Finnish depression, then the magnitude of the contribution is broadly in line with impulse responses in our model. Hence, the observed difference between output paths in Sweden and Finland is consistent with our argument that the decline of the Soviet-Finnish trade explains a significant chunk of the downturn in Finland.

V Alternative explanations of the depression

We acknowledge that there are other potential explanations of the Finnish Great Depression. One popular explanation is that a credit crunch induced by a burst of the overheated stock market and collapse of the Soviet-Finnish trade was the real cause (after all, there was a major financial crisis in Finland in 1992). A second explanation, proposed by Conesa, Kehoe and Ruhl (2007), is that the depression was caused by an adverse TFP shock combined with increased labor taxes.

We can get a sense of the extent to which a credit crunch can explain the depression by introducing into our framework an exogenous, persistent increase in the world interest rate. We assume that the interest rate increased in 1991 by one percent. We set the serial correlation of the shock to 0.9 which is approximately the persistence of the interest rate in Finland. We consider two scenarios. First, the interest rate shock is the sole source of the depression. Second, the interest rate shock happens simultaneously with the collapse of the Soviet-Finnish trade. We present impulse responses in Figure D4. Clearly, an increase in the interest rate depresses aggregate economic activity (small effects on employment, output, and consumption but a larger effect on investment) and improves the fit of the model at the sectoral level when combined with other shocks. Specifically, interest rate shocks help the model to match the downturn in the non-Soviet sector. By itself, however, the shock has small quantitative effects for variables other than investment. In addition, investment tends to overshoot after the period of high interest rates. We conclude from these results that a credit crunch could be a useful complement to our story.

With regard to the hypothesis of Conesa et al. (2007) attributing the Finnish crisis to a combination of a TFP drop with a labor tax hike, it is worth noting that our oil price shock works like a technology shock since an increase in oil prices reduce firms' profit margins (provided there is a sufficiently small substitutability of energy input). Thus what Conesa et al. interpret as a TFP shock could be partly capturing the energy price shock in our model (a similar argument was made for the case of the United States by Finn (2000)). Regarding the tax hike, however, we were unable to find evidence of changes in tax rates in the Finnish press and legislation of the early 1990s. Moreover, various measures of the tax burden on labor earnings exhibit little variation over this period (see Figure E1)

We can reconcile the labor-tax-like effects that Conesa et al. (2007) emphasize with our analysis if we interpret them as taking the place of the wage rigidities in our model. In an equilibrium without frictions, the wage received by workers is equal to their reservation wage, i.e. $w_{jt} = w_{jt}^D$. If wages are rigid, however, the reservation wage is not generally equal to the wage actually received. Furthermore, in a downturn, workers are willing to accept jobs at lower wages, but with inflexible wages there is going to be a difference between current market wages and the reservation wages, in particular $w_{jt} > w_{jt}^D$. Moreover, if firms stay on their labor demand curve, they will cut employment. Because of these arguments, we can reconcile decreased employment (as observed in the data) with fully flexible wages (as assumed by Conesa et al. (2007)), if we interpret this situation as if there was a 'labor tax' shock. In other words, one can interpret $w_{jt} > w_{jt}^D$ as arising from a labor tax τ such that $w_{jt} > (1-\tau)w_{jt} = w_{jt}^D$ where after tax wage is equal to the reservation wage. Hence, our results do not contradict results in Conesa et al. (2007), but there is an important difference in interpretation, and in this respect the empirical evidence seems to favor our approach.

VI Extensions to Transition Economies

There is ample evidence indicating that the trade and energy price shocks faced by the TEs of Eastern Europe and the former Soviet Union were at least as severe as they were for Finland. The practice of overpricing machines exported from CMEA countries to the Soviet Union and underpricing raw materials (mainly energy) exported from the Soviet Union to CMEA countries is well documented (e.g., Marrese and Vanous 1983). Orlowski (1993), Krasnov and Brada (1997) and others find the same pattern for intra-USSR trade. In addition, while there was a strong redirection of trade for transition countries from former socialist trading partners toward the EU and other industrialized countries (e.g. Campos and Coricelli 2002), there is little evidence that exports of goods manufactured in the command economy were redirected. Rodrik (1994) and others argue that reorientation to the EU market of products previously directed to CMEA was not a prominent feature of the transition period. Furthermore, Rodrik (1994) reports evidence suggesting that Soviet exports could be sold in the West only with 50 percent or more discounts. Given available micro level evidence, Repkine and Walsh (1999) contend that firms historically producing under different 5-digit SITC codes for the CMEA market could hardly reorient production toward very different products.

These observations suggest that our model may be useful for explaining the macroeconomic dynamics displayed by TEs in the early stages of transition. Our simulation results showed that the effects of eliminating the energy subsidy and Soviet trade relationship on output, employment and other aggregate outcomes are greatly amplified by real wage rigidities. Because of data limitations, it is hard to establish whether real wages were rigid in Central and Eastern European countries in the initial stages of the transition. First estimates of the wage elasticity with respect to unemployment rates suggested that real wages were fairly flexible in TEs (e.g., Blanchflower 2001). However, subsequent studies based on macro and micro level data tend to find that real wages in transition countries were almost as inflexible as wages in other European countries (e.g., Kertesi and Kollo 1997, Estevão 2003, Iara and Traistaru 2004, Von Hagen and Traistaru-Siedschlag 2005). In addition, labor markets in TEs appear to be as regulated as in other European countries (Botero et al 2004). On the other hand, it is hard to believe that real wages were strongly inflexible because inflation was high and variable.[22] However, there was also a strong political pressure to maintain living standards. Indeed, Roland (2000) argues that politicians could not allow wages to fall too fast and too much because otherwise reforms could be reversed. Wage indexation and dollarization of wages became common practice in transition economies. Furthermore, as observed in Rodrik (1994), the sharp increase in unemployment rate across transition countries is the prima facie evidence that wages were inflexible. In summary, although wages in transition countries adjusted in response to aggregate shocks, the adjustment is likely to have been relatively slow. Given that the size of distortions was greater in former CMEA countries (e.g., greater subsidy from USSR and greater

[22] Although wage arrears were another source of wage flexibility, wage arrears were largely limited to former Soviet Union republics and had little impact in other Eastern European countries.

specialization of trade with the USSR), one can expect that standard macroeconomic factors can explain a bulk of downturn in economic activity in transition countries.[23]

To support our theory that the contraction observed in TEs can be explained with the oil price and trade shocks caused by the demise of the USSR, we would like to compare simulated transitional dynamics from the model (calibrated for TEs) with the data responses at the aggregate and sectoral levels (also for TEs). Unfortunately, due to severe data limitations, this comprehensive analysis is not possible. Indeed, we focus on Finland precisely because, unlike transition countries, Finland has reliable statistics at all levels of aggregation during and before the recession. However, we can assess the model's behavior using a handful of reliable aggregate series for Poland and Hungary.

We use the model and calibration from Sections III and IV as the basis of our analysis for transition economies. Since transition and Finnish economies were different, we need to make a few adjustments to the calibration. Since wages were more flexible in TEs than in Finland, we consider a range of values for θ. We also modify the expenditure shares to match the relative sizes of the sectors. Specifically, we assume $\xi_1 = 0.2, \xi_2 = 0.15, \xi_3 = 0.5, \xi_4 = 0.15$ for Hungary and $\xi_1 = 0.2, \xi_2 = 0.15, \xi_3 = 0.45, \xi_4 = 0.2$ for Poland to match the fact that service sector was larger in Hungary.[24] Given that the energy intensity of output in the former socialist economies was twice as large as in the OECD economies (EBRD 2001), we also double a_1, a_2, a_3. These modifications in ξ's and a's are necessary to match the size of the Soviet sector, which we set to 20-25 percent in Poland and Hungary, and the share of Soviet exports in total exports, which we set to 30 percent in both countries.[25] Finally, since the reallocation of resources was probably less efficient than in Finland (e.g., none of the TEs had employment agencies or markets for used capital in the early 1990s), we double the size of adjustment costs.

[23] Interestingly, the experience of East Germany after unification is broadly in line with our arguments for transition economies. East Germany was also dependent on cheap Soviet energy and overvalued exports to the USSR. Unification with West Germany brought not only world-class institutions to East Germany but also overvalued rigid wages for workers in East Germany. After reunification, East Germany experienced a severe downturn in economic activity. Similar to the Finnish experience, wages were rigid and reallocation of resources massive. Even after almost twenty years after the reunification, East Germany continues to lag behind West Germany in many economic dimensions.

[24] In 1991 (the earliest year for which we have reliable data), services accounted for 57% of GDP in Hungary. In 1992 (the earliest year for which we have reliable data), the share was 51% in Poland. Since services contracted less during the recession, we set sector shares to small magnitudes.

[25] We do not have reliable data to assess the size of the Soviet sector. However, various sources indicate that approximately a quarter of the CMEA economies were primarily concerned with exports to the USSR. The share of Soviet exports is calculated using IMF Direction of Trade Statistics (DOTS) database.

To calibrate the size of the shock, we use the decline in the volume of exports to the (former) USSR as well as dependence of Poland and Hungary on energy imports from the Soviet Union. Hungary was heavily dependent on energy supplies from the USSR and the quality of its exports was inferior relative to Finnish exports to the USSR. Hence, we double the markup and assume that after the collapse of the Soviet Union the price of oil is effectively 20 percent more expensive relative to the pre-collapse price. Poland was less dependent on energy imports from the USSR and, consequently, we assume a 15 percent markup. To assess the size of the trade shock, we use the fact that between 1988 and 1991 exports to the USSR decreased by 60-65 percent for Hungary and by 45-50 percent for Poland.[26] However, these magnitudes probably understate the collapse of output in the Soviet sector since the trade with the former Soviet Union was picked up by the Soviet sector. Consequently, we set the trade shocks to 75 percent in both countries. Finally, we assume that the collapse of the Soviet trade occurred (or started to occur) in 1990 rather than 1991.

Figure 9 plots the dynamics of real GDP in the model and data in response to the Soviet trade shock. Strikingly, the model response to collapse of the Soviet trade is very similar to the actual responses of the Polish and Hungarian economies. The model can explain a bulk of the output contraction and the timing of the trough for both economies. The magnitude of the decline in the model depends on the speed of wage adjustment. However, it is safe to say that even for relatively flexible wages the Soviet trade shock accounts for at least 50 percent of the contraction. Hence, this shock could have been a quantitatively important source of economic downturn in transition countries.

We also conjecture that misallocation of resources in the former Soviet Union could have played an important role in the dramatic output decline in the early 1990s. Indeed, an enormous fraction of the Soviet economy was militarized (15-20 percent of GNP according to various estimates, e.g. Steinberg (1992)) and had only limited ability to switch production to non-military goods. For example, All-Russian Scientific Research Institute for Experimental Physics (the developer of nuclear and thermonuclear weapons) was supposed to be organizing the series production of pipe connections for the milk lines of dairy plants (Menshikov, 2000). A tremendous shift in demand towards consumer goods meant a gigantic transfer of resources

[26] Export statistics are taken from IMF Direction of Trade Statistics (DOTS) database. Other data sources (OECD, national statistical offices) report similar magnitudes.

which was probably even more painful and costly than in other countries of the socialist camp.[27] In other words, the shock was internal rather than external. In addition, many relatively energy-poor Soviet republics (e.g., Ukraine) had to buy oil and gas at new higher prices (the energy subsidy was partially or fully removed shortly after the collapse of the USSR) which combined with the loss of demand from other Soviet republics resembles the shock experienced by other Eastern European countries and Finland.

VII Concluding Remarks

This paper examines the Finnish Great Depression in the early 1990s and makes several substantive contributions. First, we find that the Great Depression experienced by the Finnish economy in 1991-1993 can be explained to a large extent by the exogenous Soviet trade shock which included the surge in energy prices and sudden redundancy of Soviet-oriented manufacturing caused by the collapse of the Soviet Union. Since the identification of the shock is particularly clear cut, this natural experiment evidently illustrates the behavior of a small open developed economy in response to a large exogenous trade shock. The key mechanism that amplified the initial trade shock into the depression was the rigid real wages in the Finnish economy. We show that our calibrated multi-sector model is successful in reproducing other historical episodes and produces estimates of the trade shock effects which are supported by other pieces of evidence (in particular, macroeconomic performance in Sweden v. Finland).

Second, Eastern European post-socialist economies exhibited output dynamics and Soviet trade patterns similar to those observed in Finland. This similarity is particularly striking and calls for a reinterpretation of the sources of depressions in transition economies since Finland, in contrast to transition economies, had a perfectly functioning system of markets, courts and other institutions. We provide quantitative theoretical analysis showing that the economic collapse of formerly socialist economies in the early 1990s could also have been mainly due to the same trade shocks as in Finland. Although we cannot rule out alternative explanations for contractions in transition economies, the quantitative responses to the Soviet trade shock can account for a large share of contraction in transition countries and Finland. In other words, the trade shocks we

[27] Menshikov (2000) and others report that military orders declines by almost 70 percent between 1990 and 1992. In 1992 alone, military production fell by 42 percent which constituted about a half of production decline in the military industry between 1990 and 1997. Cumulatively, between 1990 and 1997 arm procurements fell by 90 percent, employment in formerly military oriented firms fell by up to 3.5 million people, more than 54 percent of production capacity of defense firms had to be retooled.

observe in the data could lead to economic downturns in standard theoretical multi-sector models which are remarkably close to the size of downturns we observe in transition economies. This important finding suggests that alternative explanations such as institutional transformations could have had a much smaller effect than thought before.

The natural experiment of the Soviet-Finish trade downfall analyzed in this paper has broader implications. Specifically, we show that sectoral (trade) shocks can lead to significant comovement across sectors even in the absence of direct input-output linkages. Reallocation of resources can be particularly costly in presence of sticky wages and/or prices. The Finnish experience can also shed some new light on the post-WWII contractions after rapid changes in the composition of aggregate demand (e.g., disarmament in the U.S. after the Korean War). Static measures of the trade shocks can grossly overestimate the short-run cost of reallocation. Since many small open economies specialize in exporting a handful of goods, shocks to prices of these goods could be an important source of volatility in these countries.

Although our theoretical models go a long way in explaining depressions in Finland and transition economies, in our models we abstract from many important shocks and mechanisms for amplification and propagation of these shocks. For example, we do not incorporate any nominal frictions or financial sector in our models. We leave it for future research to incorporate these important elements into richer models to more completely assess contribution of various shocks and mechanisms in generating depressions.

References

Basu, Susanto, Fernald, John G., 1997. "Returns to Scale in U.S. Production: Estimates and Implications," *Journal of Political Economy* 105(2), 249-283.

Blanchard, Oliver and Michael Kremer, 1997. "Disorganization," *Quarterly Journal of Economics* 112(4), 1091-1126.

Blanchflower, David G., 2001, "Unemployment, Well-Being, and Wage Curves in Eastern and Central Europe," *Journal of Japanese and International Economics* 15(4), 364–402.

Böckerman, Petri, and Roope Uusitalo, 2006. "Erosion of the Ghent System and Union Membership Decline: Lessons from Finland," *British Journal of Industrial Relations* 44(2), 283–303.

Böckerman, Petri, Seppo Laaksonen, and Jari Vainiomaki, 2006. "Micro-level evidence on wage rigidities in Finland," Labour Institute for Economic Research, Discussion Paper 219.

Botero, Juan, Simeon Djankov, Rafael La Porta, Florencio Lopez-de-Silanes, Andrei Shleifer, 2004. "The regulation of labor," *Quarterly Journal of Economics* 119 (4), 1339-1382.

Campos, Nauro F., and Fabrizio Coricelli, 2002. "Growth in Transition: What We Know, What We Don't, and What We Should," *Journal of Economic Literature* 40(3), 793-836.

Christiano, Larry J., Martin Eichenbaum and Charles L. Evans, 2005. "Nominal rigidities and the dynamic effects of a shock to monetary policy," *Journal of Political Economy* 113 (1), 1-45.

Cole, Harold L., and Lee E. Ohanian, 2004. "New deal policies and the persistence of the great depression: A general equilibrium analysis," *Journal of Political Economy* 112(4),779-816.

Conesa, Juan Carlos, Timothy J. Kehoe, and Kim J. Ruhl, 2007. "Modeling Great Depressions: The Depression in Finland in the 1990s" in Timothy J. Kehoe and Edward C. Prescott, eds., *Great Depressions of the Twentieth Century*, Federal Reserve Bank of Minneapolis.

Dickens, William T., Lorenz Goette, Erica L. Groshen, Steinar Holden, Julian Messina, Mark E. Schweitzer, Jarkko Turunen, Melanie E. Ward, 2007. "How wages change: Micro evidence from the International Wage Flexibility Project," *Journal of Economic Perspectives* 21 (2), 195-214.

European Bank for Reconstruction and Development (EBRD), 2001. Transition Report.

Estevão, Marcello, 2003. "Structural and Cyclical Labor Market Changes in Poland," in *Republic of Poland: Selected Issues*, IMF Country Report No. 03/188, Chapter II, pp. 14–43 (Washington: International Monetary Fund).

Finn, Mary G., 2000. "Perfect Competition and the Effects of Energy Price Increases on Economic Activity," *Journal of Money, Credit and Banking* 32(3), 400-416.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W. Huffman, 1988. “Investment, Capacity Utilization, and the Real Business Cycle,” *American Economic Review* 78(3), 402-417.

Hall, Robert E., 2007, “Sources and Mechanisms of Cyclical Fluctuations in the Labor Market,” Manuscript, Stanford University.

Honkapohja, Seppo and Erkki Koskela, 1999. “The economic crisis of the 1990s in Finland,” *Economic Policy* 14(29), 399-436.

Honkapohja, Seppo, Erkki Koskela and Jouko Paunio, “The Depression of the 1990s in Finland: An Analytic View,” *Finnish Economic Papers* 9, no. 1, Spring 1996.

Iara, Anna and Iulia Traistaru, 2004. “How flexible are wages in EU accession countries?” *Labour Economics* 11(4), 431-450.

Kajaste, Ilkka, “Soviet Trade and the Finnish Economy,” Ministry of Finance of Finland, Discussion paper no. 33, 1992.

Kertesi, Gabor, and Janos Kollo, 1997. “The Birth of the ‘Wage Curve’ in Hungary, 1989-1995,” William Davidson Institute Working Papers Series No. 104, Ann Arbor, Michigan.

Krasnov, Gregory V., and Josef C. Brada, 1997. “Implicit Subsidies in Russian-Ukrainian Energy Trade,” *Europe-Asia Studies* 49(5), 825-843.

Marrese, Michael, and Jan Vanous, 1983. *Soviet Subsidization of Trade with Eastern Europe: A Soviet Perspective*. Berkeley, University of California Press.

Mendoza, Enrique G., and Linda L. Tesar, 1988. “ The International Ramification of Tax reforms: Supply-Side Economics in a Global Economy,” *American Economic Review* 88(1), 226-245.

Menshikov, Sergey, 2000. “Development Scenarios for the Military-Industrial Complex,” *Problems of Economic Transition* 42(10), 34-49.

Mottola, Kari, O. N. Bykov and I.S. Korolev, *Finnish-Soviet Economic Relations*, London: The Macmillan Press, 1983.

Oblath, Gabor, and P. Pete, “Mechanism and Institutional System of the Finnish-Soviet Economic Relations,” in *Foreign Trade in Eastern Europe and the Soviet Union*, ed. By Michael Friedlander, Boulder: Westview Press, 1990.

Orlowski, Lucjan T., 1993. “Indirect Transfers in Trade among Former Soviet Union Republics: Sources, Patterns and Policy Responses in the Post-Soviet Period,” *Europe-Asia Studies* 45(6), 1001-1024.

Repkine, Alexandre, and Patrick Paul Walsh, 1999. “Evidence of European trade and investment U-shaping industrial output in Bulgaria, Hungary, Poland, and Romania,” *Journal of Comparative Economics* 27(4), 730-752.

Rodrik, Dani, 1994. “Foreign Trade in Eastern Europe's Transition: Early Results,” in *The Transition in Eastern Europe*, vol. 2, ed. By Olivier Jean Blanchard, Kenneth A. Froot and Jeffrey D. Sachs. Chicago: The University of Chicago Press.

Roland, Gerard, 2000. *Transition and Economics: Politics, Markets and Firms*. MIT Press.

Roland, Gerard, and Thierry Verdier, 1999. “Transition and the Output Fall,” *Economics of Transition* 7, 1-28.

Rotemberg, Julio J., and Michael Woodford, 1995. “Dynamic General Equilibrium Models with Imperfectly Competitive Product Markets,” in T. Cooley, ed., *Frontiers of Business Cycle Research*, Princeton: Princeton University Press.

Snellman, Kenneth, 2004. “The structure of pay changes at the local level,” Labour Institute for Economic Research, Discussion Paper 199.

Snellman, Kenneth, 2005. “Finnish Wage Bargaining – Actual Behaviour and Preferences,” in Hannu Piekkola and Kenneth Snellman, eds., *Collective bargaining and wage formation: Performance and challenges*. Heidelberg and New York: Physica-Verlag, pp. 133-151.

Steinberg, Dmitri, 1992. “The Soviet Defence Burden: Estimating Hidden Defence Costs,” Soviet Studies 44(2), 237-263.

Sutela, Pekka, 1991. “Exporting to the Soviet Union – Microeconomic Aspects for Finland,” *Ost. Wirt.* 36(4), 301-315.

Sutela, Pekka, 1992. “Clearing, Money and Investment,” *Russian and East European Finance and Trade* 28 (4), 3-29.

Sutela, Pekka, 2005. “Finnish Trade with the USSR: Why Was It Different?” Bank of Finland/Instittue for Economies in Transition working paper 2005/7.

Sutela, Pekka, 2007. “The Folklore of Finland’s Eastern Trade,” *Europe-Asia Studies* 59(1), 137-162.

Von Hagen, J. and I. Traistaru-Siedschlag, 2005. “Macroeconomic Adjustment in the New EU Member States” in C. Detken, V. Gaspar and G. Noblet (eds), *The New EU Member States: Convergence and Stability*, Frankfurt: European Central Bank, pp. 121–174.

Table 1. Exports to USSR by sector, 1988.

	Exports to USSR as share of sectoral exports	Exports to USSR as share of sectoral value added	Share of total value added
GRAND TOTAL	**0.19**	**0.06**	
AGRICULTURE, HUNTING, FORESTRY AND FISHING	**0.03**	**0.00**	**0.058**
MINING AND QUARRYING	**0.03**	**0.01**	**0.004**
TOTAL MANUFACTURING	**0.19**	**0.24**	**0.242**
of which			
Food products, beverages and tobacco	0.27	0.06	0.027
Textiles, textile products, leather and footwear	0.29	0.34	0.012
Wood and products of wood and cork	0.07	0.12	0.014
Pulp, paper, paper products, printing and publishing	0.13	0.22	0.059
Chemical, rubber, plastics and fuel products	0.15	0.17	0.025
Other non-metallic mineral products	0.15	0.05	0.011
Machinery and equipment	0.22	0.26	0.050
Transport equipment	0.53	1.42	0.011
Motor vehicles, trailers and semi-trailers	0.09	0.23	0.005
Other transport equipment	0.84	2.24	0.007
Building and repairing of ships and boats	0.85	3.34	0.004
Aircraft and spacecraft	0.02	0.01	0.001
Railroad equipment and transport equipment n.e.c.	0.86	1.03	0.002
Manufacturing nec	0.06	0.03	0.009

Source: Finnish Ministry of Statistics, authors' calculations.

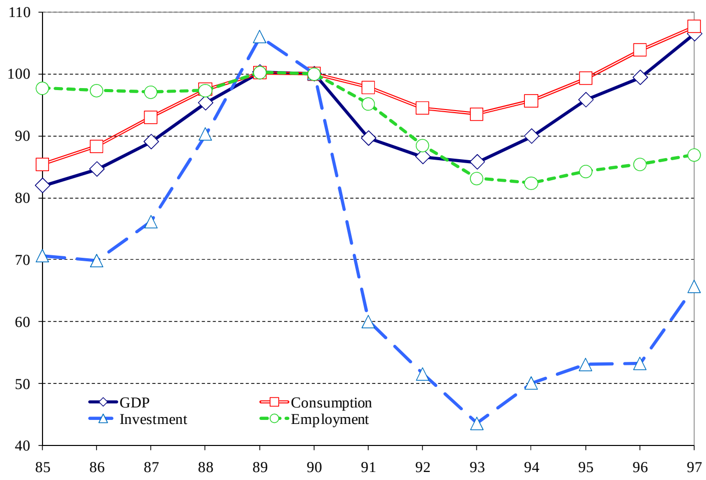
Table 2. Descriptive statistics for Soviet, non-Soviet and service sectors.

	Soviet sector	Non-Soviet sector	Service sector
Labor cost share	0.630	0.570	0.630
Wages relative to Non-Soviet Sector	0.983	1.000	0.914
Capital to labor ratio	79.318	103.152	106.137
Share of employment	0.055	0.233	0.712
Share of value added	0.056	0.269	0.675
Share of exports in total exports	0.175	0.815	-
Ratio of energy cost to value added	0.049	0.052	0.035

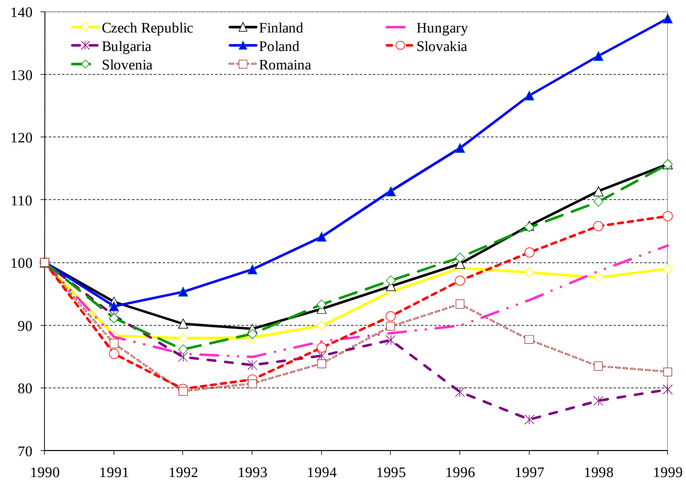
Notes: the table reports moments of the data for sectors constructed as described in Appendix. Capital to labor ratio is computed by dividing capital stock (computed using perpetual inventory with annual depreciation rate of 5 percent) by hours of work. Ratio of energy cost to value added computes the ratio of the cost of imported energy to value added in a given industry. We use the input-output table for 1989 to allocate of the cost of imported energy across sectors.

Figure 1

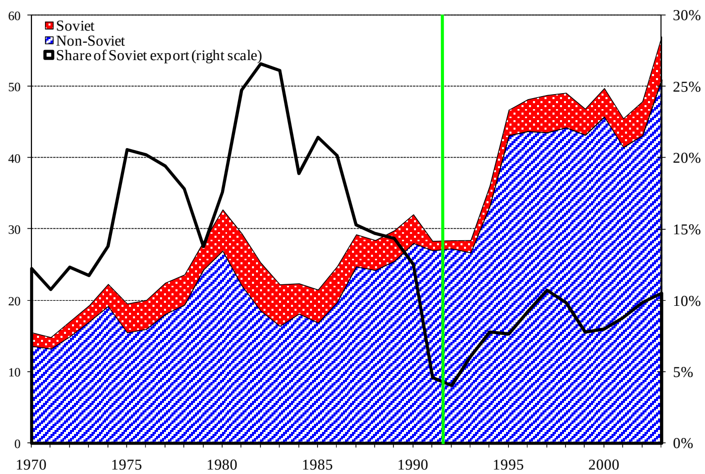
Panel A: Real GDP, Investment and Consumption in Finland.



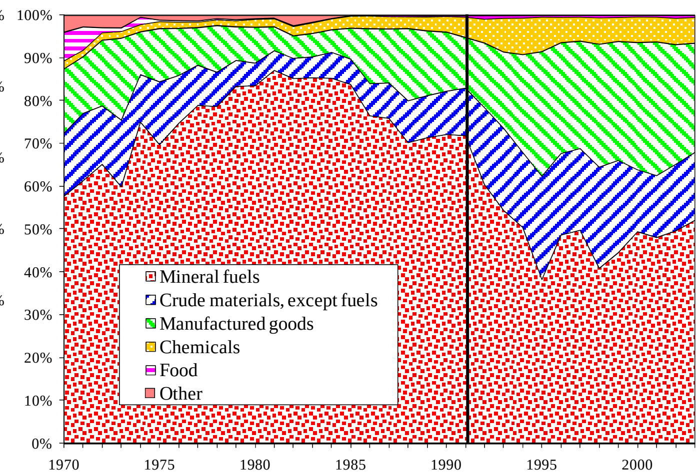
Panel B: Real GDP in Finland and Eastern Europe



Panel C: Soviet and non-Soviet exports in Finland.

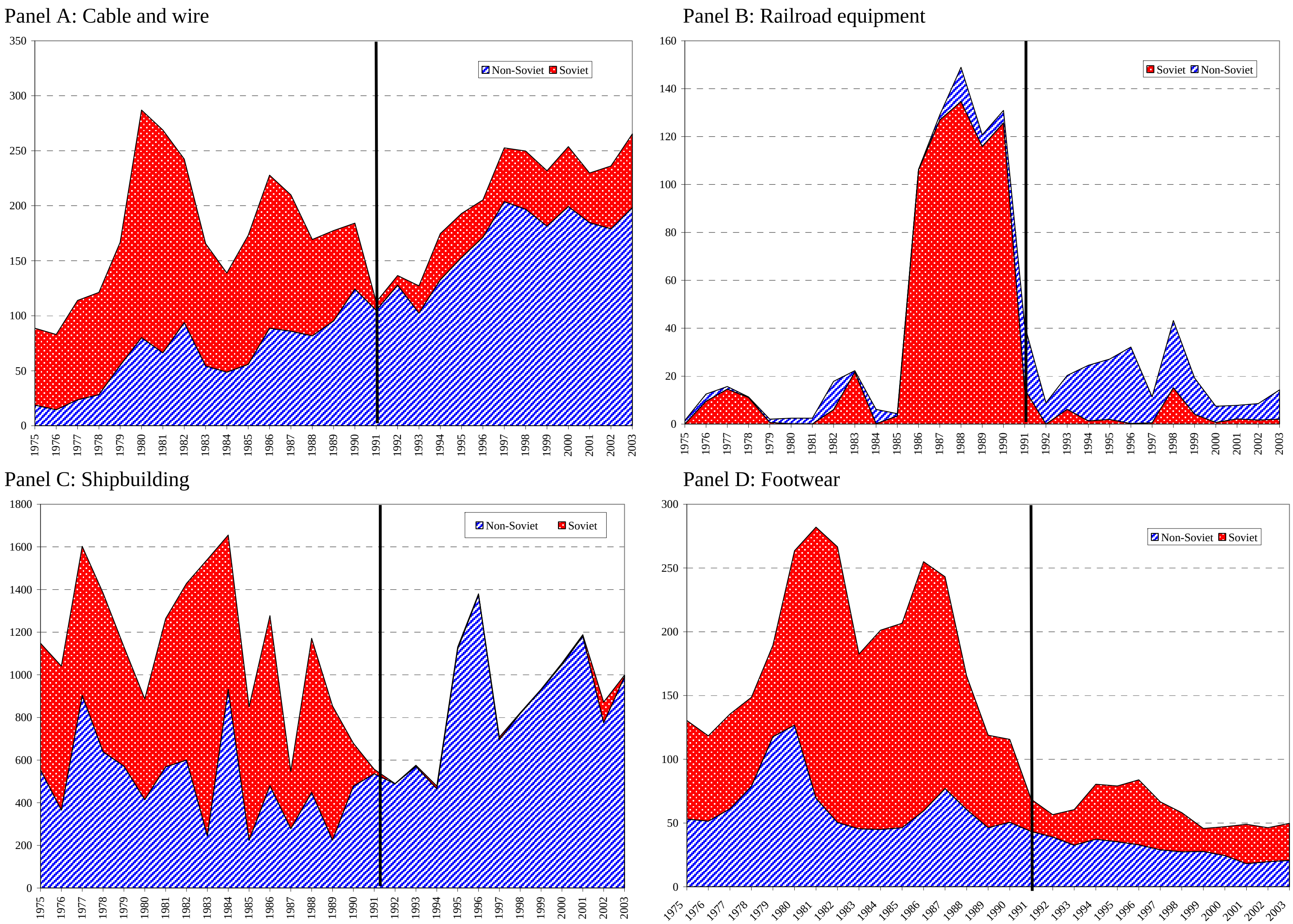


Panel D: Structure of Finnish imports from the USSR



Notes: Panel A: Series are normalized to be equal 100 in 1990. The data are from *International Financial Statistics* and *OECD* and are deflated using the consumer price index. Panel B: Series are normalized to be equal 100 in 1990. The data are from National Accounts Estimates of Main Aggregates, United Nations Statistics Division. Panel C: This figure reports exports by destination, Soviet vs. non-Soviet. Exports are in billions of fixed 2000 US dollars. For post 1991 years, Soviet Union exports are computed as the sum of exports to the 15 republics of the former Soviet Union. The vertical line shows 1991. The data are from OECD, Finnish Ministry of Statistics, author's calculations. Panel D: For post 1991 years, Soviet Union exports are computed as the sum of exports to the 15 republics of the former Soviet Union. The vertical line shows 1991. The data are from OECD, Finnish Ministry of Statistics, author's calculations.

Figure 2. Soviet and non-Soviet exports for selected industries.

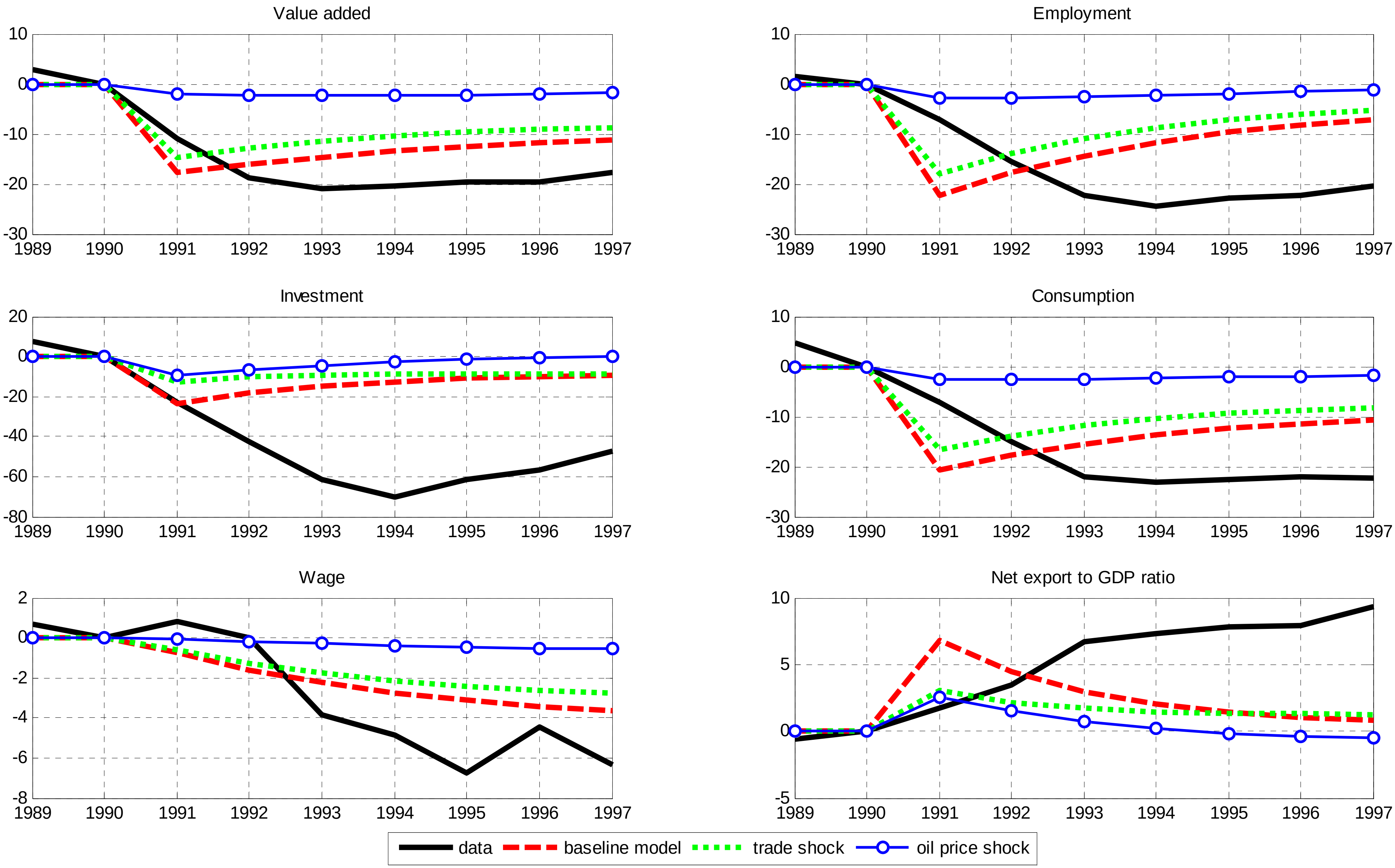


Notes: This figure reports exports by destination, Soviet vs. non-Soviet. Exports are in thousands of fixed 2000 US dollars. For post 1991 years, Soviet Union exports are computed as the sum of exports to the 15 republics of the former Soviet Union.

Figure 3. Distribution of wage changes by industry.

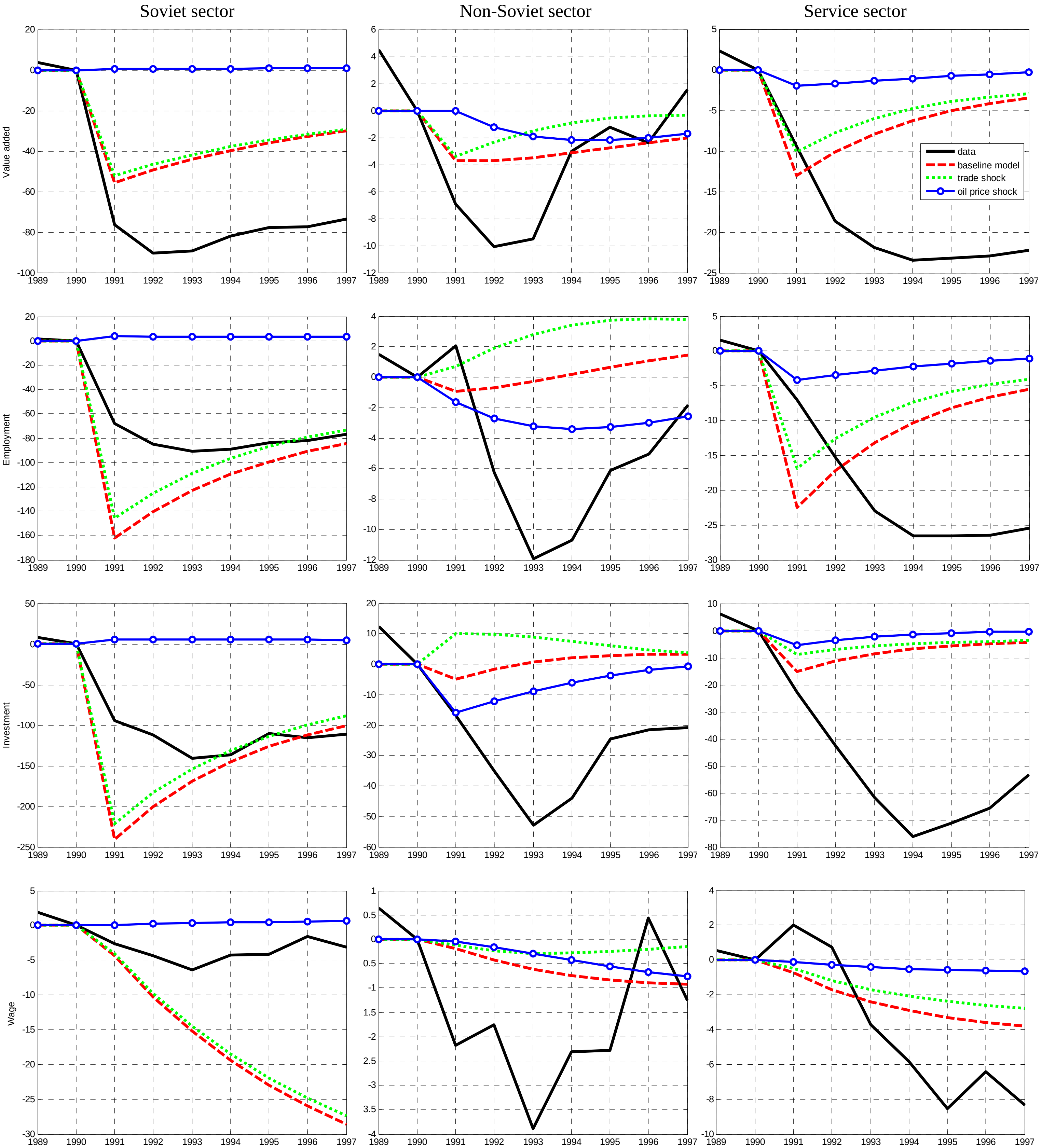
Notes: This figure reports distribution of individual workers' wages. Vertical axis measures fraction. Horizontal axis measures percent change in wages. The bar in blue indicates the level of inflation. Source: Bockerman, Laaksonen, and Vainiomaki (2006).

Figure 4. Macroeconomic aggregates: Simulated response to oil and trade shocks. Baseline calibration.



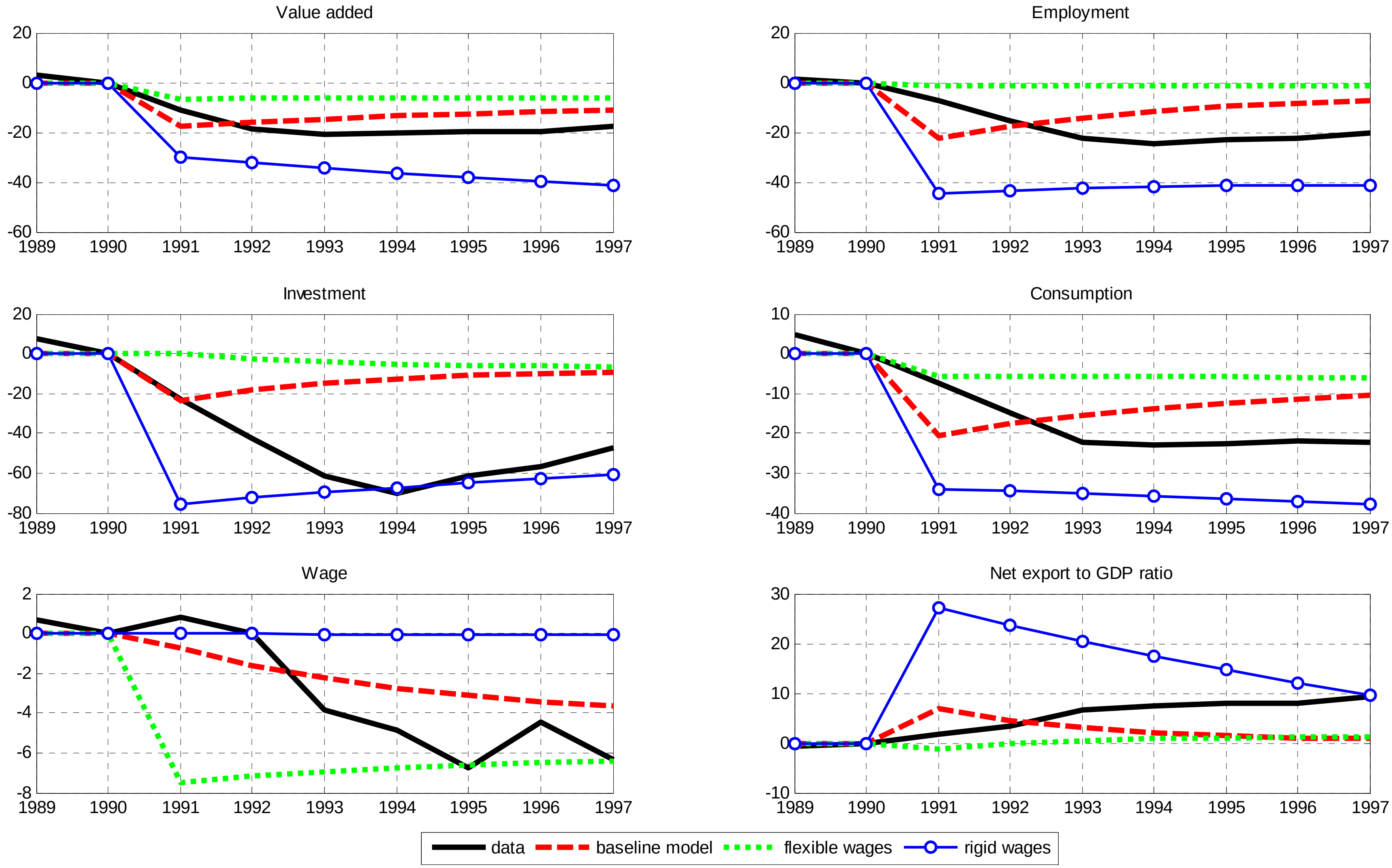
Notes: The figures plot percent deviations from trend for all variables except net export to GDP ratio. See Appendix B for more details on detrending. Trade shock is the shock with corresponds to setting trade with USSR to zero while keeping the oil price constant. Oil price shock is the 10 percent increase in the oil price while keeping the volume of trade with the USSR constant.

Figure 5. Simulated response to oil and trade shocks: Sectoral dynamics.



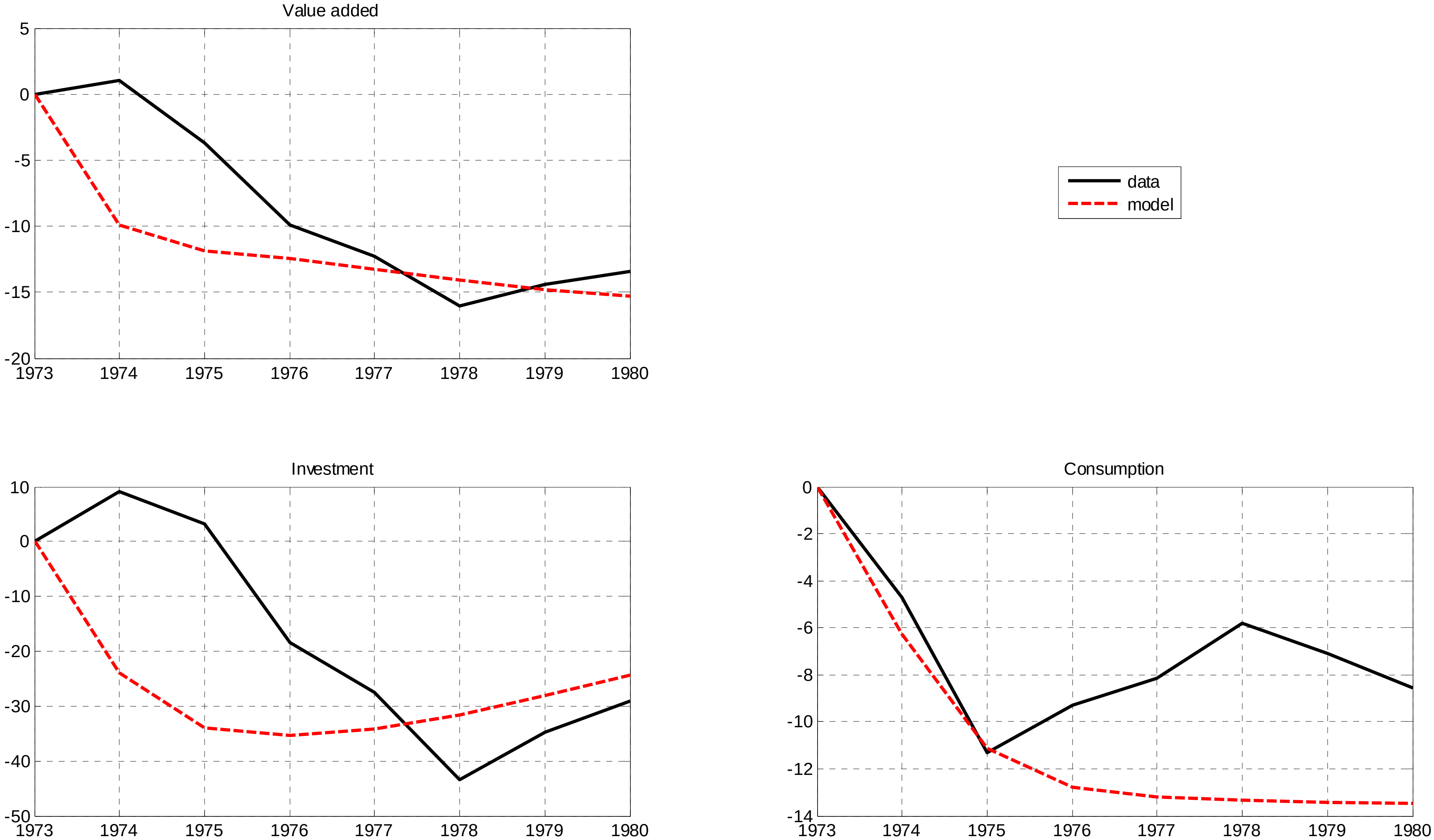
Notes: Baseline calibration. The figures plot percent deviations from trend for all variables except net export to GDP ratio. See Appendix B for more details on detrending. Trade shock is the shock with corresponds to setting trade with USSR to zero while keeping the oil price constant. Oil price shock is the 10 percent increase in the oil price while keeping the volume of trade with the USSR constant.

Figure 6. Macroeconomic aggregates: Effects of wage rigidity.



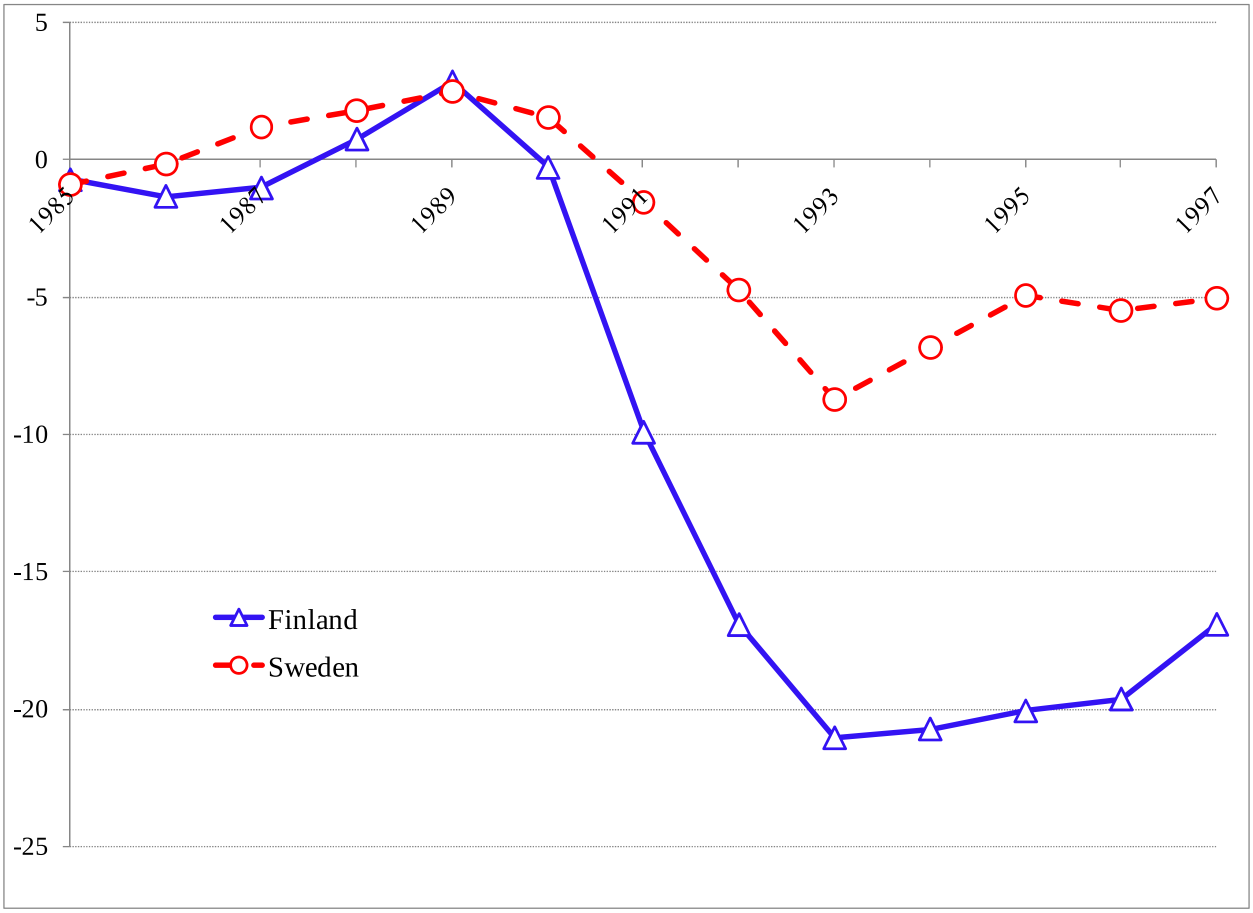
Notes: The figures plot percent deviations from trend for all variables except net export to GDP ratio. See Appendix B for more details on detrending. Trade shock is the shock with corresponds to setting trade with USSR to zero while keeping the oil price constant. Oil price shock is the 10 percent increase in the oil price while keeping the volume of trade with the USSR constant. Scenario "flexible wages" sets $\theta_1 = \theta_2 = \theta_3 = 0$. Scenario "rigid wages" sets $\theta_1 = \theta_2 = \theta_3 = 0.99975$.

Figure 7. Oil price shock in 1974.



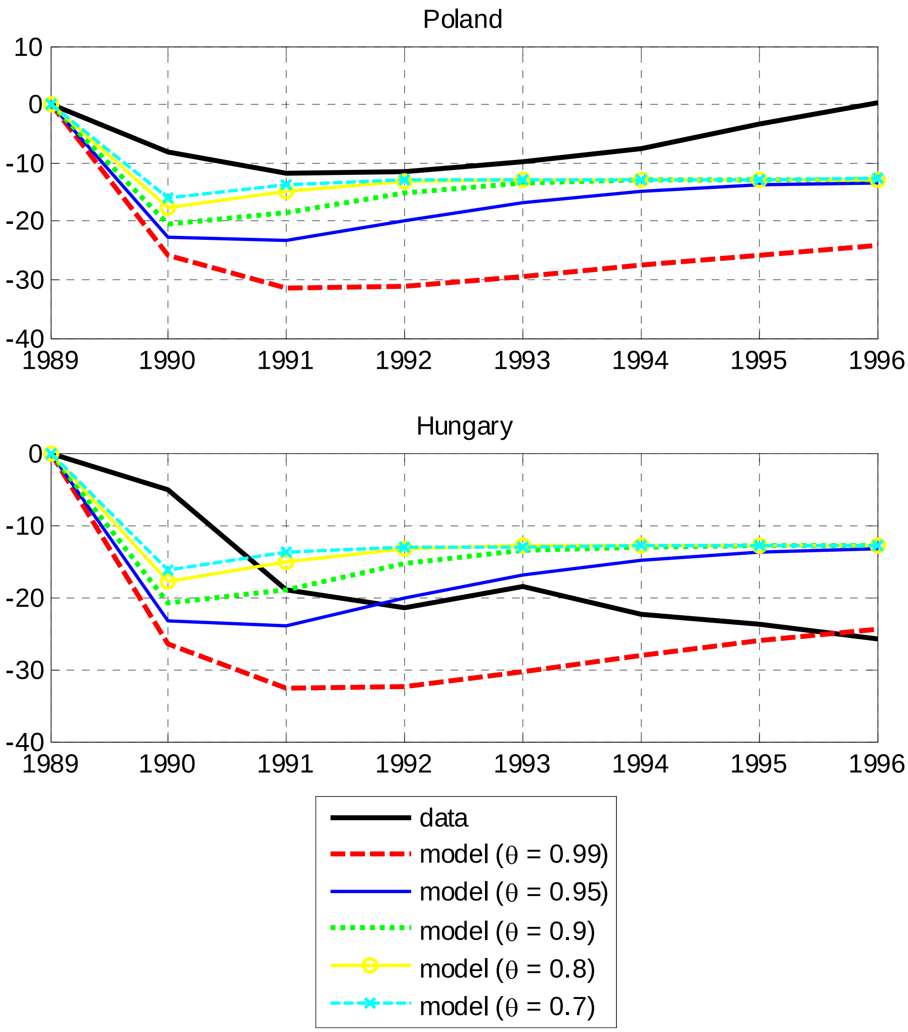
Note: Solid line is the deviation of real GDP, real consumption, and real investment from the respective linear time trends estimated on 1950-1973 data. Real GDP, real consumption, and real investment (in 2000 prices) series are taken from Penn World Tables. The deviation adjusted to be zero in 1973. Broken line is the model impulse response to 109% increase in the price of oil. Model parameters are calibrated according to their baseline values. See text for further details.

Figure 8. Real GDP in Sweden and Finland.



Notes: the figure reports percent deviations from trend estimated on 1970-1990 sample of GDP (in logs) time series.

Figure 9. Output dynamics in Poland and Hungary.



Note: Solid line is the deviation of real GDP series from the linear time trend estimated on 1970-1989 data. Real GDP (in 2000 prices) series for Hungary and Poland are taken from Penn World Tables. The deviation adjusted to be zero in 1989. Broken line is the model impulse response to collapse of the trade with the USSR. See text for further details.

Appendix A: Data sources

Export: Sectoral data on export by destination is provided by OECD STAN Bilateral Trade database and Finnish statistical yearbooks. From these data we compute the share of trade with the USSR for industry *j* in total exports of industry *j*. For the post-collapse period, we compute the shares using the total trade with Former Soviet Union countries. Service sector is assigned zero share in trade with the USSR. OECD ITCS database is used to construct exports series for 1970-2003. We aggregate exports to 15 former Soviet republics to compute the volume and structure of exports to the (former) USSR after 1991.

Output, investment, employment: Sectoral data on employment, hours of work, investment, output, total labor compensation and wage bill is taken from STAN OECD data base. Investment, output, and wage bill is in 2000 Finnish markka prices. Labor compensation includes wages, salaries, and social costs. Wage is computed as the ratio of wage bill to employment. Labor share is computed as the ratio of total labor compensation to value added. Service sector excludes public administration and defense as well as compulsory social security. Given constraints on matching consistent disaggregated production and export statistics, we use the following industries to construct Soviet and non-Soviet sectors:

- Textiles, textile products, leather and footwear
- Wood and products of wood and cork
- Pulp, paper, paper products, printing and publishing
- Coke, refined petroleum products and nuclear fuel
- Chemicals and chemical products
- Rubber and plastics products
- Other non-metallic mineral products
- Basic metals
- Fabricated metal products, except machinery and equipment
- Machinery and equipment, n.e.c.
- Office, accounting and computing machinery
- Electrical machinery and apparatus, n.e.c.
- Radio, television and communication equipment
- Medical, precision and optical instruments, watches and clocks
- Motor vehicles, trailers and semi-trailers
- Other transport equipment
- Manufacturing, n.e.c.
- Electricity, gas and water supply

Energy: Finnish statistical yearbooks (mainly for 1993) provide information on the cost and consumption of energy by industry. Unit prices for oil imports are taken from Energy Statistics 1994 published by the Statistics Finland.

Consumption: Aggregate consumption is taken from IMF IFS data base and Finnish statistical yearbooks. Consumption is in 2000 Finnish markka prices. To compute consumption shares by sector, we use a detailed Input-Output table for 1989. This table provides information for consumption expenditures by sector. We apply export shares as weights and aggregate across sectors to construct domestic consumption of Soviet, non-Soviet, non-tradables (services) and imported goods. Since we do not know the share of domestic private consumption for imported goods and in our model imported goods can be only consumed, we multiply imports by the share of private consumption expenditures in total domestic expenditures (government, investment) and treat the product as the private domestic consumption of imported goods.

Appendix B: Detrending and construction of sectoral data

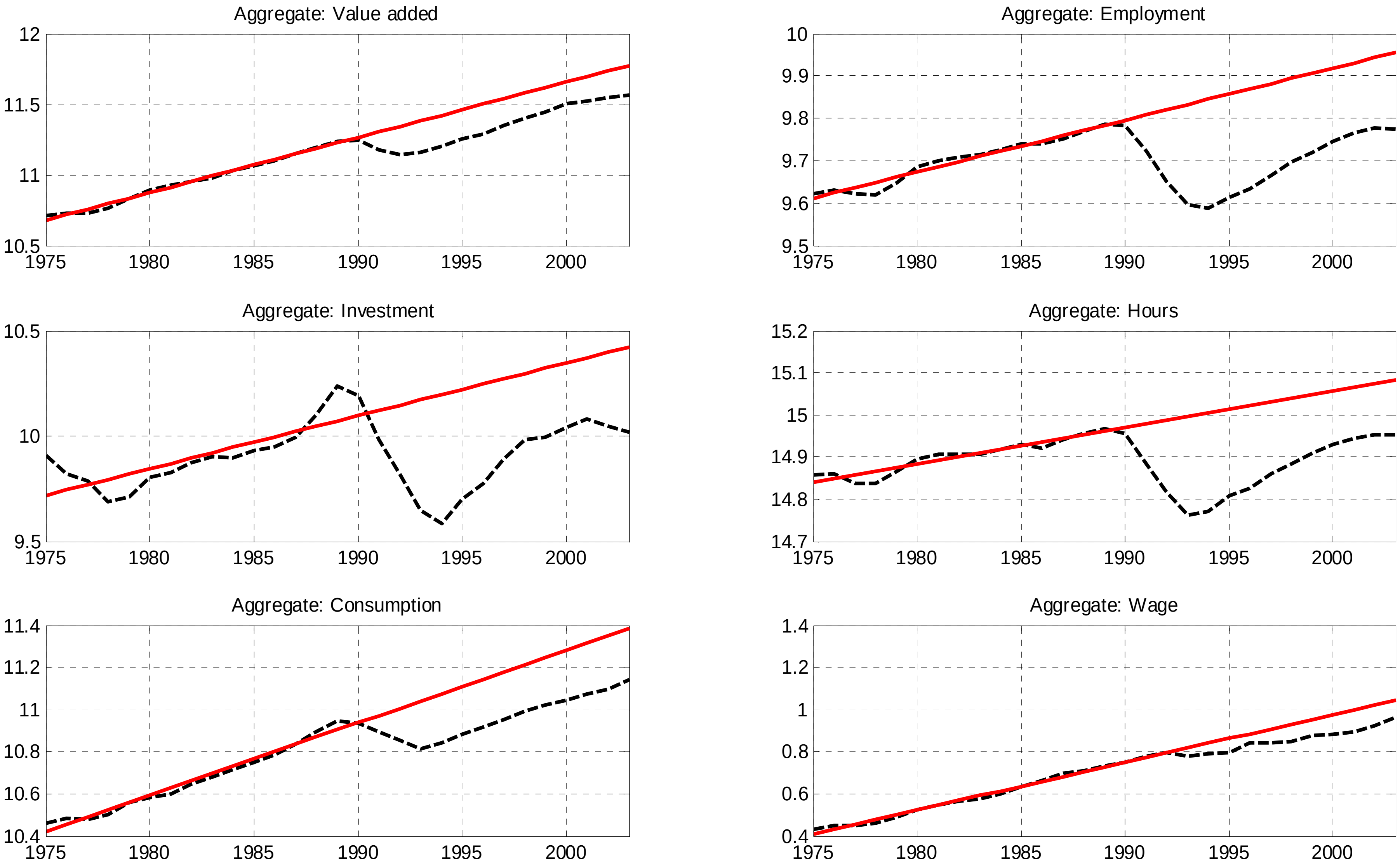
Since our study does not focus on long-run growth, we study macroeconomic aggregates filtering out their long-run trend. Figure B1 plots the dynamics of the series and the fitted linear time trend. To exclude the effect of the post-Soviet period we use data only for 1975-1989 to fit the time trend. We interpret the trend as the (counterfactual) dynamics of variables that we would have observed if there was no collapse of the Soviet Union and interpret deviations from trend as an impulse response to the Soviet trade shock. To make the comparison between model and data series straightforward, we rescale the filtered series so that they are equal to zero in 1990, see Figure B3. Note that the detrended series exhibit a much stronger decline than the raw series. For example, real value added falls by 13 percent, while filtered real value added decreases by almost 20 percent. In addition, macroeconomic series seem not to recover from the shock. Output, consumption, investment and other series stay permanently below the trend.

Further analysis of the Finnish recession requires construction of the Soviet sector. Ideally we would like to have firm-level data with product output and export by destination. With this information, we could aggregate output of goods predominantly exported to the Soviet Union and treat this aggregate as the Soviet sector. The advantage of this approach is that we would be able to control for entry/exit decisions at the firm level as well as creation and destruction of products. These data would also allow us to assess to what extent trade with the USSR was redirected to other countries. Unfortunately, these data are not available so we construct the Soviet sector using industry level data. The risk of working with industry data is that there could intra-industry entry and exit of firms and products. For example, shipbuilding firms specialized in producing icebreakers for the USSR left the market while shipbuilding firms specialized in producing cruise liners entered the market. In light of this caveat, we construct the Soviet sector with the following approach.

Define ω_{it}^{X} as the share of exports of industry *i* at time *t* to the Soviet Union in total exports of industry *i*. Let Q_{it} be value added (or any other the variable of interest) in industry *i* at time *t*. Then we compute value added in the Soviet sector as $Q_t^S = \sum_i \omega_{it}^X Q_{it}$ and correspondingly the non-Soviet sector is $Q_t^{NS} = \sum_i (1-\omega_{it}^X) Q_{it}$. To control for entry and exit of firms and products, we assume that the Soviet sector shares in exports to the post-USSR period are fixed at 1992 values when the trade with the Former Soviet Union countries reached its minimum. We also fix the Soviet sector share at 1988 values for the period before 1988 to eliminate the extraordinary expansion of the Soviet sector during the period of very high oil prices in the late 1970s and early 1980s. (Recall that trade between USSR and Finland require balanced trade and Soviet-Finnish trade agreements stipulated volumes of trade rather than values.) Thus we allow ω_{it}^{X} to vary only between 1988 and 1992. We refer to the resulting weights as 'hybrid' shares. We treat services as a separate sector producing non-tradable goods. We provide details on data sources in Appendix A.

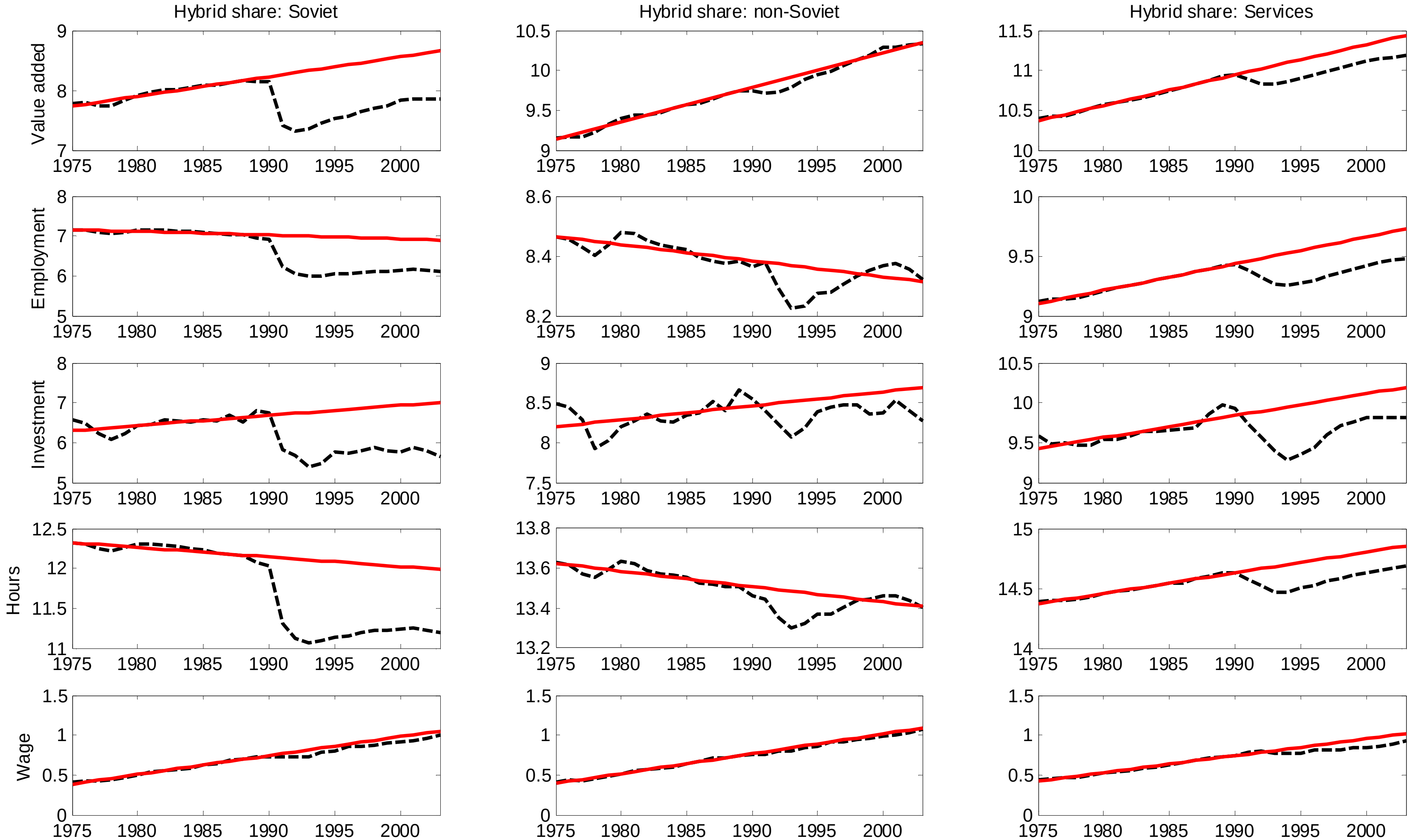
We plot series for Soviet, non-Soviet and service sector in Figure B2. Again, since most series grow over time we remove the trend component using a linear filter estimated on 1975-1989 data (Figure B3). The Soviet sector exhibited the largest decline. Value added, investment, and labor collapsed. There was also a significant, permanent decline in the service sector. The non-Soviet sector experienced a contraction in 1991-1993, but then it gradually recovered and exceeded its pre-collapse levels. Importantly, wages in each sector *gradually* decreased during the recession years.

Figure B1. Macroeconomic aggregates: Actual series and estimated trend.



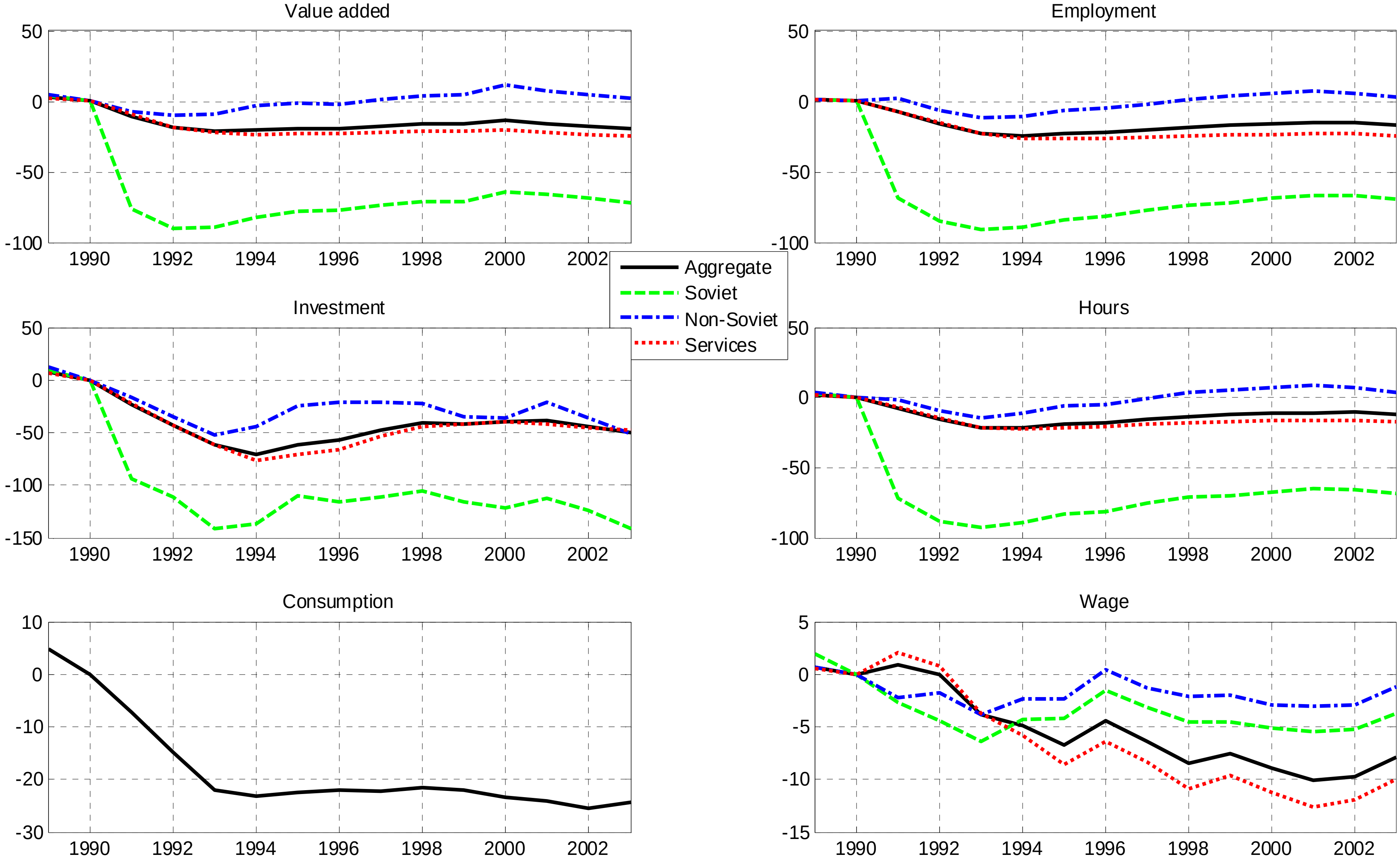
Note: The figure reports logs of real value added, real investment, real consumption, hours, and real wages. Solid line is time trend estimated on 1975-1989 data. Broken line is actual series.

Figure B2. Sectoral dynamics: Actual series and estimated trend.



Note: The figure reports logs of real value added, real investment, real consumption, hours, and real wages. Solid line is time trend estimated on 1975-1989 data. Broken line is actual series.

Figure B3. Aggregate and sectoral series: Deviations from trend.



Note: The figure plots percent deviations from time trend estimated on 1975-1989 data. The deviation is normalized to be zero in 1990.

Appendix C: Calibration.

First, we calibrate elasticity of output with respect to inputs by utilizing data on cost shares

$$s_j^L \equiv \frac{\text{labor cost}_j}{\text{Value Added}_j} = \frac{w_j L_j}{p_j Q_j - a_j E_j} = \frac{p_j \alpha_{jL}(1-\frac{p_E}{p_j a_j})Q_j}{p_j(1-\frac{p_E}{p_j a_j})Q_j} = \alpha_{jL}$$

and hence $s_j^K = 1 - s_j^L$. Using data on wages (calculated as value added divided by hours of work) and on employment shares, we calibrate the disutility of labor. Specifically,

$$share_j^L \equiv \frac{L_j}{L_1+L_2+L_3} = \frac{(\frac{w_j}{\chi_j})^{1/\eta}}{(\frac{w_1}{\chi_1})^{1/\eta}+(\frac{w_2}{\chi_2})^{1/\eta}+(\frac{w_3}{\chi_3})^{1/\eta}} = \frac{(\frac{w_j}{w_1}\frac{\chi_1}{\chi_j})^{1/\eta}}{1+(\frac{w_2}{w_1}\frac{\chi_1}{\chi_2})^{1/\eta}+(\frac{w_3}{w_1}\frac{\chi_1}{\chi_3})^{1/\eta}}$$

and hence $\chi_2 = \chi_1\left(\frac{w_2}{w_1}\right)\left(\frac{share_1^L}{share_2^L}\right)^{\eta}$ and $\chi_3 = \chi_1\left(\frac{w_3}{w_1}\right)\left(\frac{share_1^L}{share_3^L}\right)^{\eta}$.

Using cost share and relative wages, we can link employment shares to output shares

$$share_j^Y \equiv \frac{Y_j}{Y_1+Y_2+Y_3} = \frac{L_j w_j/\alpha_{jL}}{\sum_{i=1}^3 L_i w_i/\alpha_{iL}} = \frac{(\frac{w_j}{w_1})\frac{share_j^L}{\alpha_{jL}}}{1+(\frac{w_2}{w_1})\frac{share_2^L}{\alpha_{2L}}+(\frac{w_3}{w_1})\frac{share_3^L}{\alpha_{3L}}}$$

and verify that output shares are consistent with employment shares and relative wages.

We can also impute prices of Soviet and service goods using wages and capital/labor ratios. Note that we can combine first order conditions for capital and labor to get

$$\frac{\alpha_{1L}}{\alpha_{1K}}\frac{K_1}{L_1} = w_1,\; p_2\frac{\alpha_{2L}}{\alpha_{2K}}\frac{K_2}{L_2} = w_2,\; p_3\frac{\alpha_{3L}}{\alpha_{3K}}\frac{K_3}{L_3} = w_3$$

and therefore $p_2 = \frac{w_2}{w_1}\times\frac{(\frac{\alpha_{1L}}{\alpha_{1K}}\frac{K_1}{L_1})}{(\frac{\alpha_{2L}}{\alpha_{2K}}\frac{K_2}{L_2})}, \quad p_3 = \frac{w_3}{w_1}\times\frac{(\frac{\alpha_{1L}}{\alpha_{1K}}\frac{K_1}{L_1})}{(\frac{\alpha_{3L}}{\alpha_{3K}}\frac{K_3}{L_3})}$.

Given the implied prices of goods, we can compute the energy requirements from:

$$\text{Energy Requirement} \equiv ER_j \equiv \frac{p_E E_j}{Q_j(p_j - p_E/a_j)} = \frac{p_E Q_j/a_j}{Q_j(p_j - p_E/a_j)} \Rightarrow a_j = \frac{p_E(1+ER_j)}{p_j ER_j}.$$

The implied share of Soviet export in total export is given by:

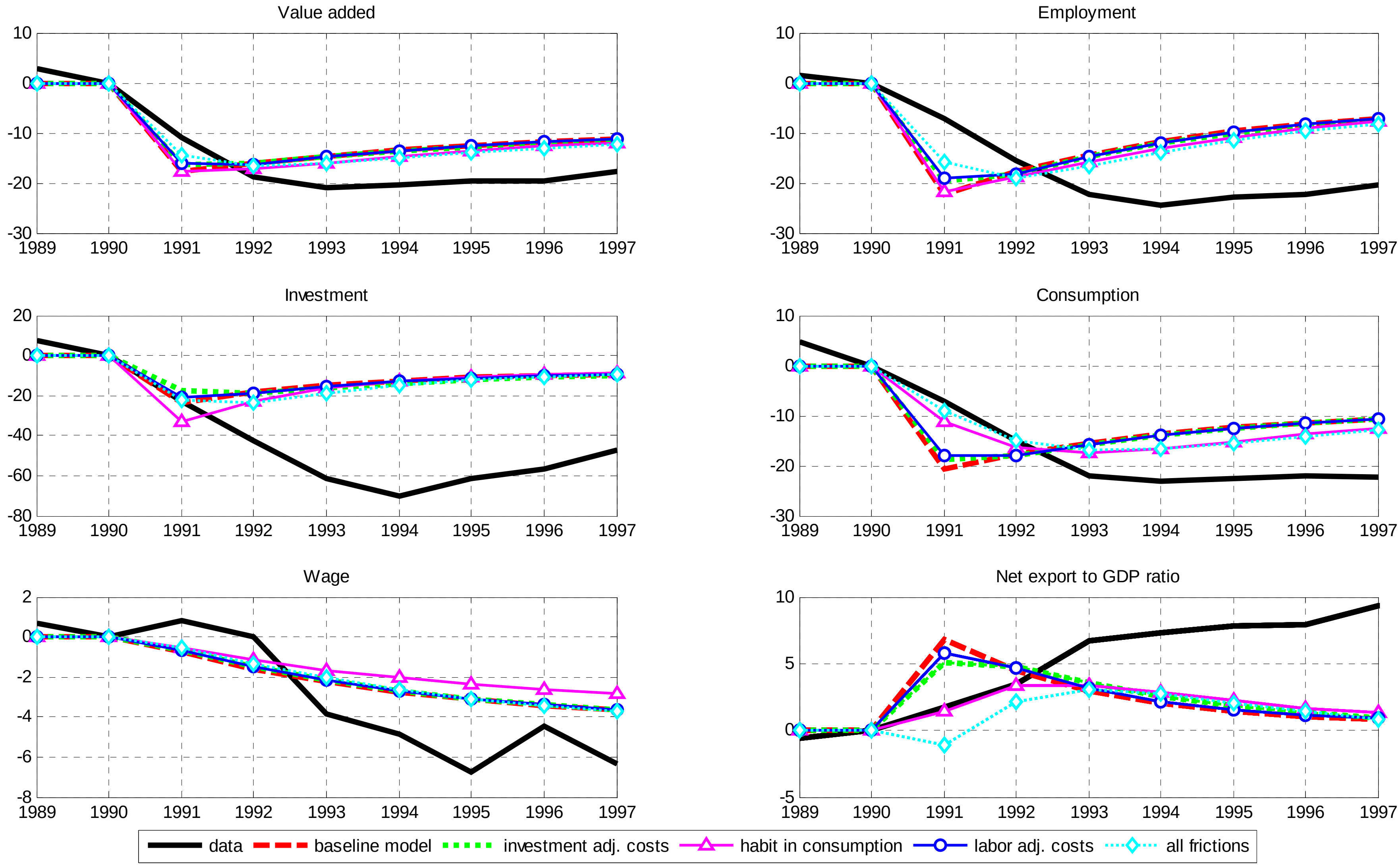
$$\frac{p_2 X_{2j}}{X_1+p_2X_{2j}} = \frac{p_E(E_1+E_2+E_3)}{p_E(E_1+E_2+E_3)+X_1} = \frac{\frac{p_E VA_1}{(a_1-p_E)}+\frac{p_E VA_2}{(p_2a_2-p_E)}+\frac{p_E VA_3}{(p_3a_3-p_E)}}{\frac{p_E VA_1}{(a_1-p_E)}+\frac{p_E VA_2}{(p_2a_2-p_E)}+\frac{p_E VA_3}{(p_3a_3-p_E)}+\frac{VA_1}{(1-p_E/a_1)}\times\frac{(\zeta_4/\zeta_1)}{1+(\zeta_4/\zeta_1)}\times[1-\frac{\beta(1-p_E/a_1)\alpha_{1K}\delta}{1-\beta(1-\delta)}]}$$

$$= \frac{\frac{p_E share_1^Y}{(a_1-p_E)}+\frac{p_E share_2^Y}{(p_2a_2-p_E)}+\frac{p_E share_3^Y}{(p_3a_3-p_E)}}{\frac{p_E share_1^Y}{(a_1-p_E)}+\frac{p_E share_2^Y}{(p_2a_2-p_E)}+\frac{p_E share_3^Y}{(p_3a_3-p_E)}+\frac{share_1^Y}{(1-p_E/a_1)}\times\frac{(\zeta_4/\zeta_1)}{1+(\zeta_4/\zeta_1)}\times[1-\frac{\beta(1-p_E/a_1)\alpha_{1K}\delta}{1-\beta(1-\delta)}]}$$

Hence, we can calibrate key parameters of the model using data cost shares, employment shares, wages, and capital/labor ratios.

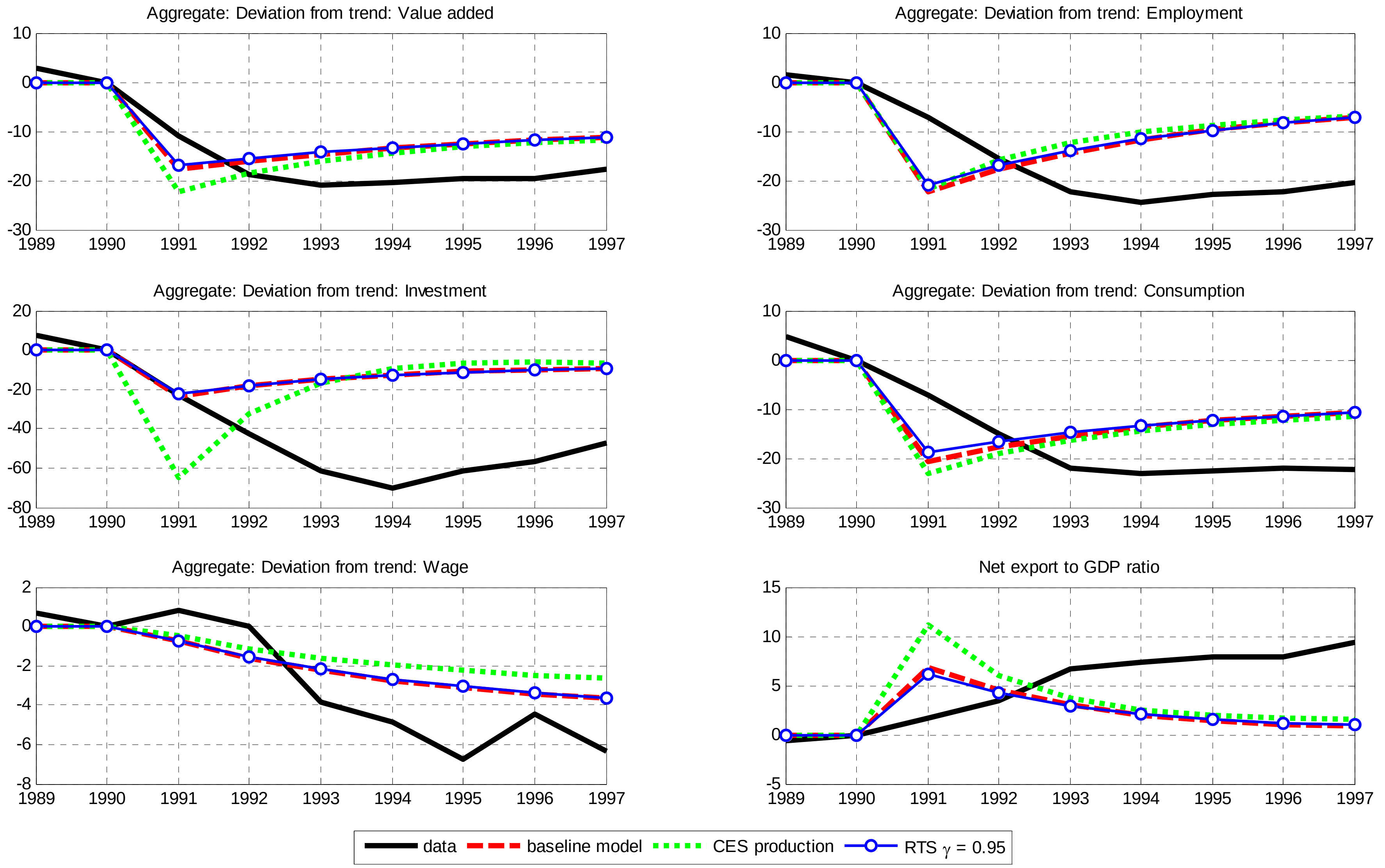
Appendix D: Sensitivity analysis

Figure D1. Macroeconomic aggregates: Effects of adjustment costs and habit formation.



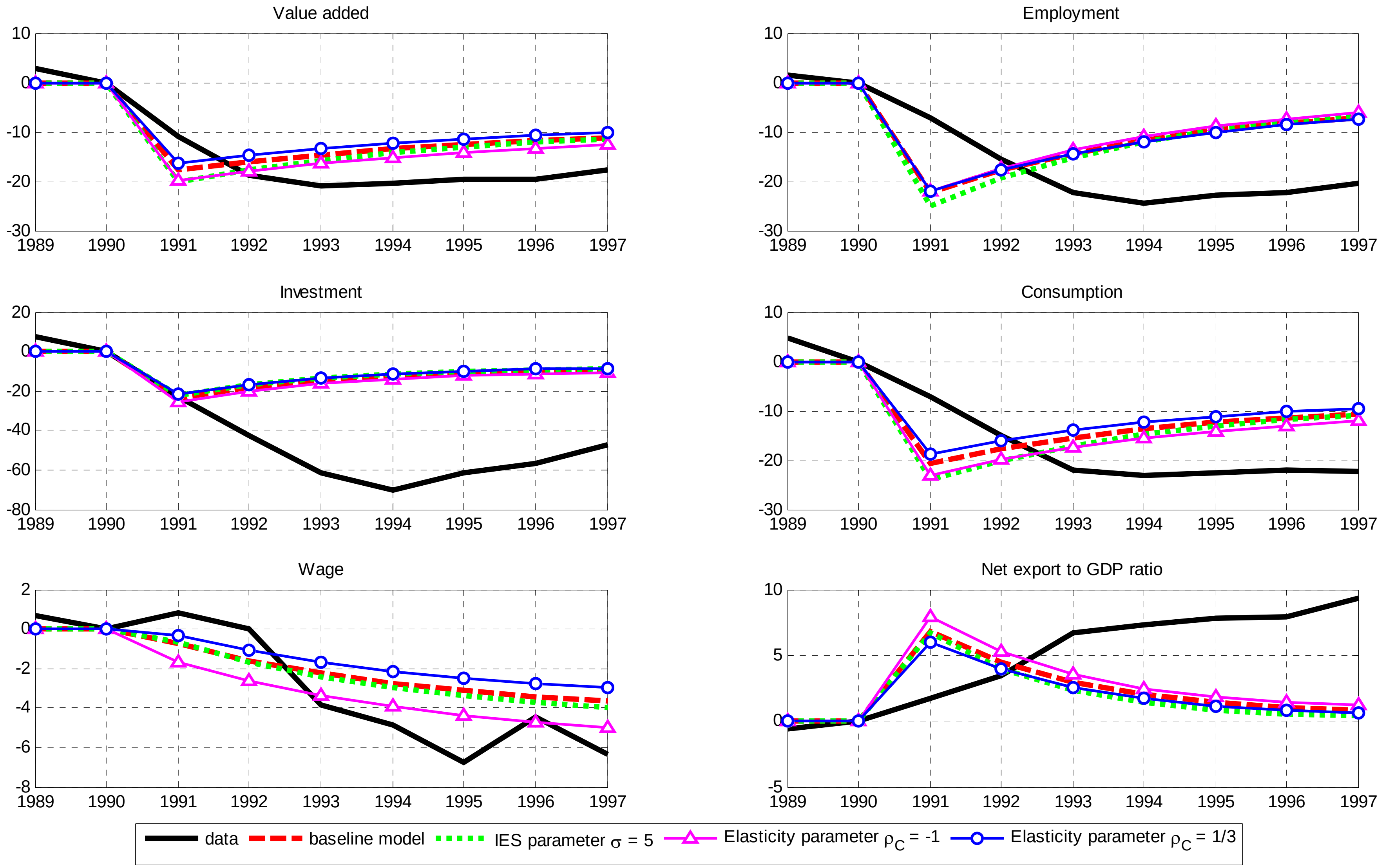
Notes: The figures plot percent deviations from trend for all variables except net export to GDP ratio. See Appendix B for more details on detrending. Trade shock is the shock with corresponds to setting trade with USSR to zero while keeping the oil price constant. Oil price shock is the 10 percent increase in the oil price while keeping the volume of trade with the USSR constant. Scenario "all frictions" includes habit formation in consumption (h = 0.8 for types of consumption goods), investment adjustment costs (ψ=0.5 in all sectors), and labor adjustment costs (λ=1 in all sectors).

Figure D2. Macroeconomic aggregates: Effects of production function parameters.



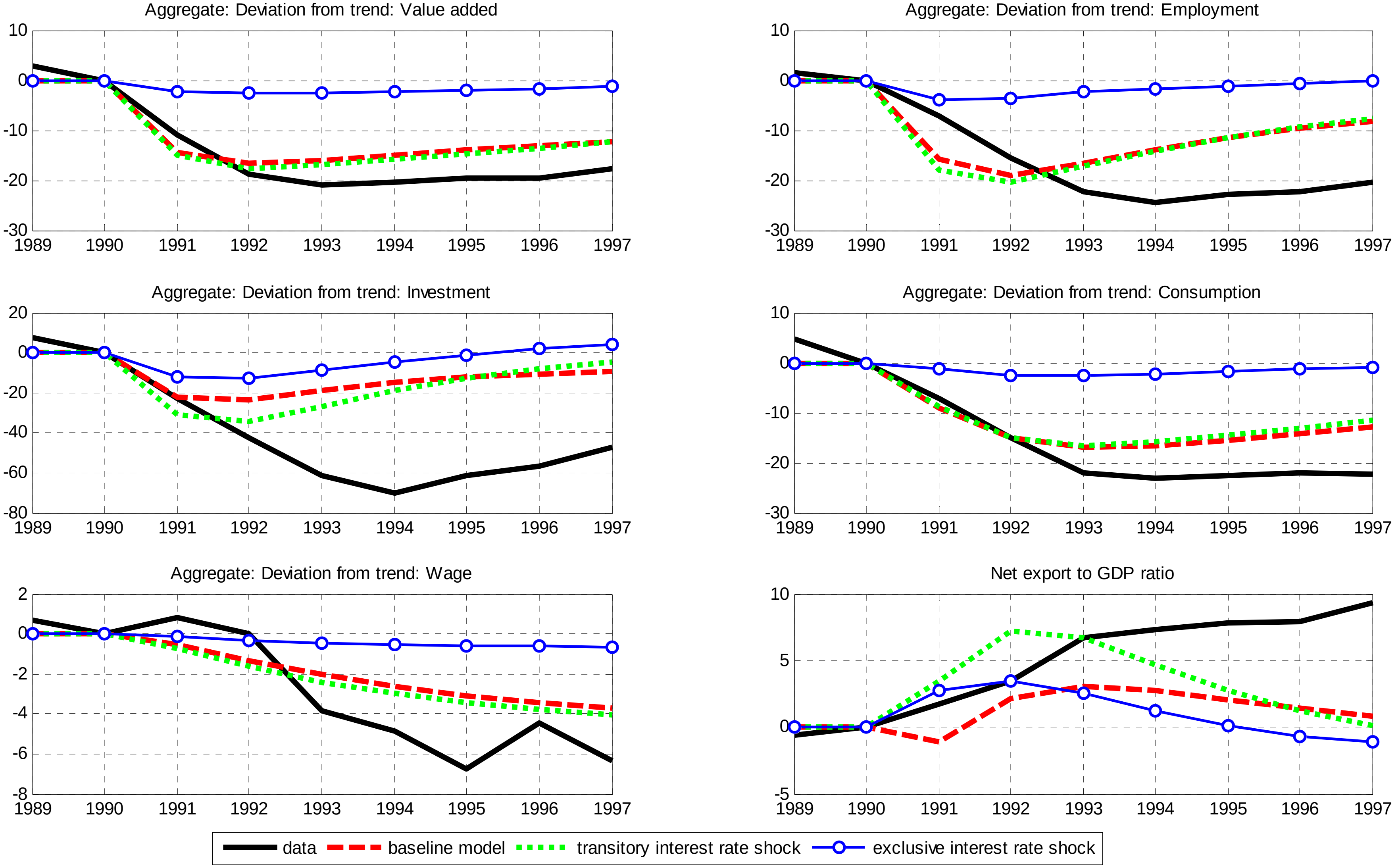
Notes: The figures plot percent deviations from trend for all variables except net export to GDP ratio. See Appendix B for more details on detrending. Trade shock is the shock with corresponds to setting trade with USSR to zero while keeping the oil price constant. Oil price shock is the 10 percent increase in the oil price while keeping the volume of trade with the USSR constant. Scenario "CES production" assumes CES production function in all sectors with elasticity of substitution between capital and labor equal to 0.5. Scenario "RTS γ =0.95" sets returns to scale in each sector equal to 0.95.

Figure D3. Macroeconomic aggregates: Effects of consumption parameters.



Notes: The figures plot percent deviations from trend for all variables except net export to GDP ratio. See Appendix B for more details on detrending. Trade shock is the shock with corresponds to setting trade with USSR to zero while keeping the oil price constant. Oil price shock is the 10 percent increase in the oil price while keeping the volume of trade with the USSR constant. Scenario "IES parameter $\sigma = 5$" corresponds to setting intertemporal elasticity of substitution to 1/5. Scenario "Elasticity parameter $\rho_C = -1$" corresponds to setting the elasticity of substation across consumption goods (in the consumption aggregator) equal to ½. Scenario "Elasticity parameter $\rho_C = 0.33$" corresponds to setting the elasticity of substation across consumption goods (in the consumption aggregator) equal to 1.5.

Figure D4. Macroeconomic aggregates: Interest rate shock.



Notes: The figures plot percent deviations from trend for all variables except net export to GDP ratio. See Appendix B for more details on detrending. Trade shock is the shock with corresponds to setting trade with USSR to zero while keeping the oil price constant. Oil price shock is the 10 percent increase in the oil price while keeping the volume of trade with the USSR constant. All models include frictions such as habit formation in consumption (h = 0.8 for types of consumption goods), investment adjustment costs (ψ=0.5 in all sectors), and labor adjustment costs (λ=1 in all sectors).

Appendix E: Auxiliary tables and figures.

Table E1. Static cost of the collapse in Soviet trade.

		1989	1990	1991
Panel A:				
A	Imports from the USSR	14,816	12,655	7,455
F	Exports to the USSR	16,160	14,324	4,520
	Change in prices in Soviet trade (%Δ from previous year)			
C	Export prices	6.17	25.02	-24.33
B	Import prices	22.43	12.99	-5.86
D	Price premium in Soviet market in 1990 (markup over price available in other markets)		36	36
H	Change in export volume to USSR		-11.36	-68.44
J	Increase in the domestic price of energy		15.98	-1.14
K	Value of energy imports from USSR (at domestic prices)		7,642	6,009
L	Reduction in energy use by subsidized users		-0.94	-2.43
M Market loss effect = **D** × **F**(-1) × **H**			-661	-3529
N Terms of trade effect = **A** × (**C** – **B**)			1,522	-1,376
R Removal of subsidy effect = ½ × **J** × **K** ×**L**			-5.8	0.8
Total loss of income = **M** + **N** + **R**			856	-4,905
Total loss of income (million USD)				-1,212
Gross Domestic Product (GDP)			521,021	498,067
Private sector value added (PSVA)			389,798	356,207
Total loss of income				
% of GDP			0.16%	-0.98%
% of PSVA			0.22%	-1.38%
Lost ruble surpluses (million Finnish markka)				-7,500
Lost ruble surpluses (million USD)				-1,853
Total loss of income incl. lost ruble surpluses				
% of GDP				-2.5%
% of PSVA				-3.5%

Panel B:

Cumulative 1990-1991 total loss of income	% of GDP	Billion USD
Poland	-3.5%	-2.20
Hungary	-7.8%	-1.97
Czech Republic	-7.5%	-3.40

Note: The cost of the collapsed trade is compute according to the method developed in Rodrik (1994). Estimate of cumulative shocks for Poland, Hungary and Czech Republic are taken from Rodrik (1994). Unless indicated, Finnish exports, imports, value added, and lost ruble reserves are in million of Finnish markka. Sources: Finnish Ministry of Statistics, OECD STAN database.

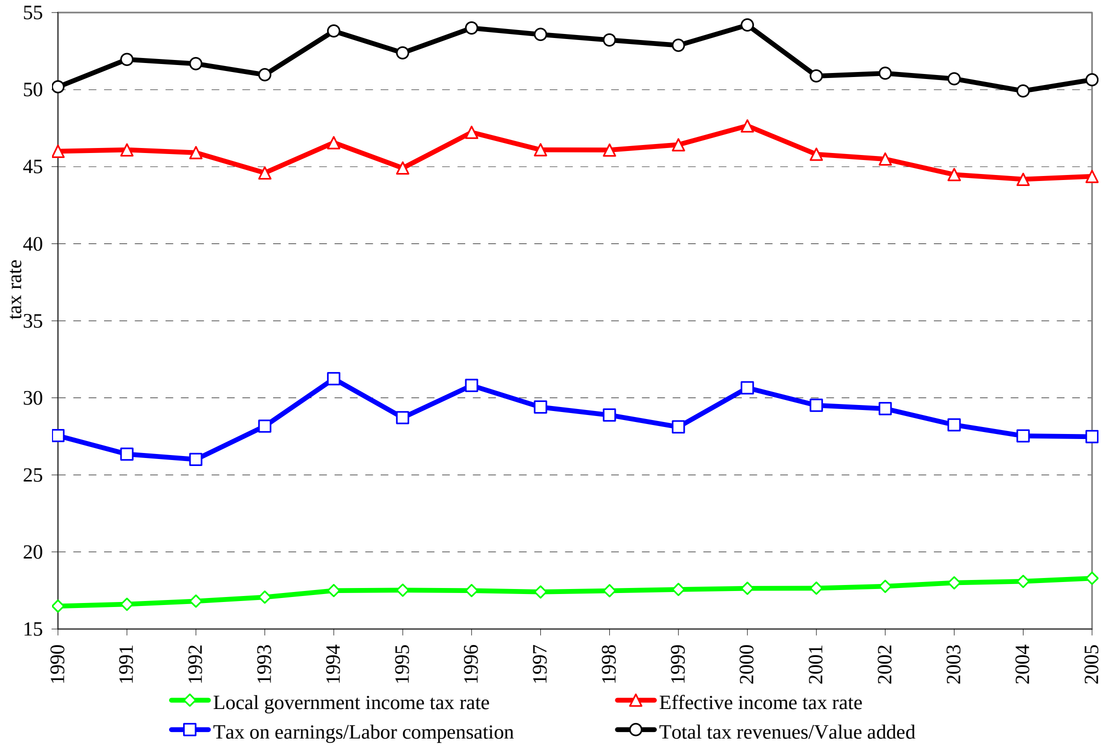
Table E2. Wage bargaining agreements.

Year	Agreement	Period of validity	Increase effective from	General Increase %	General Increase p/hour	Minimum and low-pay increase %	Average increase[28] %	Reforms Related to Centralized Agreement
1988	Union-level agreements	2 year	01.03.1988		98-145		5.3	
1989	Combined economic and incomes policy settlement	1 year	01.03.1989	min. 1	40	0.1%	3.6	– employees' real disposable income to be increased by 2.5 % – earnings development guarantee of 70 p above the agreed increase paid in addition to the general and equality raise
1990	Kallio 15.01.1990	2 year	01.03.1990 01.10.1990	min. 0.7 min. 0.7	30 30	0.4%	5.4	– state measures, including tax revision – target for growth in employees' real disposable incomes 1990 - 91 4.5% – earnings development guarantee III/89 - III/90 4% above agreed increase
1991	2nd phase 15.11.1990		01.05.1991	min. 0.9	50	0.3%	1.7	– shop stewards agreement – working time issues – adult education, housing and social policy measures
1992	Ihalainen-Kahri 29.11.1991	2 year	Present agreement prolonged to 31.11.1993	0	0	0	0.2	– financing of employment pensions and the employees' contribution – government measures including maintaining
1993	Ihalainen-Kahri 2nd phase 30.11.1992			0	0	0	0	– the level of unemployment benefits – development of agreements' system
1994	Union-level agreements	1 year	1.11.1993				3.2	
1995	Union-level agreements	1-2 year					5.2	
1996	Economic, Employment and Labor Market Policy	2 year	1.11.1995	min. 1.8	105		2.1	– indexation clause – earnings development guarantee 1996 and 1997 – working life development
	Agreement 1996 - 97 10.9.1995		1.10.1996	min. 1.3	65	0.3%	1.7	– state measures i.e. concerning taxation and unemployment security
1997	2nd phase						0.0	
1998	Incomes policy agreement 1998 - 1999 12.12.1997	2 year	1.1.1998	min. 1.6	85 p	0.3%	2.5	– indexation clause – earnings development examination – quality of working life – taxation measures
1999	2nd phase		1.1.1999	min. 1.6	85 p		1.7	

Source: Central Organization of Finnish Trade Unions (SAK).

[28] Industrial workers.

Figure E1. Tax burden.



Note: This figure reports the tax burden on income. Source: OECD, Finnish Ministry of Finance.

Appendix F: Log-linearized model

Hats denote percent deviations from steady state. This model allows for adjustment costs in investment and labor as well as habit formation in consumption. This generalized model has the following modifications in the consumer and firm problems. Specifically, we assume that the consumption aggregator is given by $G_t = \left\{ \zeta_1 \bar{C}_{1t}^{\rho_C} + \zeta_2 \bar{C}_{2t}^{\rho_C} + \zeta_3 \bar{C}_{3t}^{\rho_C} + \zeta_4 \bar{C}_{4t}^{\rho_C} \right\}^{1/\rho_C}$ where $1/(1-\rho_C)$ is the elasticity of substitution in consumption, ζ_j are weights in the consumption aggregator, $\bar{C}_{jt} = \frac{1}{1-h_j} C_{jt} - \frac{h_j}{1-h_j} C_{j,t-1}$ is the habit-adjusted consumption for good *j*, and parameter h_j describes habit in consuming good *j*. Firm's objective (profit) function is $\sum_{t=0}^{\infty} \frac{1}{\prod_{s=o}^{t} R_s} \Big(p_{jt} Q_{jt} - p_t^E E_{jt} - w_{jt} L_{jt} - p_{jt} I_{jt} - p_{jt} \{ \frac{\phi_j}{2} (\frac{K_{jt}}{K_{j,t-1}} - 1)^2 K_{j,t-1} + \frac{\psi_j}{2} (\frac{I_{jt}}{I_{j,t-1}} - 1)^2 I_{j,t-1} + \frac{\lambda_j}{2} (\frac{L_{jt}}{L_{j,t-1}} - 1)^2 L_{j,t-1} \} \Big)$, where the parameters $\phi_j, \psi_j, \lambda_j$ are adjustment cost coefficients on capital, investment and labor respectively.

Household problem

$$\frac{\partial \ell}{\partial C_{1t}} = \hat{U}'_{C_1} - \hat{\mu}_{1t} = 0,\ \frac{\partial \ell}{\partial C_{2t}} = \hat{U}'_{C_2} - \hat{p}_{2t} - \hat{\mu}_{1t} = 0,\ \frac{\partial \ell}{\partial C_{3t}} = \hat{U}'_{C_3} - \hat{p}_{3t} - \hat{\mu}_{1t} = 0,\ \frac{\partial \ell}{\partial C_{4t}} = \hat{U}'_{C_4} - \hat{p}_{4t} - \hat{\mu}_{1t} = 0,$$

$$\frac{\partial \ell}{\partial L_{1t}} = \hat{U}'_{L_1} + \hat{w}_{1t}^D + \hat{\mu}_{1t} = 0,\ \frac{\partial \ell}{\partial L_{2t}} = \hat{U}'_{L_2} + \hat{w}_{2t}^D + \hat{\mu}_{1t} = 0,\ \frac{\partial \ell}{\partial L_{3t}} = \hat{U}'_{L_3} + \hat{w}_{3t}^D + \hat{\mu}_{1t} = 0,$$

$$-\hat{B}_t + (1+r)\hat{B}_{t-1} + (1+r)\hat{R}_t + \frac{w_1 L_1}{S}(\hat{w}_{1t} + \hat{L}_{1t}) + \frac{w_2 L_2}{S}(\hat{w}_{2t} + \hat{L}_{2t}) + \frac{w_3 L_3}{S}(\hat{w}_{3t} + \hat{L}_{3t})$$
$$- \frac{C_1}{S}\hat{C}_{1t} - \frac{p_2 C_2}{S}(\hat{p}_{2t} + \hat{C}_{2t}) - \frac{p_3 C_3}{S}(\hat{p}_{3t} + \hat{C}_{3t}) - \frac{p_4 C_4}{S}(\hat{p}_{4t} + \hat{C}_{4t}) + \frac{\pi_1}{S}\hat{\pi}_{1t} + \frac{\pi_2}{S}\hat{\pi}_{2t} + \frac{\pi_3}{S}\hat{\pi}_{3t} = 0,$$

$$-\hat{L}_t + \frac{L_1}{L_1+L_2+L_3}\hat{L}_{1t} + \frac{L_2}{L_1+L_2+L_3}\hat{L}_{2t} + \frac{L_3}{L_1+L_2+L_3}\hat{L}_{3t} = 0,$$

$$\frac{\partial \ell}{\partial B_t} = -\hat{\mu}_{1t} + \hat{\mu}_{1,t+1} + \hat{R}_{t+1} = 0\,.$$

Utility

$$U'_{C_{1t}} = \underbrace{\left(G_t - \frac{\chi_1}{\eta_1+1} L_{1t}^{\eta_1+1} - \frac{\chi_2}{\eta_2+1} L_{2t}^{\eta_2+1} - \frac{\chi_3}{\eta_3+1} L_{3t}^{\eta_3+1} \right)^{-\sigma}}_{U_0} G'_{C_{1t}} = U_{0t} G'_{C_{1t}} = \frac{1}{1-h_1} U_{0t} s_{\bar{C}_1 t} G_t / \bar{C}_{1t} - \frac{\beta h_1}{1-h_1} U_{0,t+1} s_{\bar{C}_1,t+1} G_{t+1} / \bar{C}_{1t+1}\,.$$

Note that in steady state $\bar{C}_j = C_j$ and $U'_{C_j t} = \frac{1-\beta h_j}{1-h_j} U_0 s_{\bar{C}_j} G / \bar{C}_j$.

$\hat{U}_0 = -\sigma(s_G \hat{G}_t + s_{L_1}(1+\eta_1)\hat{L}_{1t} + s_{L_2}(1+\eta_2)\hat{L}_{2t} + s_{L_3}(1+\eta_3)\hat{L}_{3t})$ where

$s_G = G_t / (G_t - \frac{\chi_1}{\eta_1+1} L_{1t}^{\eta_1+1} - \frac{\chi_2}{\eta_2+1} L_{2t}^{\eta_2+1} - \frac{\chi_3}{\eta_3+1} L_{3t}^{\eta_3+1})$ and $s_{L_j} = -\frac{\chi_j}{\eta_j+1} L_{jt}^{\eta_j+1} / (G_t - \frac{\chi_1}{\eta_1+1} L_{1t}^{\eta_1+1} - \frac{\chi_2}{\eta_2+1} L_{2t}^{\eta_2+1} - \frac{\chi_3}{\eta_3+1} L_{3t}^{\eta_3+1})$.

Hence $\hat{G}_t = s_{C_1}\hat{\bar{C}}_{1t} + s_{C_2}\hat{\bar{C}}_{2t} + s_{C3}\hat{\bar{C}}_{3t} + s_{C_4}\hat{\bar{C}}_{4t}$ and

$$\hat{s}_{\bar{C}_1 t} = \rho_C \left[(1-s_{C_1})\hat{\bar{C}}_{1t} - s_{C_2}\hat{\bar{C}}_{2t} - s_{C3}\hat{\bar{C}}_{3t} - s_{C_4}\hat{\bar{C}}_{4t} \right] = \rho_C \hat{\bar{C}}_{1t} - \rho_C \hat{G}_t \text{ where } \hat{\bar{C}}_{1t} = \frac{1}{1-h_1}\hat{C}_{1t} - \frac{h_1}{1-h_1}\hat{C}_{1,t-1}\,.$$

It follows that

$$\hat{U}'_{C_j t} = \frac{1}{1-\beta h_j}(\hat{U}_{0t} + \hat{s}_{C_j,t} + \hat{G}_t - \hat{\bar{C}}_{jt}) - \frac{\beta h_j}{1-\beta h_j}(\hat{U}_{0,t+1} + \hat{s}_{C_j,t+1} + \hat{G}_{t+1} - \hat{\bar{C}}_{jt+1}) =$$
$$= \frac{1}{1-\beta h_j}(\hat{U}_{0t} + (1-\rho_C)\hat{G}_t + (\rho_C - 1)\hat{\bar{C}}_{jt}) - \frac{\beta h_j}{1-\beta h_j}(\hat{U}_{0,t+1} + (1-\rho_C)\hat{G}_{t+1} + (\rho_C - 1)\hat{\bar{C}}_{jt+1})$$

$$U'_{L_j} = \underbrace{\left(G - \frac{\chi_1}{\eta_1+1} L_{1t}^{\eta_1+1} - \frac{\chi_2}{\eta_2+1} L_{2t}^{\eta_2+1} - \frac{\chi_3}{\eta_3+1} L_{3t}^{\eta_3+1} \right)^{-\sigma}}_{U_0} (-\chi_j L_{jt}^{\eta_j}) = -U_0 \chi_j L_{jt}^{\eta_j} \text{ and hence } \hat{U}'_{L_j} = -\hat{U}_0 - \eta_j \hat{L}_{jt}.$$

Firm's problem in the non-Soviet sector

$$\frac{\partial \ell}{\partial K_{1t}} = -\hat{\upsilon}_{1t} - \hat{R}_{t+1} + \frac{F'_{1K}}{F'_{1K} + (1-\delta)}\hat{F}'_{1K,t+1} + \frac{\phi_1}{F'_{1K} + (1-\delta)}\hat{K}_{1,t+1} - \frac{\phi_1}{F'_{1K} + (1-\delta)}\hat{K}_{1t},$$

$$\frac{\partial \ell}{\partial I_{1t}} = -\hat{\upsilon}_{1t} + \phi_1(\hat{K}_{1t} - \hat{K}_{1t-1}) + \psi_1(\hat{I}_{1t} - \hat{I}_{1t-1}) - \beta\psi_1(\hat{I}_{1t+1} - \hat{I}_{1t}) = 0,$$

$$\frac{\partial \ell}{\partial L_{1t}} = \hat{F}'_{1Lt} - \hat{w}_{1t} - \frac{\lambda_1}{w_1}(\hat{L}_{1t} - \hat{L}_{1t-1}) + \frac{\beta\lambda_1}{w_1}(\hat{L}_{1,t+1} - \hat{L}_{1t}) = 0,$$

$$\hat{\pi}_{1t} = \tfrac{Y_1}{\pi_1} Y_{1t} - \tfrac{w_1 L_1}{\pi_1}(\hat{w}_{1t} + \hat{L}_{1t}) - \tfrac{(\delta+r)K_1}{\pi_1}\hat{K}_{1t-1},$$
$$\hat{Q}_{1t} = \gamma_1 s_{1K}\hat{K}_{1,t-1} + \gamma_1 s_{1L}\hat{L}_{1t},$$
$$\hat{F}'_{1L} = \hat{s}_{1L,t} + \hat{Y}_{1t} - \hat{L}_{1t} = \rho_P\left[-s_{1L}\hat{L}_{1t} - s_{1K}\hat{K}_{1,t-1}\right] + \hat{Y}_{1t} + (\rho_P - 1)\hat{L}_{1t},$$
$$F'_{1K} = \hat{s}_{1K,t} + \hat{Y}_{1t} - \hat{K}_{1,t-1} = \rho_P\left[-s_{1L}\hat{L}_{1t} - s_{1K}\hat{K}_{1,t-1}\right] + \hat{Y}_{1t} + (\rho_P - 1)\hat{K}_{1,t-1},$$
$$\hat{Y}_{1t} = \hat{Q}_{1t} - \tfrac{p^E/a_{1E}}{1-p^E/a_{1E}}\hat{p}_t^E,\ \ \hat{E}_{1t} = \hat{Q}_{1t},\ \ -\hat{K}_{1t} + (1-\delta)\hat{K}_{1,t-1} + \hat{I}_{1t} = 0.$$

Firm's problem in the Soviet sector

$$\tfrac{\partial \ell}{\partial K_{2t}} = -\hat{\upsilon}_{2t} - \hat{R}_{t+1} + \tfrac{F'_{2K}}{F'_{2K} + p_2(1-\delta)}\hat{F}'_{2K,t+1} + \tfrac{p_2(1-\delta)}{F'_{2K} + p_2(1-\delta)}\hat{\upsilon}_{2,t+1} + \tfrac{p_2\phi_2\delta}{F'_{2K} + p_2(1-\delta)}\hat{K}_{2,t+1} - \tfrac{p_2\phi_2\delta}{F'_{2K} + p_2(1-\delta)}\hat{K}_{2t},$$
$$\tfrac{\partial \ell}{\partial I_{2t}} = -\hat{\upsilon}_{2t} + \hat{p}_{2t} + \phi_2(\hat{K}_{2t} - \hat{K}_{2t-1}) + \psi(\hat{I}_{2t} - \hat{I}_{2t-1}) - \beta\psi_2(\hat{I}_{2t+1} - \hat{I}_{2t}) = 0,$$
$$\tfrac{\partial \ell}{\partial L_{2t}} = \hat{F}'_{2Lt} - \hat{w}_{2t} - \tfrac{p_2\lambda_2}{w_2}(\hat{L}_{2t} - \hat{L}_{2t-1}) + \tfrac{\beta p_2\lambda_2}{w_2}(\hat{L}_{2,t+1} - \hat{L}_{2t}) = 0,$$
$$\hat{\pi}_{2t} = \tfrac{Y_2}{\pi_2} Y_{2t} - \tfrac{w_2 L_2}{\pi_2}(\hat{w}_{2t} + \hat{L}_{2t}) - \tfrac{(\delta+r)K_2 p_2}{\pi_2}(\hat{p}_{2t} + \hat{K}_{2t-1}),$$
$$\hat{Q}_{2t} = \gamma_2 s_{2K}\hat{K}_{2,t-1} + \gamma_2 s_{2L}\hat{L}_{2t},$$
$$\hat{F}'_{2L} = \hat{s}_{2L,t} + \hat{Y}_{2t} - \hat{L}_{2t} = \rho_P\left[-s_{2L}\hat{L}_{2t} - s_{2K}\hat{K}_{2,t-1}\right] + \hat{Y}_{2t} + (\rho_P - 1)\hat{L}_{2t},$$
$$F'_{2K} = \hat{s}_{2K,t} + \hat{Y}_{2t} - \hat{K}_{2,t-1} = \rho_P\left[-s_{2L}\hat{L}_{2t} - s_{2K}\hat{K}_{2,t-1}\right] + \hat{Y}_{2t} + (\rho_P - 1)\hat{K}_{2,t-1},$$
$$\hat{Y}_{2t} = \hat{Q}_{2t} + \tfrac{p_2}{p_2 - p^E/a_{2E}}\hat{p}_{2t} - \tfrac{p^E/a_{2E}}{p_2 - p^E/a_{2E}}\hat{p}_t^E,\ \ \hat{E}_{2t} = \hat{Q}_{2t},\ \ -\hat{K}_{2t} + (1-\delta)\hat{K}_{2,t-1} + \hat{I}_{2t} = 0.$$

Firm's problem in the Service sector

$$\tfrac{\partial \ell}{\partial K_{3t}} = -\hat{\upsilon}_{3t} - \hat{R}_{t+1} + \tfrac{F'_{3K}}{F'_{3K} + p_3(1-\delta)}\hat{F}'_{3K,t+1} + \tfrac{p_3(1-\delta)}{F'_{3K} + p_3(1-\delta)}\hat{\upsilon}_{3,t+1} + \tfrac{p_3\phi_3\delta}{F'_{3K} + p_3(1-\delta)}\hat{K}_{3,t+1} - \tfrac{p_3\phi_3\delta}{F'_{3K} + p_3(1-\delta)}\hat{K}_{3t},$$
$$\tfrac{\partial \ell}{\partial I_{3t}} = -\hat{\upsilon}_{3t} + \hat{p}_{3t} + \phi_3(\hat{K}_{3t} - \hat{K}_{3t-1}) + \psi_3(\hat{I}_{3t} - \hat{I}_{3t-1}) - \beta\psi_3(\hat{I}_{3t+1} - \hat{I}_{3t}) = 0,$$
$$\tfrac{\partial \ell}{\partial L_{3t}} = \hat{F}'_{3Lt} - \hat{w}_{3t} - \tfrac{p_3\lambda_3}{w_3}(\hat{L}_{3t} - \hat{L}_{3t-1}) + \tfrac{\beta p_3\lambda_3}{w_3}(\hat{L}_{3,t+1} - \hat{L}_{3t}) = 0,$$
$$\hat{\pi}_{3t} = \tfrac{Y_3}{\pi_3} Y_{3t} - \tfrac{w_3 L_3}{\pi_3}(\hat{w}_{3t} + \hat{L}_{3t}) - \tfrac{(\delta+r)K_3 p_3}{\pi_3}(\hat{p}_{3t} + \hat{K}_{3t-1}),$$
$$\hat{Q}_{3t} = \gamma_3 s_{3K}\hat{K}_{3,t-1} + \gamma_3 s_{3L}\hat{L}_{3t},$$
$$\hat{F}'_{3L} = \hat{s}_{3L,t} + \hat{Y}_{3t} - \hat{L}_{3t} = \rho_P\left[-s_{3L}\hat{L}_{3t} - s_{3K}\hat{K}_{3,t-1}\right] + \hat{Y}_{3t} + (\rho_P - 1)\hat{L}_{3t},$$
$$\hat{F}'_{3K} = \hat{s}_{3K,t} + \hat{Y}_{3t} - \hat{K}_{3,t-1} = \rho_P\left[-s_{3L}\hat{L}_{3t} - s_{3K}\hat{K}_{3,t-1}\right] + \hat{Y}_{3t} + (\rho_P - 1)\hat{K}_{3,t-1},$$
$$\hat{Y}_{3t} = \hat{Q}_{3t} + \tfrac{p_3}{p_3 - p^E/a_{3E}}\hat{p}_{3t} - \tfrac{p^E/a_{3E}}{p_3 - p^E/a_{3E}}\hat{p}_t^E,\ \ \hat{E}_{3t} = \hat{Q}_{3t},\ \ -\hat{K}_{3t} + (1-\delta)\hat{K}_{3,t-1} + \hat{I}_{3t} = 0.$$

General equilibrium

$$\hat{Q}_{1t} - \tfrac{C_1}{Q_1}\hat{C}_{1t} - \tfrac{X_1}{Q_1}\hat{X}_{1t} - \tfrac{I_1}{Q_1}\hat{I}_{1t} = 0,$$
$$\hat{Q}_{2t} - \tfrac{C_2}{Q_2}\hat{C}_{2t} - \tfrac{X_2}{Q_2}\hat{X}_{2t} - \tfrac{I_2}{Q_2}\hat{I}_{2t} = 0,$$
$$\hat{Q}_{3t} - \tfrac{C_3}{Q_3}\hat{C}_{3t} - \tfrac{I_3}{Q_3}\hat{I}_{3t} = 0,$$
$$0 = \hat{p}_{2t} + \hat{X}_{2t} - \hat{p}_t^S - \hat{M}_t^S,$$
$$\tfrac{1}{M^S}\hat{M}_t^* + \tfrac{M^S}{M^* + M^S}\hat{M}_t^S - \tfrac{E_1}{E_1+E_2+E_3}\hat{E}_{1t} - \tfrac{E_2}{E_1+E_2+E_3}\hat{E}_{2t} - \tfrac{E_3}{E_1+E_2+E_3}\hat{E}_{3t} = 0,$$
$$\hat{w}_{1t} = \theta_1\hat{w}_{1,t-1} + (1-\theta_1)\hat{w}_{1t}^D,\ \ \hat{w}_{2t} = \theta_2\hat{w}_{2,t-1} + (1-\theta_2)\hat{w}_{2t}^D,\ \ \ \hat{w}_{3t} = \theta_3\hat{w}_{3,t-1} + (1-\theta_3)\hat{w}_{3t}^D.$$