THE FINNISH GREAT DEPRESSION: FROM RUSSIA WITH LOVE*

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Abstract

Why did Finland experience in 1991-93 the deepest recession observed in an industrialized country since the 1930s? Using a dynamic general equilibrium model with labor frictions, we argue the reason was the costly restructuring of the manufacturing sector and sharp increase in energy costs caused by the collapse of trade with the USSR. Finland's experience mirrors that of the transition economies of Eastern Europe, which suffered similar deep recessions coupled with institutional changes. By focusing on the Finnish case we isolate the effects of the Soviet trade collapse and shed new light on the sources of recessions in transition economies.

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1. Introduction

Understanding great depressions has long been one of the central challenges in macroeconomics. The massive costs as well as disagreement over their causes and propagation are subject to continuous debate. We examine the Finnish Great Depression of the early 1990s to shed new light on important transmission mechanisms that can drive depressions through disruption of international trade relationships. We also show that our analysis of the Finnish Great Depression can be useful for understanding the macroeconomic implications of large structural shocks affecting trade arrangements and the terms of trade in other countries (particularly in the case of the transition economies of Eastern Europe in the aftermath of the collapse of the Soviet Union).

During the 1991-93 period, Finland experienced the deepest economic slump in an industrialized country since the 1930s and the deepest recorded peace-time recession in Finnish history. As illustrated in Panel A of Figure 1, between 1990 and 1993 real GDP declined by 11 percent, real consumption declined by 10 percent and investment fell to 55 percent of its 1990 level. The declines are even more dramatic when measured as deviations from trend. Using this metric, value added in the private sector fell about 20 below trend (see Panels C and D in Figure 1). 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 argue that the cause of the Finnish Great Depression was the costly restructuring of the manufacturing sector and a sudden, sharp increase in energy costs caused by the demise of the Soviet Union. The barter-type trade arrangements 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 collapse of the USSR provides a unique natural experiment for which we know with precision the timing, nature and size of the exogenous shocks that hit 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 and calibrate a multi-sector dynamic general equilibrium model that accounts for the key features of the Finnish Great Depression. The model captures the economy's response to the two shocks caused by the collapse of the Soviet Union: the sudden loss of the market for specialized exports to the USSR and the surge in the relative price of imported energy. The model generates large declines in aggregate output, consumption and employment, and replicates the dynamics of the sector devoted to manufacturing goods for export to the USSR, the sector producing goods for the rest of the world, and the nontradables sector. Our simulations suggest that downward wage rigidity coinciding with a contraction

in demand for nontraded goods observed in Finland played a key role in the amplification of the downturn produced by these shocks.

We validate the model by examining its ability to match the behavior of the Finnish economy in a previous episode of a sudden rise in energy costs, the oil price hike of the 1970s. The model does well at reproducing the dynamics of macroeconomic variables in this episode. In addition, we compare the experience of Finland in the aftermath of the collapse of the Soviet Union with that of Sweden. The Swedish economy is widely regarded as sharing many of the same structural features that characterize the Finnish economy, and it went through a similar economic downturn in the early 1990s (including currency and banking crises). Sweden did not, however, have a similar trade relationship with the Soviet Union. Hence this comparison provides us with a natural experiment in which one country (Finland) was hit by the two shocks triggered by the Soviet collapse and the other (Sweden) was not. Our findings from this comparison support the model's quantitative predictions, because the downturn in Sweden was much milder and of shorter duration than in Finland. Finally, we document that Finnish manufacturing industries exposed to Soviet trade experienced a deeper contraction than those that were not.

The impact of the shocks caused by the collapse of Soviet trade 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 the dynamics of real GDP in the Czech Republic, Hungary, Poland, Slovenia, Slovakia, Bulgaria and Finland. The figure captures the familiar "U-shaped" path for output characteristic for TEs (Blanchard and Kremer 1997, Roland and Verdier 1999). The 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 shocks induced by the collapse of trade with the USSR, 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 effects due solely to the shocks caused by the collapse of trade with the USSR from the other burdens of adjustment borne by TEs. To the best of our knowledge, these results provide the first quantitative assessment of the significance of these shocks for explaining the downturn in these economies. To the extent that these shocks, combined with standard macroeconomic reallocation costs and frictions, can account for the depressions in TEs, the role of other factors such as institutional transformations may be smaller than previously thought.

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[1] In an early contribution, Rodrik (1994) explored the possible impact of trade on output in transition economies. He 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 he wrote his article, it was too early to characterize the transition path and U-shaped pattern of output resulting from the loss of trade. Thus, his analysis was necessarily static while we emphasize the dynamic effects. Nonetheless, his work suggested that trade was an important factor in understanding the dramatic decline in output in the early 1990s.

Other studies have offered alternative explanations of the Finnish crisis. One view is that the origins of the Finnish depression were largely financial, working through the banking sector and ultimately triggering a twin currency-banking crisis (Honkapohja and Koskela 1999, Honkapohja et al. 1996). There is little doubt that financial factors played a role in the persistence and amplification of the crisis—yet, Finland was already two years into the depression at the time of the banking crisis and the large depreciation of the Finnish markka. Another view argues that labor tax hikes and negative productivity shocks may have been the culprit (Conesa et al. 2007). However, it is difficult to find evidence of large tax hikes in available tax rate estimates and policy documents of the time. Also, as we argue below, a decline in measured productivity may be a symptom rather than a cause of contraction in a multi-sector economy.

In the next section of the paper we describe the key features of Finland's trading relationship with the USSR that are central to our argument. In Section 3, we develop a dynamic model of the Finnish economy. In Section 4 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 5, we compare our trade theory of the Finnish recession with alternative explanations proposed in the literature. In Section 6, we compare the Finnish experience with the experience of TEs, and discuss how our conclusion for Finland can be extended to TEs. We make concluding remarks in Section 7.

2. Finnish-Soviet Trade

We argue that five factors—factors shared with other countries bordering the USSR—contributed to the deep economic contraction that occurred in Finland following the cancellation of its trade arrangement with the Soviet Union in December 1990. First, the share of total exports to the USSR was large, and a number of heavy manufacturing sectors were particularly dependent on Soviet trade. Second, exports to the USSR were produced to Soviet specifications. Once the Soviet market collapsed, these goods had no alternative market. Third, the trading arrangement involved the exchange of Finnish manufactures for Soviet oil at an overvalued exchange rate. This meant that Finland simultaneously experienced both the collapse of a major export market and an effective increase in the price of energy. Fourth, the loss of trade with the USSR was largely unexpected. Finally, the rigidity of wages in Finland meant that the adjustment to the trade shock resolved itself primarily through increased unemployment, rather than an adjustment in wages. Below we present the evidence on each of these points.

A. *Soviet trade share*

The Soviet Union was Finland's largest trading partner until the collapse of the Soviet regime, accounting for roughly 20 percent of Finnish exports during the 1980s. 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). While some manufacturing sectors were particularly specialized in goods destined for the Soviet market, no sector was fully isolated from the loss of Soviet trade.

B. *Specialized products for the Soviet market*

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 the four-digit level of CCCN classification and finds strong concentration of trade. Conditional on exporting a good 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 identifies 133 items with a Soviet export share exceeding 90 percent. These items constituted approximately 40 percent of exports to the USSR. Kajaste also reports that because of the highly specialized nature of goods traded with countries in the Council of Mutual Economic Assistance (CMEA), 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 virtually obsolete overnight.[2,3]

Figure 2 shows the exports of four industries that sent a significant share of their exports to the USSR (Cable and wire with a Soviet share of total exports of 30 percent in 1990; Railroad equipment

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[2] The fact that Finnish exports to the USSR would have little success in the West was clearly understood at the time. Urho Kekkonen, President of the Republic and an active promoter of economic cooperation with the Soviet Union, wrote 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).

[3] 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 CMEA. Given this concentration, economies of scale were often cited as an important source of profitability in the Finnish-Soviet trade.

with 96 percent; Shipbuilding with 74 percent; and Footwear with 43 percent). 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 trade with the USSR in December of 1990, entire industries had to be reorganized. 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.[4]

C. Overvalued terms of trade

Trade between Finland and the USSR was governed by 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. By the late 1980s the trade arrangements had evolved into a barter of Finnish manufactures for Soviet raw materials, principally crude oil. Trade was to be balanced annually, though arrangements were periodically made to allow for temporary imbalances.[5] Trade imbalances were the 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.[6] 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.

More than 90 percent of imported oil and 100 percent of Finland's imported natural gas came from the USSR. In principle, the rate of exchange of Finnish goods for Soviet energy was to take place at

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[4] 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 array 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.

[5] 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.

[6] Although trade deficits were usually cleared through adjustments in the supply of goods, by the late 1980s the Soviet Union had accumulated a sizable deficit in its "ruble account." The outstanding deficit was approximately 1.5 percent of Finnish GDP and was written off at the time of the collapse of the Soviet Union. We do not take into account the loss of this outstanding debt in the model below, which therefore underestates the wealth effect of the Soviet collapse on the Finnish economy.

world prices. The value of crude oil was easy to observe and was set at the dollar price of crude oil on the world market and then converted to rubles using the official ruble/dollar exchange rate. The market value of Finnish exports to the USSR was less obvious. The evidence suggests that over time the rate of exchange (goods per barrel of oil) tilted in Finland's favor. The first piece of evidence is the response of the business community to the opportunity to export to the USSR. Interviews and surveys with managers and industry experts suggest that exporting to the USSR was a lucrative business for Finnish firms (Kajaste, 1992). Pre-commitment to the five-year contracts eliminated exchange rate and business cycle risk for firms. Kajaste (1992, p. 29) concludes that "[Soviet] exports seem to have been exceptionally profitable."

A more formal measure of the premium associated with exporting to the USSR is the markup on Soviet exports relative to similar goods destined for western markets. Using data from the 1980s, Kajaste (1992) estimates the markup using unit prices of Soviet and non-Soviet exports and finds that the prices of exports to the Soviet Union were at least 9.5 percent higher than those for exports to western markets. We replicate this analysis using trade data at the 5-digit-level of disaggregation for 1990 and find an even larger markup of 36 percent. This 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.[7] Hence, the Finnish economy was subsidized by overvalued prices of Finnish manufactures bartered for Soviet oil so that the effective price of Soviet oil was at least 10 percent cheaper than its market price.

D. The unanticipated collapse of trade

It seems remarkable ex post that Finnish firms, and indeed the world at large, were caught short by the implosion of the Soviet Union. To be sure, trade flows to the Soviet Union had fallen off in the late 1980s. Part of the decline 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 firms to identify those with real authority on the Soviet end of the bargain.

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[7] 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, etc. Other countries had much tighter export controls against the Soviet bloc that were designed to block 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).

However, the expressed belief that the trade arrangement with the USSR would persist appeared in government reports, interviews with policy makers, and corporate forecasts. Even after the announcement that the trade contracts were to be canceled, 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. Nokia, a major exporter of telecommunications technology to the USSR, forecast strong sales to the Soviet Union for 1991. However, actual sales in January and February of 1991 came in at just 2 million markka ($469,000 US) instead of the projected 121 million markka ($28.1 million US), forcing the company to dramatically change its business plan (Haikio, 2001, p. 76).

The collapse was quick and deep. On December 6, 1990 the Soviet authorities informed their Finnish counterparts that all trade arrangements were cancelled without any transitional period. Imports of oil from the (former) USSR fell from 8.2 million tons in 1989 to 1.3 million tons in 1992. Finnish exports to the (former) USSR tumbled down by 84 percent over the same period.

E. Rigidity of the labor market

To fully understand the reaction of the Finnish economy to the shocks caused by the collapse of Soviet trade, it is important to examine the Finnish labor market, which is notable for its very high degree of unionization. In the early 1990s 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 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 for 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.[8] 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.[9] 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.[10] Strikingly, the fraction of workers with no wage change reached 75

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[8] See Snellman (2005) for a more detailed description of the wage bargaining process in Finland.

[9] Appendix D provides a summary of wage agreements in the 1990s.

[10] 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).

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 a country with one of the greatest downward wage rigidities.

3. A Model of the Finnish Economy

In this section we develop a model of the Finnish economy that captures the key features of its trading relationship with the Soviet Union and 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.

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. We use baseline functional forms and parameters that produce equilibrium allocations consistent with the Finnish economy prior to the Soviet trade collapse.[11]

A. Households

The representative household chooses a lifetime plan for consumption and labor allocations to maximize utility taking all goods and factor prices as given. The utility function is $U \equiv \sum_{t=0}^{\infty} \beta^t U(G_t, L_{1t}, L_{2t} L_{3t})$, where G is a consumption aggregator over four consumption goods and L_{jt} for $j = 1,2,3$ is the labor supplied to each sector. The consumption aggregator is given by $G_t = C_{1t}^{\xi_1} C_{2t}^{\xi_2} C_{3t}^{\xi_3} C_{4t}^{(1-\xi_1-\xi_2-\xi_3)}$ where ξ_j are weights in the consumption aggregator, C_{1t} is the consumption of the non-Soviet traded good produced by sector 1, C_{2t} is the consumption of the good produced by the sector with Soviet exposure, C_{3t} is the consumption of services, and C_{4t} is the consumption of a good imported from the western markets.[12]

We follow Greenwood et al. (1988) and assume a period utility function $U(G_t, L_{1t}, L_{2t} L_{3t}) = \frac{1}{1-\sigma}(G_t - \sum_{j=1}^{3} \frac{\chi_j}{1+\eta} L_{jt}^{1+\eta})^{1-\sigma}$ where $1/\sigma$ is the elasticity of intertemporal substitution, $1/\eta$ is the Frisch elasticity of labor supply and χ_j is the scale of disutility from working in sector j. Note that under this

[11] Appendix C shows that our results are robust to relaxing several assumptions of the baseline setup. In particular, we introduce habit persistence in consumption, vary the elasticities of substitution between sectoral labor supplies, allow for adjustment costs in investment and labor, allow for less-than-unitary elasticity of substitution between capital and labor, and introduce imperfect substitutability of labor supply across sectors.

[12] The fourth consumption good allows the model to capture the fact that the Soviet trade accounted only for a fraction of total trade.

assumption households can adjust their labor input in each sector. However, the utility from each type of leisure is not perfectly substitutable so a decrease in labor input in sector 2, which will occur in response to the collapse of export to the Soviet Union, will not translate into a one-for-one increase in labor supply in the other, expanding sectors. In this sense, labor is sector specific and hence wages are not generally equalized across sectors. Total employment is defined as $L_t = L_{1t} + L_{2t} + L_{3t}$.

We assume that households are exclusive owners of domestic firms. Households face the following budget constraint:

$$w_{1t}L_{1t} + w_{2t}L_{2t} + w_{3t}L_{3t} + (q_{1t} + d_{1t})K_{1,t-1} + (q_{2t} + d_{2t})K_{2,t-1} + (q_{3t} + d_{3t})K_{3,t-1} + R_t B_{t-1} = B_t + q_{1t}K_{1t} + q_{2t}K_{2t} + q_{3t}K_{3t} + C_{1t} + p_{2t}C_{2t} + p_{3t}C_{3t} + p_{4t}C_{4t}, \quad (1)$$

where w_{jt} is the wage rate in sector $j = 1,2,3$, B_t is a one-period bond denominated in units of the world tradable good and traded in international markets at the gross world interest rate of R_t, q_{jt} is the price of capital K_{jt} in sector j, d_{jt} is the dividend rate on capital in sector j and p_{jt} is the relative price of goods in sector j (we take good 1 as numeraire so $p_{1t} = 1$).

B. *Firms*

Firms in all three sectors use inputs of capital, labor and energy (E) to produce the final good in that sector. The problem faced by the representative firm in each sector is to choose inputs to maximize profits taking factor prices as given. In sector $j = 1,2,3$, the representative firm solves the following problem:

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

where δ is the rate of depreciation of the capital stock, ϕ is a capital adjustment cost coefficient, and p_t^E is the relative price of energy.

Production functions are given by $Q_{jt} = \min\left\{a_{jE}E_{jt}, \left(L_{jt}^{\alpha_{Lj}} K_{j,t-1}^{1-\alpha_{Lj}}\right)\right\}$, for $j = 1,2,3$, where a_{jE} is the energy requirement in sector j, and α_{Lj} is the labor weight in the capital-labor aggregator. We assume that energy and value added are perfect complements because the ability of firms to substitute away from energy is very small in the short run. At an optimum, no input is wasted so $Q_{jt} = a_{jE}E_{jt}$. Value added is defined as $Y_{jt} = p_{jt}Q_{jt} - p_t^E E_{jt} = (p_{jt} - p_t^E/a_{jE})Q_{jt}$ and the corresponding value added function as $Y_{jt} \equiv F_j(L_{jt}, K_{j,t-1}, p_{jt}, p_t^E)$. Note that for simplicity the three sectors do not have direct linkages via input-output relationships. Using first-order conditions, we can derive expressions for the shadow prices of capital and dividend rates:

$$q_{jt} = p_{jt}\left(1 + \phi\left[\frac{K_{jt}}{K_{j,t-1}} - 1\right]\right),$$

$$d_{jt} = MPK_{j,t+1} - \delta q_{j,t+1} + p_{j,t+1}\phi\left[\frac{K_{j,t+1}}{K_{jt}} - 1\right]\left[\frac{K_{j,t+1}}{K_{jt}} + \delta\right],$$

where $MPK_{j,t+1} = \partial Y_{j,t+1}/\partial K_{jt}$ is the marginal product of capital.

C. *Market clearing and equilibrium*

In sector 1, output is consumed, invested in that same sector (since investment *I* is also sector specific) or exported:

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

where X_{1t} measures net exports of the non-Soviet good. These are exports of goods to western markets in exchange for energy imports, M_t^*, purchased at a world relative price p_t^*, and for imports of good C_{4t} purchased at world relative price p_{4t}. Hence, the non-Soviet balance of trade can be defined as follows:

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

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

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

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

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

where p_t^S is the barter price of energy contracted with the Soviet union for a quantity M_t^S of energy imports. The values of p_t^S and M_t^S are fixed, since they were 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 imports of energy are equal to domestic consumption of energy:

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

In sector 3 goods are nontradable and thus domestic production equals domestic absorption:

$$Q_{3t} - C_{3t} - I_{3t} = 0, \quad (8)$$

We follow Shimer (2010) and model the rigidity of the labor market as a slow adjustment of wages in each sector $j = 1,2,3$:

$$w_{jt} = \theta_j w_{j,t-1} + (1 - \theta_j) w_{jt}^D, \quad (9)$$

where the parameter θ governs the degree of wage stickiness and w^D is the reservation wage given by the household labor supply. One interpretation of these wage 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, we set $w_j^D = w_j$ in the pre-Soviet-collapse steady state. Given the wage, clearing in the labor market is demand determined (i.e. by finding the labor allocation that satisfies the labor demand condition and the settled wage).

An equilibrium of this economy is defined by sets of intertemporal sequences of allocations $\{L_{1t}, L_{2t}, L_{3t}, C_{1t}, C_{2t}, C_{3t}, C_{4t}, I_{1t}, I_{2t}, I_{3t}, Y_{1t}, Y_{2t}, Y_{3t}, E_{1t}, E_{2t}, E_{3t}, Q_{1t}, Q_{2t}, Q_{3t}, X_{1t}, X_{2t}, B_t\}_{t=0}^{\infty}$ and

prices $\{p_{2t}, p_{3t}, w_{1t}, w_{2t}, w_{3t}, q_{1t}, q_{2t}, q_{3t}\}_{t=0}^{\infty}$ that solve the household's problem and the problem of each representative firm, and that satisfy the market clearing conditions (3)-(9), for given initial conditions $\{K_{10}, K_{20}, K_{30}, w_{10}, w_{20}, w_{30}\}$ and sequences of exogenous variables $\{p_t^E, M_t^S, p_{4t}, R_t\}_{t=0}^{\infty}$. In our quantitative analysis we focus on equilibria that start from initial conditions calibrated to match the Finnish economy at a stationary equilibrium just before the collapse of the Soviet Union, and with the sequence of exogenous variables set to reflect the sudden increase in the cost of energy and the collapse of the market for exports to the USSR. The precise specification of these initial conditions and shocks is described in the next section.

4. Quantitative Analysis

A. Detrending and definition of the "Soviet" sector

Since our study does not focus on either long-run growth or regular business cycles, but rather on macro dynamics around a Great Depression episode, we filter the data in the following way. First, we express a data series in log first differences and compute the average growth rate over 1975-1989. Then we use this estimate of the growth rate to extrapolate actual series (in levels) for the post-1990 period to construct a forecast, or counterfactual, of the macro dynamics that would have been observed without the Finnish Great Depression during the 1990s (see Figure 4 and Appendix B). Deviations from the predicted trend are interpreted as the dynamics resulting from the depression. We will compare these deviations with the dynamics produced by the model.

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. The "Soviet-exposed" sector will be defined in the data 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 Y_{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 $Y_t^S = \sum_i \omega_{it}^X Y_{it}$ and correspondingly the non-Soviet-exposed sector is $Y_t^{NS} = \sum_i (1 - \omega_{it}^X) Y_{it}$. 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. Since our model does not include the government sector, we adjusted the data to exclude the public sector.

B. Calibration

We calibrate the model at quarterly frequency to match macroeconomic aggregates in the year 1989. The discount factor is $\beta = 0.99$ which, given that output per capita grew approximately 2 percent per year in Finland before 1991, implies an annual real interest rate of 6 percent per year, consistent with the 6.1

percent per year real lending rate in Finland before 1991. We choose an intertemporal elasticity of substitution of $\sigma^{-1} = 0.5$. Hall (2007) and Kimball and Shapiro (2010) provide evidence indicating that the elasticity of labor supply at the macro level is about one in the United States. In line with this evidence, we set $\eta = 1$. The results of the model are not sensitive to reasonable variations in σ and η. Under our assumption of Cobb-Douglas preferences over the four types of consumption goods, consumption shares can be computed from data on consumption expenditures by sector. We find that $\xi_1 = 0.15,\ \xi_2 = 0.04,\ \xi_3 = 0.54,\ \xi_4 \equiv 1 - \xi_2 - \xi_3 - \xi_4 = 0.27$.

Turning to the production side of the model, the parameters α_{jL} can be determined from labor compensation in value added so that $\alpha_{1L} = 0.57,\ \alpha_{2L} = 0.63$ and $\alpha_{3L} = 0.63$. The quarterly deprecation rate of capital, δ, is the same across sectors and set to match an annual depreciation rate of ten percent. We assume small to moderate adjustment costs in capital stock ($\phi = 1$).[13] Without loss of generality, 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., $p^E = 1$). Because energy and value added are Leontief complements, the energy requirement in the non-Soviet sector is given by $a_{1E} = p_1 Q_1/(p^E E_1)$. Since we know the cost structure (specifically expenditures on energy), we can compute the 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 at 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: $a_{2E} = 37.84$ and $a_{3E} = 47.51$. 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. The final parameter to be determined is χ, the disutility weight on labor. These are set to match the sectoral share of employment (i.e. L_j/L) in each sector.

These parameters pin down the ratios of macroeconomic variables relative to total output and the allocation of factors across sectors (see Table 2). The model captures the ratios of aggregate consumption, investment and exports to output. At the sectoral level, parameters are chosen to match consumption, labor and energy allocations. The model slightly overstates the size of the non-Soviet sector relative to the size of the service sector.

The final parameter to be calibrated is the extent of wage rigidity which affects the transition dynamics, but not the steady state allocations. As we have discussed above, wages in Finland are downwardly 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 Figure 3). In light of these facts, we

[13] Groth (2006) presents the range of estimates reported in the literature.

set $\theta_j = 0.96$, which is just a notch higher than $\theta = 0.95$ calibrated in Shimer (2010) for the U.S. Even at this relatively high level of wage stickiness, wages reach their new equilibrium in four to ten quarters. We also report results for alternative values of θ.

C. Simulating the Effects of the Soviet Shocks: Benchmark results

We now use the calibrated version of our model to show that the shocks caused by the loss of Soviet trade can result in a significant reduction of output, similar to the decline observed in the data. We model these shocks as a once-and-for-all unanticipated event at $t = 0$ in a deterministic environment. As we explained above, this event produced two shocks for Finland. First, Finland lost one of its major export markets. Further, because of the specialized nature of trade with the USSR, Finnish firms could not easily redirect trade to other countries. We model this shock as a permanent drop in Soviet oil imports M_t^S to zero for all $t > 0$ which implies that exports to the USSR X_{2t} also vanish for all $t > 0$. The second shock was the end of the Soviet Union's provision of subsidized energy for Finland. Our discussion in Section 2 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 $p^E = 1.1$ also for all $t > 0$. We hit our model economy with these shocks as of the initial date $t = 0$ and compute the transitional dynamics leading to the new post-Soviet-collapse stationary equilibrium. We assume that the bond position B_t is zero at $t = 0$.[14]

Figure 4 plots actual and simulated responses for key macroeconomic variables measured as percent deviations from the pre-collapse steady state.[15] The baseline model comes close to capturing the depth of the output drop: the peak-to-trough decline in output is 17.2 percent in the model and 21 percent in the data. The model produces a more sudden drop in output than observed in the data—the trough is reached in 1991 in the model versus 1993 in the data—and output in the model also recovers more quickly. Seven years after the shock, output in the model settles at roughly 10 percent below trend, while output in the data remains depressed at 20 percent below trend. A similar result emerges for the dynamics of consumption and employment. The simulated series both decline by about as much as in the data (about 20 percent below trend), but both reach their troughs a year earlier than in the data. Similarly, after seven years, both settle at a level that is below trend, but not as far below trend as the actual data. Note

[14] Following Mendoza and Tesar (1998), we address the dependency on initial conditions of the steady state of net foreign assets by combining a shooting algorithm with log-linear approximations around the post-Soviet-collapse steady state. We set the initial condition $B_t = 0$ because, in the Finnish NIPA accounts, the 1980-1990 average net exports (or current account) to GDP ratio was close to zero. Lane and Milesi-Ferretti (2007) find that, once valuation effects are taken in account, Finland had a relatively small negative net foreign asset position in 1980-1990. We ignore these valuation effects in our analysis.

[15] Note that since we fit trends to each series in the data individually, we can have a discrepancy between the dynamics of output and inputs. Value added and consumption are computed in constant pre-collapse prices. Also note that model series are aggregated from quarterly frequency to annual frequency to compare with the dynamics in the data.

that with very rigid wages ($\theta_j = 0.99975$), the model can generate large, persistent declines in output, consumption, and employment similar to what is observed in the data seven years after the shock.

The model predicts a 26 percent decline in investment over 1991-1993 and a recovery to about 12 percent below trend. The actual collapse in investment was more severe in both the short- and the long-run. In the model, the recovery of investment reflects the fact that given our functional form assumptions and calibrated parameter values, the capital-to-output ratio (and hence the investment-to-output ratio) is fairly insensitive to changes in the price of energy, relative prices and wages.[16] Consequently the post-shock steady-state level of aggregate investment is fairly invariant to the Soviet shock. If utilization of capital required energy (see, for example, Finn (2000)), the relative price of capital would be higher in the post-Soviet-collapse period and the decline in investment larger and more persistent.

The model also captures well some of the features of the adjustment of net exports. The ratio of net exports to gross output rises by about five percentage points shortly after shocks hit the model economy, but this is a transitory surplus. The data show a surplus of similar magnitude, but it builds up more gradually and is more persistent than in the model.

Table 3 compares the model's predictions for the output drop under different scenarios. Each cell of the table shows the maximum output drop as well as the output decline seven years after the initial shock. Reading down each column, the table shows the results for different parameter values relative to the benchmark: increasing the markup on Finnish exports to the USSR from 10 to 30 percent, increasing the rigidity of wages, and adding other frictions to the model (habit formation in consumption and quadratic labor and investment adjustment costs; see appendix C for more details on specification of these frictions). Reading across the table, each column shows the predictions for output resulting from different shocks to the model economy. Column 2 shows the output drop when the shock is the loss of trade but the energy subsidy is not removed. Column 3 performs the opposite experiment – the only shock is a spike in the price of oil, with no loss in Soviet trade. Column 4 examines the drop in output when the shock is assumed to have no effect on the demand for nontradables. Finally, Column 5 shows the results in an economy with fully flexible wages.

Beginning with the third row, we find that a higher markup on Finnish exports to the USSR (effectively a bigger shock to the price of oil) deepens the output drop in both the short- and the long-run. Imposing more rigid wages (fourth row) relative to the benchmark (second row) similarly produces a larger drop in the both the short- and the long-run. Adding further frictions to the model economy (the last

[16] Specifically, in the steady state $K_j/Q_j=[(1-\alpha_{jL})\beta(1-p^E/(a_{jE}p_j))]/(1-\beta(1-\delta))$, which follows from the first order condition for capital in sector j. Note that since a_{jE} is relatively large, one needs large variation in p^E and p_j to change capital to output ratio significantly.

row of the table) has minimal impact on the depth of the output drop, but slows the recovery of output after the shock.

A comparison of Columns 2 and 3 can be interpreted as a decomposition of the Soviet trade shocks into the effects induced by the reallocation of factors away from the Soviet-goods industry and the effects of the loss of the energy subsidy. It is clear that factor reallocation costs account for most of the drop in output. However, the bigger the markup, the bigger the pre-shock subsidy to energy, and the more severe the economic contraction when the subsidy is removed.

The results in Column 4 illustrate the pivotal role played by the service (nontraded) sector. When all goods are tradable, the collapse of Soviet trade puts 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. Sector 2 contracts, sector 1 expands and aggregate output drops by 5 to 6 percent. A higher markup on exports and more rigid wages contribute to the output drop, but the two-sector model (i.e., when the service sector is held fixed) cannot come close to the data.

Another critical ingredient for generating a deep contraction is wage stickiness. With flexible wages, the maximum contraction is less than half of that in the baseline model (compare Columns 1 and 5). However, it is the combination of imperfectly flexible wages and a collapse in the demand for nontradables that leads to a large amplification of the Soviet trade shock. In effect, the nontraded goods sector is struck by two negative shocks. First, the increase in the price of energy increases the cost of production. Second, the income effect from the collapse of Soviet trade reduces the demand for nontraded goods. These two effects together lead to a decline in the relative price of nontraded goods and output. Both of these negative shocks are larger the more rigid are wages because more rigid wages force firms to cut employment rather than adjust the wage, the price of nontradables falls more, and the income effect is larger.

Figure 5 provides suggestive evidence that these sectoral dynamics were an important part of the Finnish depression. Note that the benchmark model predicts a large contraction of output in the services sector (especially with rigid wages), which we see in the data. Likewise, the model predicts a 9.5 percent fall in the relative price of the nontradables (the benchmark case) which is close to the 13 percent decline in the data. The model does not, however, captures the full decline in the non-Soviet sector.

In summary, there are two key determinants of a deep contraction: wage stickiness and dynamics in the service sector. To the extent our results depend on adjustment of real wages being sufficiently slow, our findings echo the results in Cole and Ohanian (2004). As reported in Section 2, there is strong evidence suggesting that this was indeed the case in Finland. Since habit formation and labor/investment

adjustment costs improve the fit of the model, our subsequent analysis incorporates these additional frictions.

D. 1974 Oil shock

A useful cross-check on the performance of the model in explaining the recession in the 1990s is to ask how well this framework can reproduce dynamics in response to previous episodes of energy price shocks. We examine in particular how the model fares in accounting for the macroeconomic dynamics in Finland after the 1974 oil price shock. Like the collapse of Soviet trade, this shock produced a large increase in energy costs for Finland. Unlike the Soviet trade collapse, however, 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 1974 oil shock experiment the model dynamics are still consistent with those observed in the data, we gain more confidence about the conclusions derived in the previous subsection. In this exercise, we keep the model calibrated as before. The only modifications we make is to energy intensity, which we set 25 percent higher than in the baseline calibration, because the Finnish economy was more energy intensive in 1970s than in early 1990s.[17] Since Finland was also less unionized in the early 1970s, we also consider a faster wage adjustment process with $\theta_j = 0.9$ for all j.

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 6 plots the model's transitional dynamics in response to the oil price shock and the dynamics of actual output, consumption and investment. 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, the model predicts that exports to the USSR expanded in response to the oil price shock. The model also predicts that output in the Soviet sector expanded relative to output in the non-Soviet sector. These theoretical predictions are consistent with anecdotal evidence (e.g., Sutela 2007) on sectoral dynamics in Finland after the 1974 oil price shock.

E. Sweden vs. Finland

An alternative way to assess the importance of the collapse in the Soviet-Finnish trade in accounting for the Finnish recession and to validate our baseline simulations is to compare the output dynamics in

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

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 the USSR.[18] We see Sweden as a counterfactual for what could have happened to Finland if it did not trade so much with the USSR and use this natural experiment to evaluate the predictions from our model.

Figure 7 plots the time series of percent deviations of output from time trend (estimated on 1975-1989 data) for Finland and Sweden. At the trough of the recession the output drop in Finland was about 21 percent from trend, while for Sweden it was 8 percent below trend. If we take the 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 fraction of the downturn in Finland.

F. Sectoral responses

An additional observation that favors our trade-shocks approach to explain the Finnish Great Depression is that industries exposed to the Soviet trade experienced a deeper downturn than industries not oriented to the Soviet market. This pattern is clearly reproduced by our model, while shocks other that the Soviet trade shock should be unable to generate this pattern in general. Figure 8 presents a scatter plot for export shares to the USSR in 1988 and deviations of employment from trend in 1993 by industry. The slope of the OLS fitted line presented in the figure is -14.54 with a standard error 6.4, which suggests a statistically and economically significant relationship between an industry's exposure to the Soviet trade and its decline in employment.[19] A one percentage point increase in the share of exports going to the Soviet Union is associated with a 1.4 percent decline in employment in 1993 relative to trend.

5. Alternative explanations of the depression

As we noted in the Introduction, two other competing explanations of the Finnish Great Depression are the "financial view," which attributes the Depression to the major financial crisis experienced in Finland in 1992, and the "tax and productivity view" of Conesa et al. (2007), which argues that the Depression was caused by adverse total factor productivity (TFP) and labor tax shocks. According to the financial

[18] Comparing the developments in Sweden and Finland between 1985 and 2000, Jonung et al. (2009) observe that the two countries behaved as if they were "economic twins."

[19] The estimate based on the Huber-robust regression, which downweighs outliers (e.g., non-metallic mineral products), is -17.6 with standard error 5.3.

view, 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 can also be interpreted as a byproduct of the financial-sector effects of the Soviet trade shocks that first caused a severe collapse of the real economy. Indeed, troubles in the Finnish financial sector seem to have followed the collapse of the Soviet trade rather than preceded it.[20] This interpretation of the financial sector as "following" the real economy can be rationalized if we assume that financial variables responded to real developments as in a classic cash-in-advance setup. Hence, the severe retrenchment in consumption and investment expenditures due only to the Soviet trade collapse could have caused a proportional collapse in demand for real balances, which under a fixed or managed exchange rate and a set level of foreign reserves, could have been large enough to trigger a currency crash. If we consider also the possibility of financial amplification via a working-capital or a financial accelerator channel, these developments could have fed back into the real economy and enlarged the magnitude and duration of the recession.

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 (a relatively modest increase). 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. The corresponding impulse responses are shown in Panel A of Figure 9. The results show that an increase in the interest rate depresses aggregate economic activity with relatively small effects on output (similar small effects on employment and consumption) but a larger effect on investment. We also find that adding the interest rate shock 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. We conclude from these results that a credit crunch indeed can be a useful complement to our story, especially for matching the dynamics of investment.

[20] Real domestic credit, which had increased at a steady pace since the late 1970s, began to fall in 1992:1 and the exchange rate 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. In a comprehensive analysis of the banking crisis and credit crunch in Finland, Vihriälä (1997) concludes that collapse of lending is better explained by a decline in firm and household balance sheets and creditworthiness than by a contraction in supply of credit.

With regard to the tax and productivity hypothesis of Conesa et al. (2007), it is worth noting that our oil price shock works like a technology shock since an increase in the oil price reduces firms' profit margins (provided there is a sufficiently small substitutability of energy input).[21] Although the effect of the oil price shock on measured TFP is relatively small in our model, the trade shock leads to a significant decline in measured TFP with dynamics that resemble the path of measured TFP in the data (Panel C, Figure 9). Intuitively, with sector specific factors, changes in sectoral demands drive a wedge in returns on inputs across sectors in the short run. In contrast, the standard approach to TFP accounting assumes that returns are equalized across sectors, which can overstate the contribution of inputs in relatively unproductive sectors such as the Soviet sector in our model, and hence can show a decrease in aggregate measured TFP even when TFP at the sectoral level does not change. Thus what Conesa et al. interpret as a TFP shock could be partly capturing the energy price and trade shocks in our model.

We can also reconcile Conesa et al.'s labor-tax-like effects with our analysis by interpreting those effects as taking the place of the wage rigidities in our model. In an equilibrium without labor frictions, the wage received by workers is equal to their reservation wage, i.e. $w_{jt} = w_{jt}^{D}$. If wages are rigid 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 $w_{jt} > w_{jt}^{D}$. Since firms stay on their labor demand curve, they cut employment. In light 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 the after-tax wage is equal to the reservation wage.

While both labor tax hikes and wage rigidities can have similar theoretical effects, we were unable to find actual evidence of significant changes in tax rates in the Finnish press and legislation of the early 1990s. In addition, various measures of the tax burden on labor earnings exhibit little variation over this period (see Panel B, Figure 9). If anything, marginal rates of the personal income tax in Finland fell in the early 1990s. For example, the top bracket tax rate fell from 51% in 1988 to 43% in 1990 and further to 39% in 1991. By contrast, we documented earlier strong evidence of labor rigidities, including wage stickiness. Hence, the empirical evidence suggests that labor frictions may be more relevant than tax shocks. Overall, we agree with the view of Conesa et al. (2007), however, that productivity and wage-wedge movements are necessary to explain the dynamics of macroeconomic aggregates. We differ in that

[21] Finn (2000) makes a similar argument for the United States.

we interpret these movements as symptoms and argue that the Soviet trade shock is the fundamental force behind these movements.

6. Extension to Transition Economies

There is ample evidence indicating that the trade and energy price shocks faced by the transition economics (TEs) of Eastern Europe and the former Soviet Union were at least as severe as those experienced by 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. 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 discounts of 50 percent or more. Given the 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 Eastern European countries in the early stages of the transition. Initial 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) and 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. Roland (2000) argues that politicians could not allow wages to fall too fast and too much because otherwise reforms could be reversed. Furthermore, wage indexation and dollarization

[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.

of wages became common practice in transition economies. Finally, 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 incomplete and spread over time. Given that the size of distortions was greater in former CMEA countries than in Finland (e.g., greater subsidy from USSR and greater specialization of trade with the USSR), one can expect that standard macroeconomic factors can explain the bulk of downturn in economic activity in transition countries.[23]

To support our hypothesis that the contraction observed in TEs can be explained with the oil price and trade shocks caused by the demise of the USSR, we 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 chose these two countries because they embody two different strategies of adjustment in transition. Poland allowed a quick and deep adjustment of real wages, while in Hungary real wages had gradual and modest adjustment (see e.g. Tonin 2007).[24]

We use the model and calibration from Sections 3 and 4 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 that $\xi_1 = 0.2, \xi_2 = 0.15, \xi_3 = 0.5, \xi_4 = 0.15$ 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 the service sector was larger in Hungary.[25] 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_{1E}, a_{2E}, a_{3E}. These modifications in ξ's and a's are necessary to match

[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 twenty years since the reunification, East Germany continues to lag behind West Germany in many economic dimensions. See Akerlof et al. (1991) for more detailed discussion on East Germany and effects of high and inflexible real wages.

[24] In our analysis we exclude countries which traded with the Soviet Union but whose exports were not tailored to the special demands of the Soviet economy. For example, Iceland, Syria and Nicaragua exported goods which were low value-added items and were easily sellable in other markets: fish, carpets, fruits.

[25] 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.

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.[26]

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 percent for Hungary and by 45 percent for Poland.[27] Consequently, we set the Soviet trade shocks to 60 percent for Hungary and 45 percent for Poland. Finally, we assume that the collapse of the Soviet trade occurred (or started to occur) in 1990 rather than 1991 as CMEA started to disintegrate before 1991.

Figure 10 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 similar to the actual responses of the Polish and Hungarian economies. The model can explain the 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. In line with our model's prediction that greater wage inflexibility leads to deeper downturns, the model has a better fit to the data for Hungary when we use a higher value of θ which is consistent with the fact that Hungary had a slower wage adjustment than Poland. In any case, 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 recessions in transition countries.

Although we do not have reliable data for many other transition countries, we can use fragmentary employment data to check whether adjustment of real wages is correlated with the response of employment in transition economies. Figure 11 displays a strong negative relationship between real wages and employment suggesting that countries with smaller declines in real wages experienced a larger contraction of employment between 1989 and 1995, which is consistent with our argument that incomplete adjustment of real wages could have contributed to the depth of downturn in transition economies.

[26] 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.

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

We also conjecture that misallocation of resources in the former Soviet Union could have played an important role in the dramatic output decline in Russia and other former Soviet republics 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, the All-Russian Scientific Research Institute for Experimental Physics (the developer of nuclear and thermonuclear weapons) was supposed to be organizing the mass 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 which was probably even more painful and costly than in other countries in the socialist camp.[28] 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.

7. Concluding Remarks

This paper examines the Finnish Great Depression of the early 1990s using a dynamic general equilibrium framework with labor frictions. Our analysis delivers two key results. First, we find that the Finnish Great Depression can be explained to a large extent by two exogenous shocks produced by the collapse of the USSR: the surge in energy prices and the sudden redundancy of the Soviet-oriented manufacturing industry. Since the identification of these shocks is particularly clear cut, this natural experiment clearly illustrates the behavior of a small open economy in response to large exogenous shocks affecting energy costs and sectoral factor allocations. We found that two important features of the Finnish economy contributed to amplification of the initial shocks into a Great Depression: rigid real wages and the collapse of demand for nontraded goods. We show that our calibrated multi-sector model is also successful in reproducing the Finnish response to the 1974 oil-price shock and in explaining the striking contrast in observed macroeconomic performance between Sweden and Finland in the early 1990s.

The second main result is that our model can account for the main features of the early 1990s adjustment observed in Eastern European transition economies, which displayed output dynamics and shocks to energy costs and sectoral factor allocation induced by the collapse of trade with the USSR

[28] Menshikov (2000) and others report that military orders declined 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.

similar to those observed in Finland. This similarity is particularly striking and calls for a reinterpretation of the sources of deep recessions in transition economies since Finland, in contrast to transition economies, had a well functioning system of markets, courts and other institutions. Although we cannot rule out alternative explanations for contractions in transition economies, the quantitative responses to the shocks triggered by the demise of the USSR can account for a large share of the contraction in transition countries and Finland. In other words, the energy price and sectoral factor allocation shocks triggered by the collapse of Soviet trade we observed in the data could lead to economic downturns in standard theoretical multi-sector models which are remarkably close to the size of downturns we observed in transition economies. This important finding suggests that alternative explanations such as institutional transformations could have had a smaller effect than previously thought.

The natural experiment of the shocks caused by the Soviet trade collapse on Finland analyzed in this paper has broader implications. Specifically, we show that sectoral factor allocation shocks can lead to significant comovement across sectors even in the absence of direct input-output linkages, and static measures of effects of these shocks can grossly underestimate the short-run cost of reallocation. Reallocation of resources can be particularly costly in the presence of sticky wages and/or prices. The Finnish experience can also shed 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).

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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 n.e.c.	0.06	0.03	0.009

Source: Finnish Ministry of Statistics, authors' calculations.

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

Panel A: Sectoral statistics	Soviet sector		Non-Soviet sector		Service sector	
	Data	Model	Data	Model	Data	Model
Labor cost share	0.630	0.630	0.570	0.570	0.630	0.630
Share of employment	0.055	0.065	0.233	0.259	0.712	0.676
Share of value added	0.056	0.083	0.269	0.456	0.675	0.507
Share of exports in total exports	0.175	0.151	0.815	0.849	-	-
Ratio of energy cost to value added	0.049	0.029	0.052	0.049	0.035	0.025

Panel B: Aggregate statistics	Data	Model
Consumption to value added ratio	0.705	0.719
Investment to value added ratio	0.295	0.281
Export to value added ratio	0.211	0.228
Energy cost to value added ratio	0.042	0.034

Notes: the table reports moments of the data for sectors constructed as described in appendixes A and B. 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.

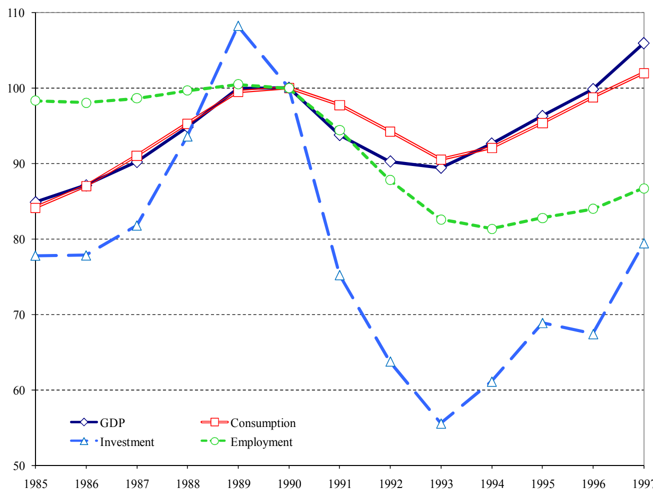
Table 3. Contraction of output: Data vs. Simulated paths.

	Total	Loss of trade shock only	Oil price shock only	Hold service sector fixed	No wage rigidity
	(1)	(2)	(3)	(4)	(5)
Data					
Output drop (peak to trough)	-21.0				
Output drop after 7 years	-17.8				
Model					
Baseline					
Output drop (peak to trough)	-17.2	-14.5	-2.7	-6.4	-8.3
Output drop after 7 years	-8.9	-7.2	-1.7	-4.6	-7.9
Higher markup, 30%					
Output drop (peak to trough)	-22.8	-14.5	-8.3	-10.0	-11.8
Output drop after 7 years	-12.2	-7.2	-5.0	-8.3	-11.0
More rigid wages, θ=0.99					
Output drop (peak to trough)	-20.5	-17.2	-3.3	-6.9	-8.3
Output drop after 7 years	-13.4	-11.0	-2.4	-6.0	-7.9
All adjustment costs included					
Output drop (peak to trough)	-17.0	-14.5	-2.5	-6.4	-8.2
Output drop after 7 years	-10.8	-9.0	-1.8	-5.2	-7.9

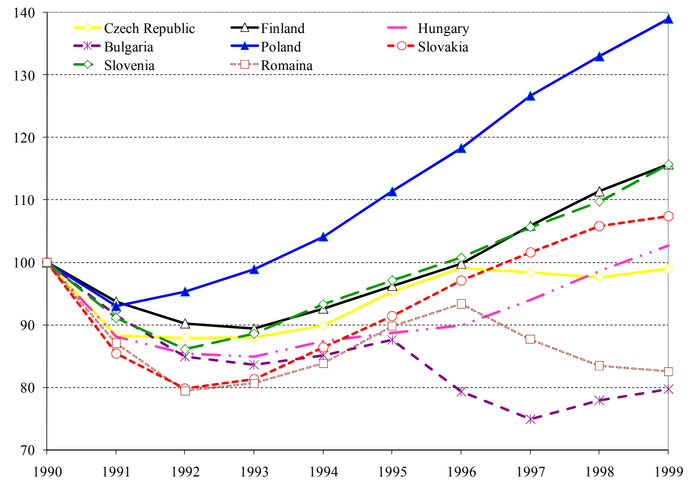
Notes: "Loss of trade shock only" scenario assumes that the price of oil is the same before and after the collapse of the USSR. "Oil price shock only" scenario assumes that the volume of trade with the USSR does not change but the price of oil increases. "Hold service sector fixed" scenario assumes that the service sector is fixed at pre-collapse levels and does not respond to shocks. "No wage rigidity" scenario assumes that $\theta_j = 0$ for all j. The case "Higher markup, 30%" sets the size of the oil price increase equal to 30 percent. The case "All adjustment costs included" augments the baseline model with internal habit formation, quadratic labor and investment adjustment costs (see Appendix C for more details on specification of these frictions).

Figure 1. Macroeconomic dynamics in Finland.

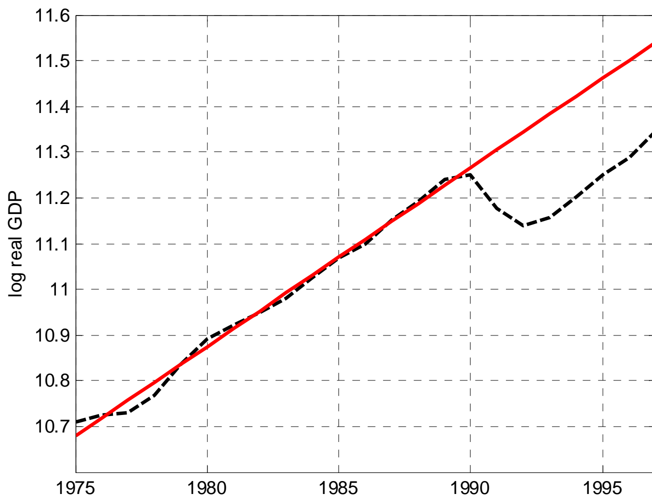
Panel A: Real GDP, Investment and Consumption in Finland.



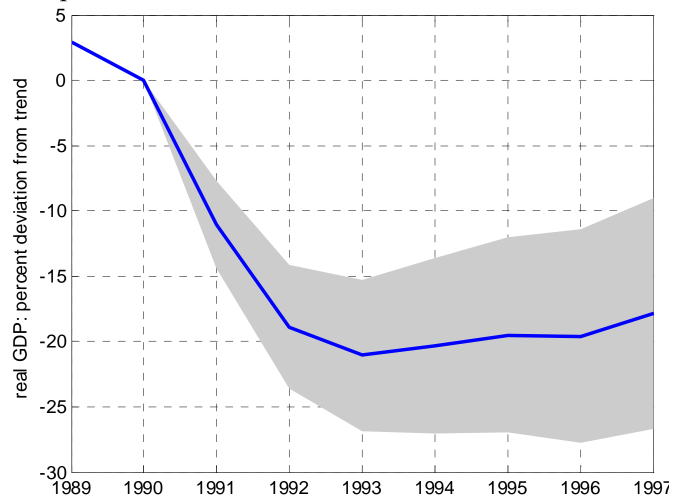
Panel B: Real GDP in Finland and Eastern Europe.



Panel C: Log real value added in the private sector and its trend.



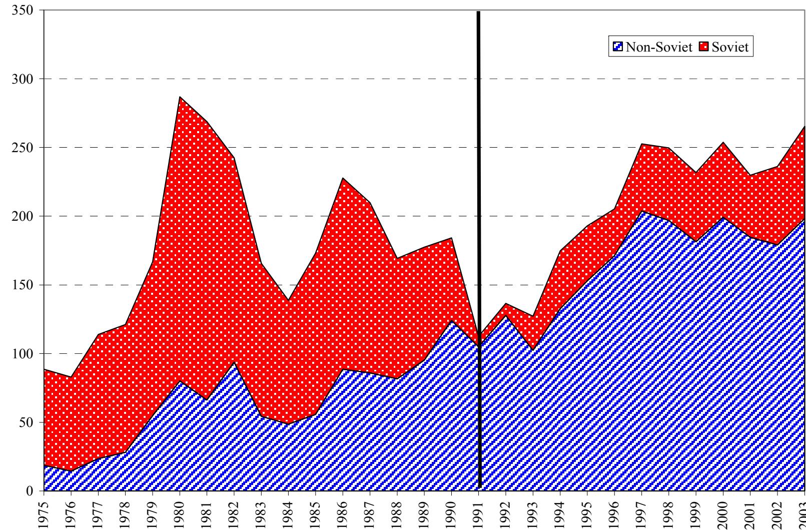
Panel D: Deviation of real value added in the private sector from trend.



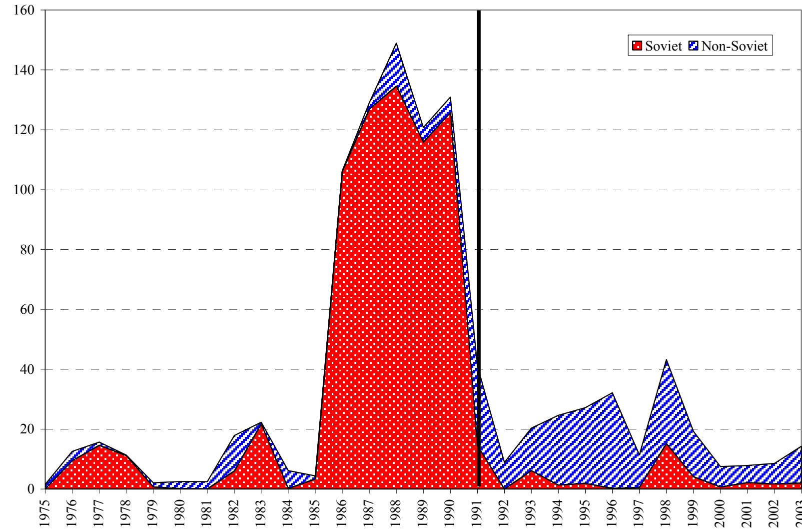
Notes: Panel A: Series are normalized to be equal 100 in 1990. The data are from *OECD* National Accounts database. Panel B: Series are normalized to be equal 100 in 1990. The data are from National Accounts Estimates of Main Aggregates, United Nations Statistics Division. Panel C: time series of log real value added in private sector and time trend fitted on 1975-1989 data. Panel D: Deviation of real value added in the private sector from its trend shown in Panel C. The shaded region shows 90% confidence interval (consistent with unit root tests, the series is assumed to be a difference stationary process).

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

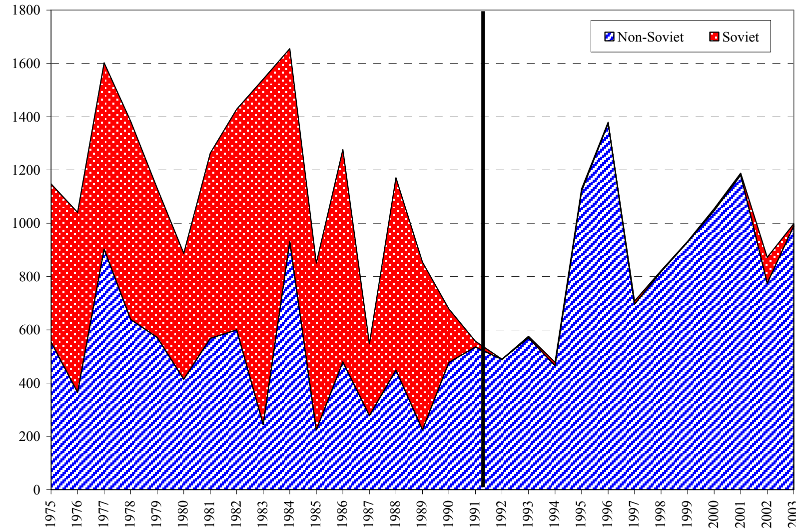
Panel A: Cable and wire



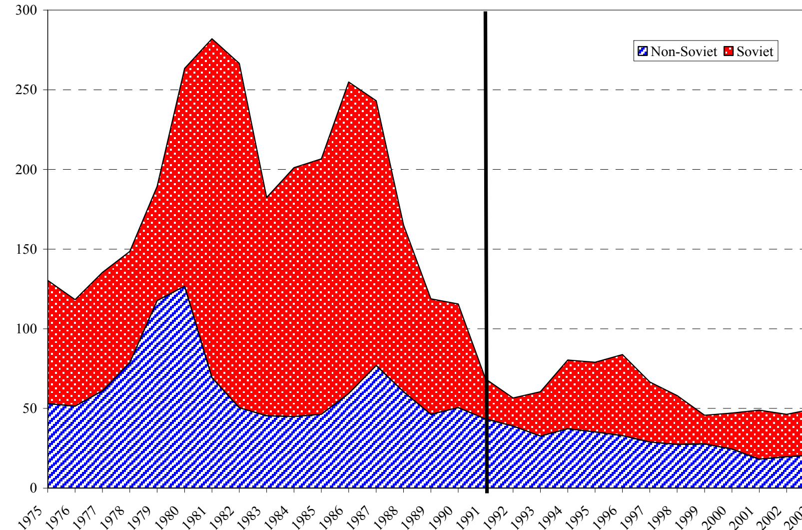
Panel B: Railroad equipment



Panel C: Shipbuilding



Panel D: Footwear

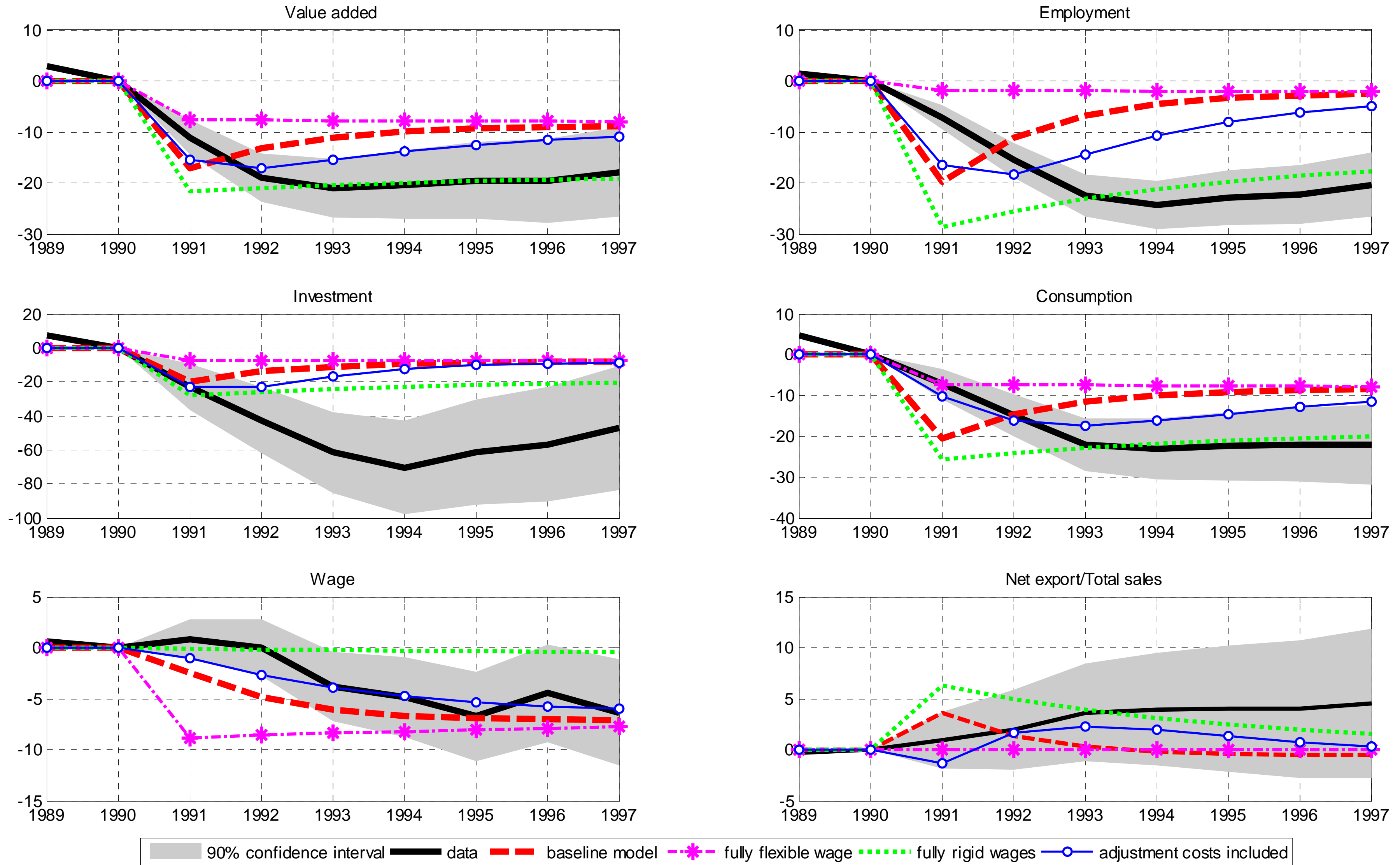


Notes: The stacked area charts display exports by destination, Soviet vs. non-Soviet. Combined area shows total exports. Exports are in thousands of fixed 2000 US dollars. For post 1991 years, Soviet Union exports are computed as the sum of exports to the 15 republics of the former Soviet Union.

Figure 3. Distribution of annual nominal wage growth by industry.

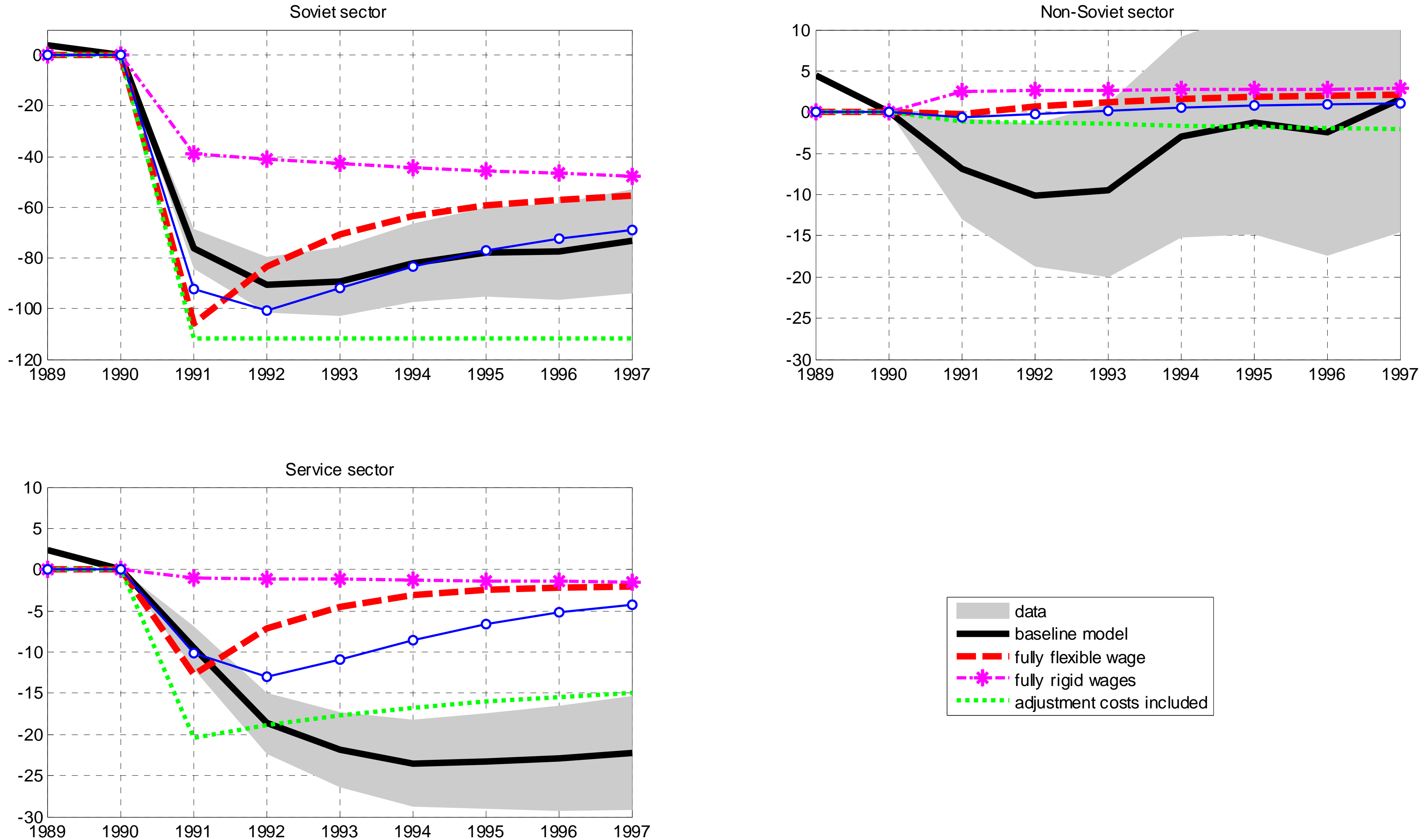
Notes: This figure reports distribution of individual workers' annual nominal wage growth rate. Vertical axis measures fraction. Horizontal axis measures percent change in annual nominal wages. The bar in blue indicates the level of inflation. Source: Böckerman, Laaksonen, and Vainiomaki (2006).

Figure 4. Macroeconomic aggregates: Data vs. Simulated responses, percent deviations from trend.



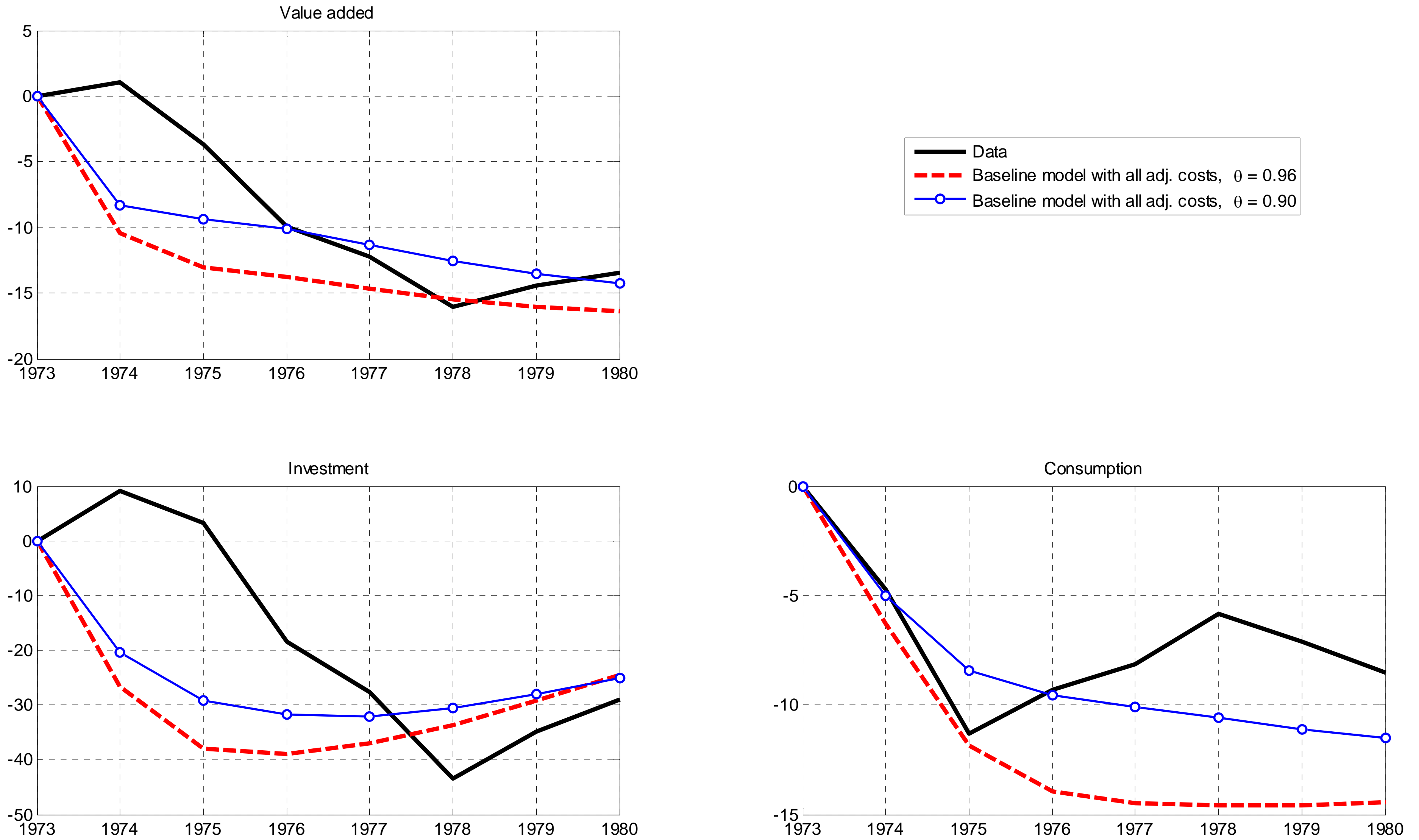
Notes: The figures plot percent deviations from trend in the data and simulated model series. Scenario "fully flexible wages" sets $\theta_1 = \theta_2 = \theta_3 = 0$. Scenario "fully rigid wages" sets $\theta_1 = \theta_2 = \theta_3 = 0.99975$. Scenario "adjustement costs included" presents the response of the economy when, in addition to capital adjustment costs, the following is included: habit formation in consumption ($h = 0.8$), quadratic investment adjustment costs ($\psi = 0.5$), quadratic labor adjustment costs ($\lambda = 1$) and wage adjustment is set to $\theta_1 = \theta_2 = \theta_3 = 0.98$. See Appendix C for more details on specification of these frictions. The shaded region shows 90% confidence interval (consistent with unit root tests, each series is assumed to be a difference stationary process).

Figure 5. Sectoral dynamics: Data vs. Simulated responses, percent deviations from trend.



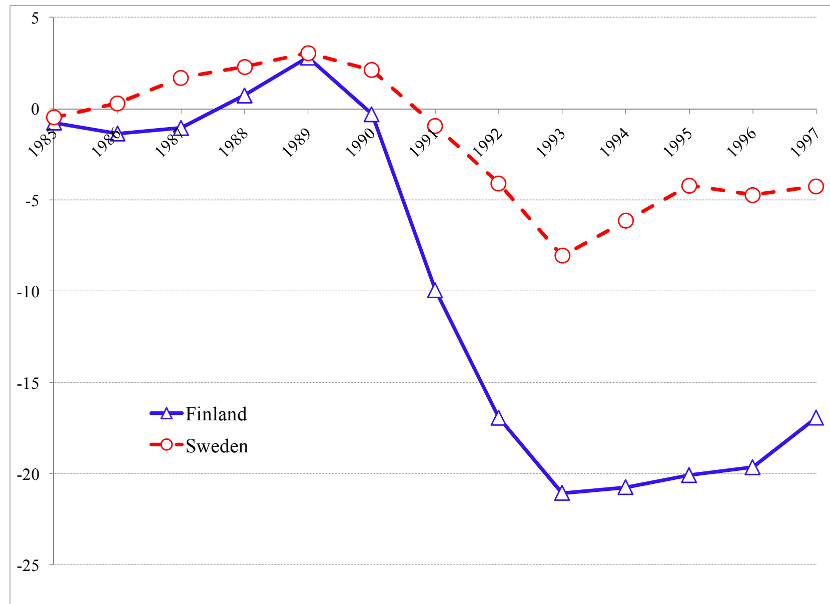
Notes: The figures plot percent deviations from trend in the data and simulated model series. Scenario "fully flexible wages" sets $\theta_1 = \theta_2 = \theta_3 = 0$. Scenario "fully rigid wages" sets $\theta_1 = \theta_2 = \theta_3 = 0.99975$. Scenario "adjustement costs included" presents the response of the economy when, in addition to capital adjustment costs, the following is included: habit formation in consumption ($h = 0.8$), quadratic investment adjustment costs ($\psi = 0.5$), quadratic labor adjustment costs ($\lambda = 1$) and wage adjustment is set to $\theta_1 = \theta_2 = \theta_3 = 0.98$. See Appendix C for more details on specification of these frictions. The shaded region shows 90% confidence interval (consistent with unit root tests, each series is assumed to be a difference stationary process).

Figure 6. Oil price shock in 1974, percent deviations from trend.



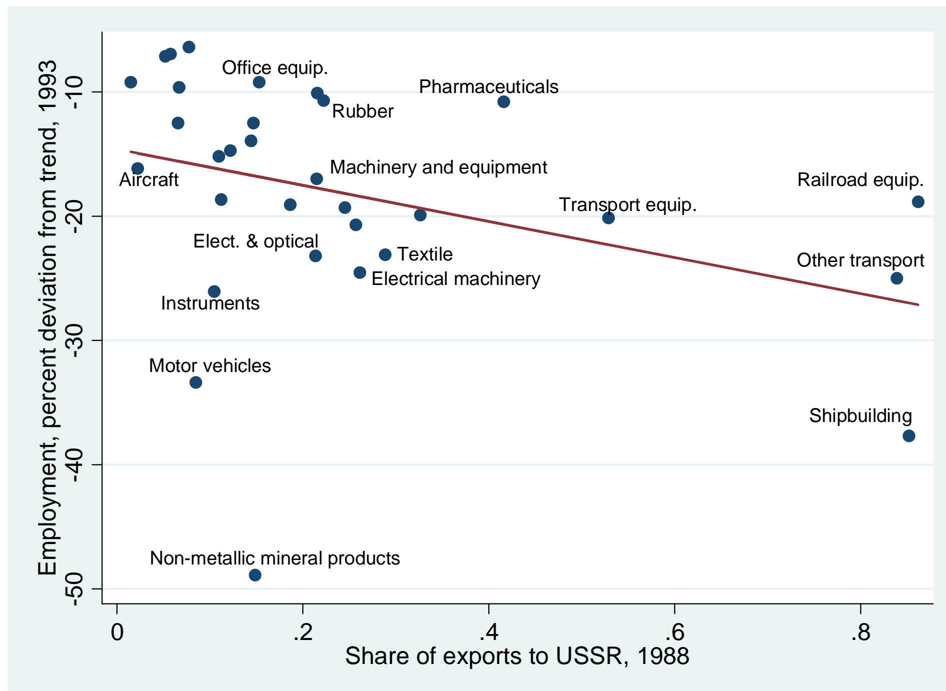
Notes: Solid line is the deviation of real GDP, real consumption, and real investment from the respective time trends estimated on 1950-1973 data. Real GDP, real consumption, and real investment (in 2000 prices) series are taken from Penn World Tables. The deviations are adjusted to be zero in 1973. 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 7. Real GDP in Sweden and Finland, percent deviations from trend.



Notes: the figure reports percent deviations from time trend estimated on 1975-1989 sample.

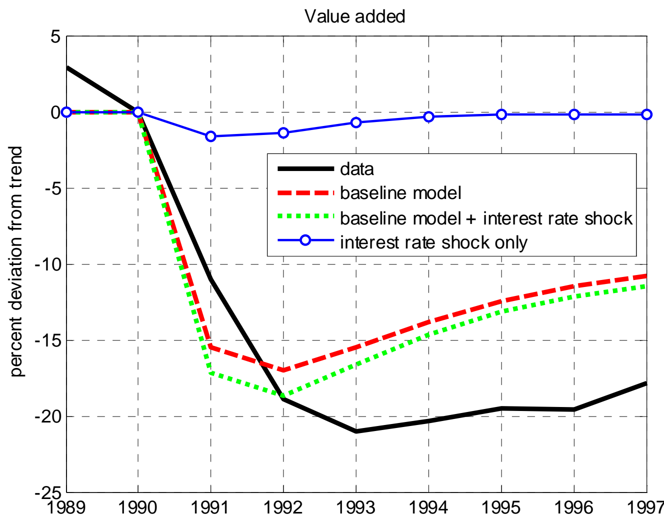
Figure 8. Employment dynamics and exposure to Soviet trade, by industry.

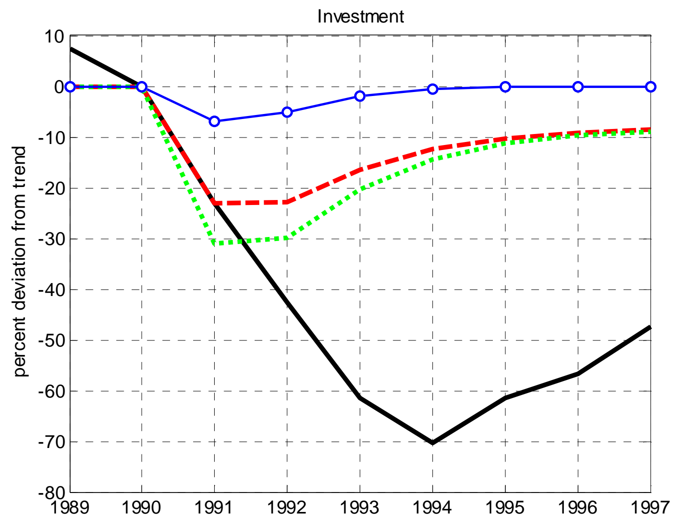


Notes: Deviation from trend for employment is computed as the log difference between actual value of employment in 1993 and predicted value for the trend estimated on 1980-1989 data. For shipbuilding and railroad equipment industries, the deviation is computed as the difference between employment in 1993 and 1989 because these industries had volatile time series. The slope of the OLS fitted line presented in the figure is -14.54 with standard error 6.4. (The slope of the Huber-robust fitted line is -17.6 with standard error 5.3.) Data are from STAN OECD.

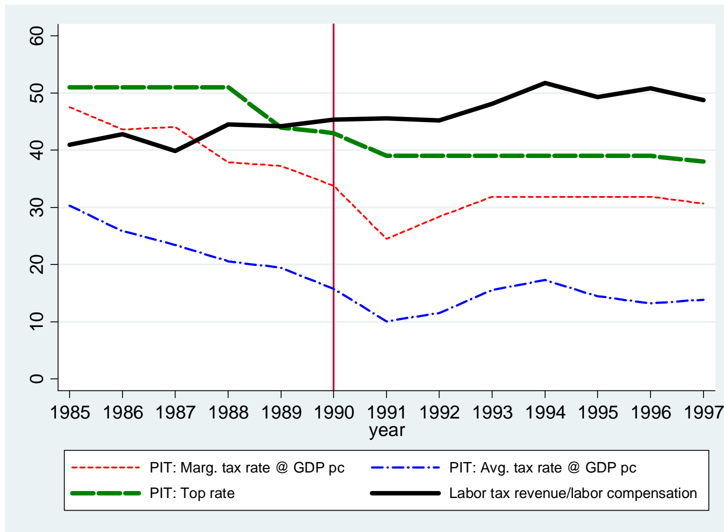
Figure 9. Alternative theories

Panel A: Interest rate shock

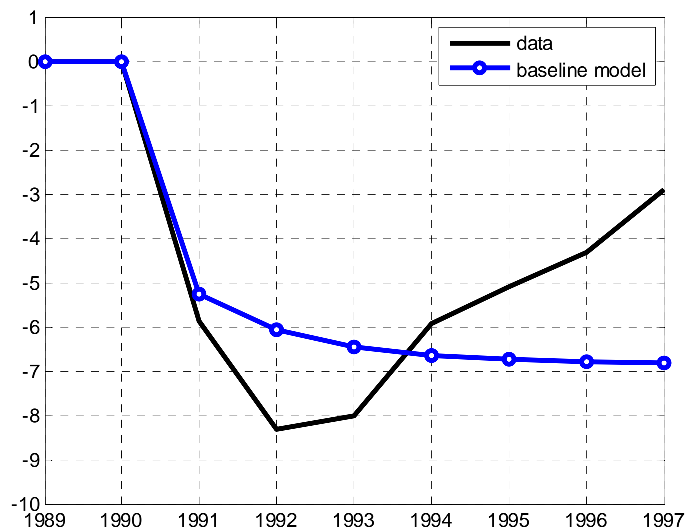




Panel B: Tax burden on labor income.

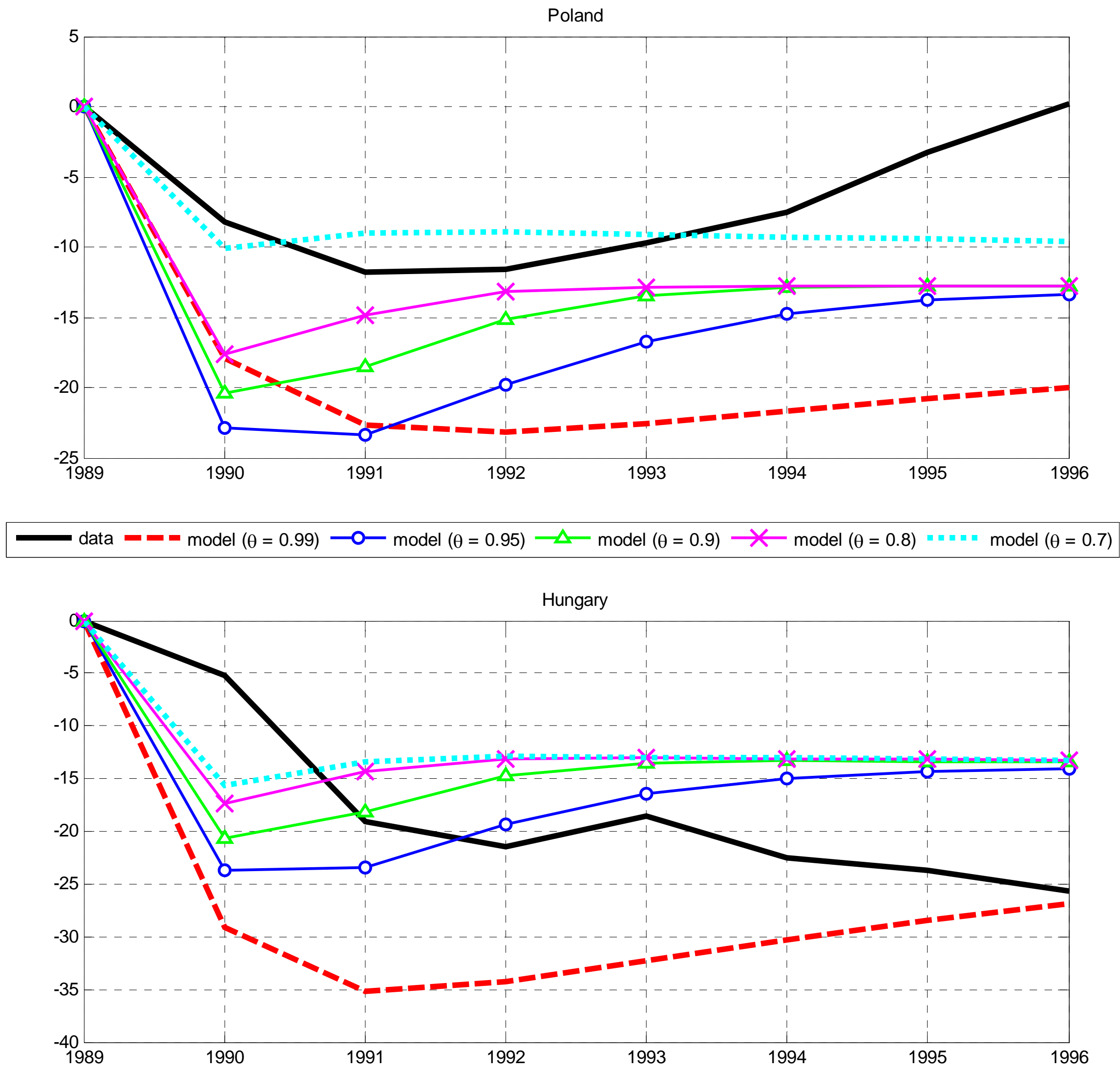


Panel C: Measured TFP in Finland, 1991-1997.



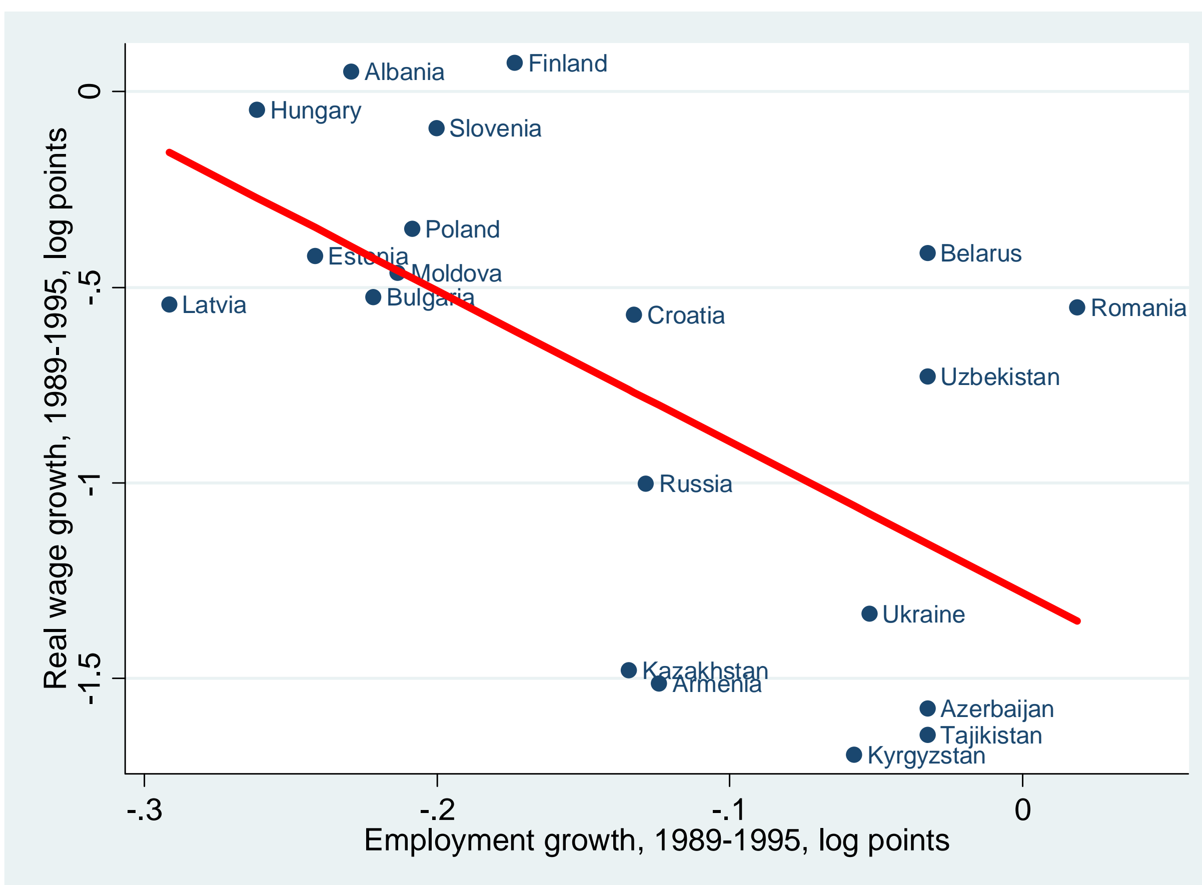
Notes: Panel A plots the effect of a transitory increase in the real interest rate by one percentage point separately and in conjunction with the collapse of Soviet trade. All simulations include adjustment costs and habit formation and correspond to scenario "adjustement costs included" in Figure 4. Panel B reports the tax burden on labor income. *GDP pc* means income equal to GDP per capita. Sources: OECD; Buttrick et al. (2010). Panel C plots TFP measured according to standard growth accounting applied to aggregate series in the data (taken from Conesa et al. 2007) and impulse responses of aggregate series in the model. The method is described in Conesa et al. (2007).

Figure 10. Output dynamics in Poland and Hungary, percent deviations from trend.



Notes: Solid line is the percent deviation of real GDP series from the trend estimated on 1975-1989 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. Other lines are simulated model responses. See text for further details.

Figure 11. Real wages and employment in transition economies.



Notes: Real wages are computed as the ratio of average annual nominal wages to the average consumer prices index in the given year. Employment covers all sectors. The solid line shows the fit of the linear regression of the change in real wages on the change in employment. The slope of the fitted line is -3.1 and the associated standard error is 1.3. Data on employment, price level, and wages are from International Labor Organization, International Monetary Fund, and "10 Years of Commonwealth of Independent States" ("10 let Sodruzhestva Nezavisimykh Gosudarstv," published by the Russian Statistical Office in 2001). For countries in the Commonwealth of Independent States and Baltic countries, statistics are computed for 1991-1995 because consistent data prior to 1991 at the country level are not available.

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 republics. Service sector is assigned zero share in trade with the USSR. OECD ITCS database is used to construct exports series. 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 are 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 and treat the product as the private domestic consumption of imported goods.

Appendix B: Detrending and construction of sectoral data

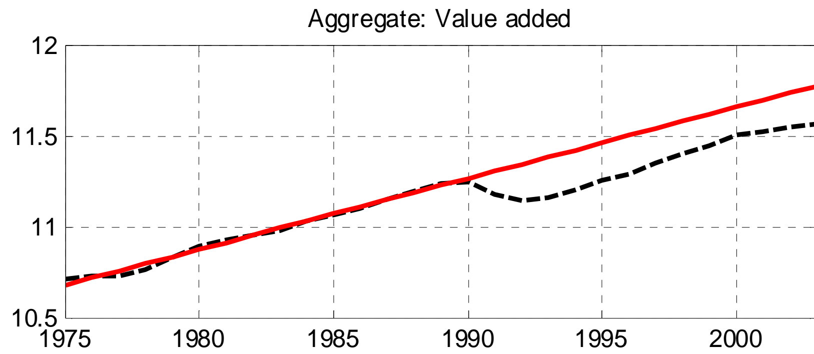
Since our study does not focus on long-run growth, we study macroeconomic aggregates after filtering out their long-run trends. Figure B1 plots the dynamics of the series and the fitted time trend. To exclude the effect of the post-Soviet period we use data only for 1975-1989 to fit the time trend. We 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 11 percent, while filtered real value added decreases by more than 20 percent.

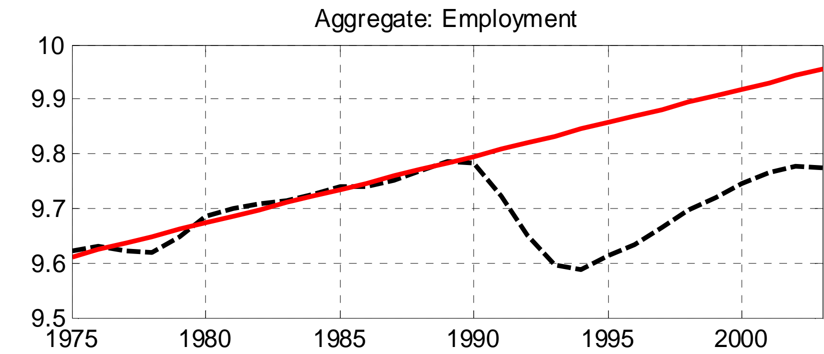
Our analysis of the Finnish recession requires construction of the Soviet sector. Ideally we would like to have firm-level data with product output and export by destination. With this information, we could aggregate output of goods predominantly exported to the Soviet Union and treat this aggregate 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 be 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.

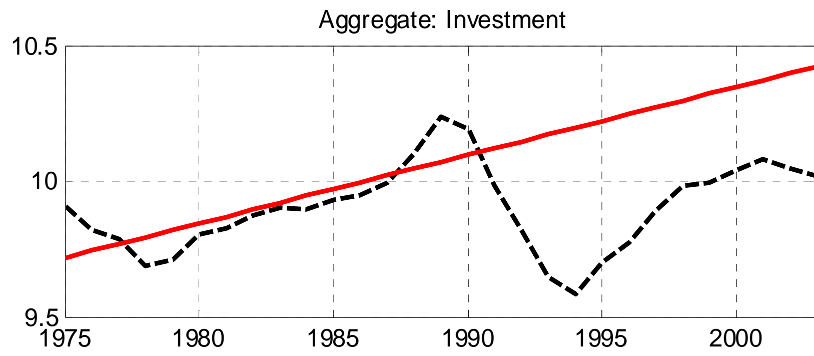
Define ω_{it}^{X} as the share of exports of industry *i* at time *t* to the Soviet Union in total exports of industry *i*. Let Y_{it} be value added (or any other the variable of interest) in industry *i* at time *t*. Then we compute value added in the Soviet sector as $Y_t^S = \sum_i \omega_{it}^X Y_{it}$ and correspondingly the non-Soviet sector is $Y_t^S = \sum_i (1 - \omega_{it}^X) Y_{it}$. 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.

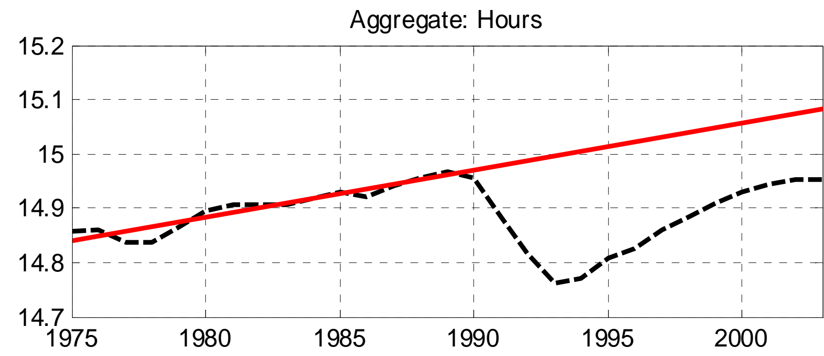
We plot series for Soviet, non-Soviet and service sector in Figure B2. Again, since most series grow over time we remove the trend component by fitting a time trend to each series individually on 1975-1989 data (Figure B3). Note that we do not impose a common trend across series.

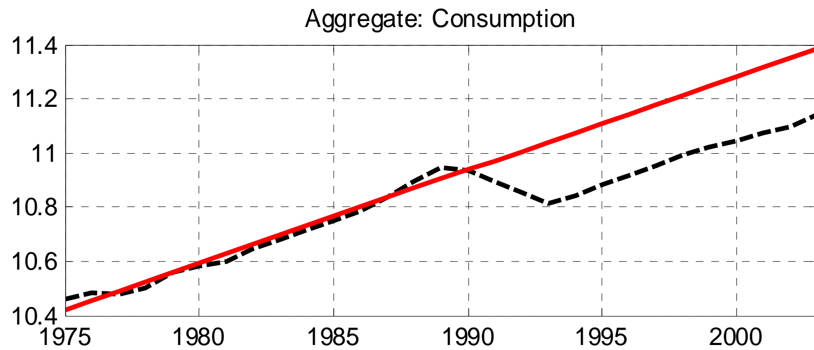
Figure B1. Macroeconomic aggregates: Actual series and estimated trend.

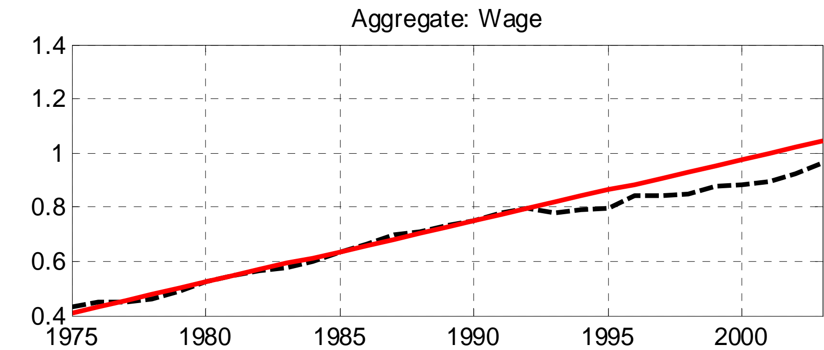






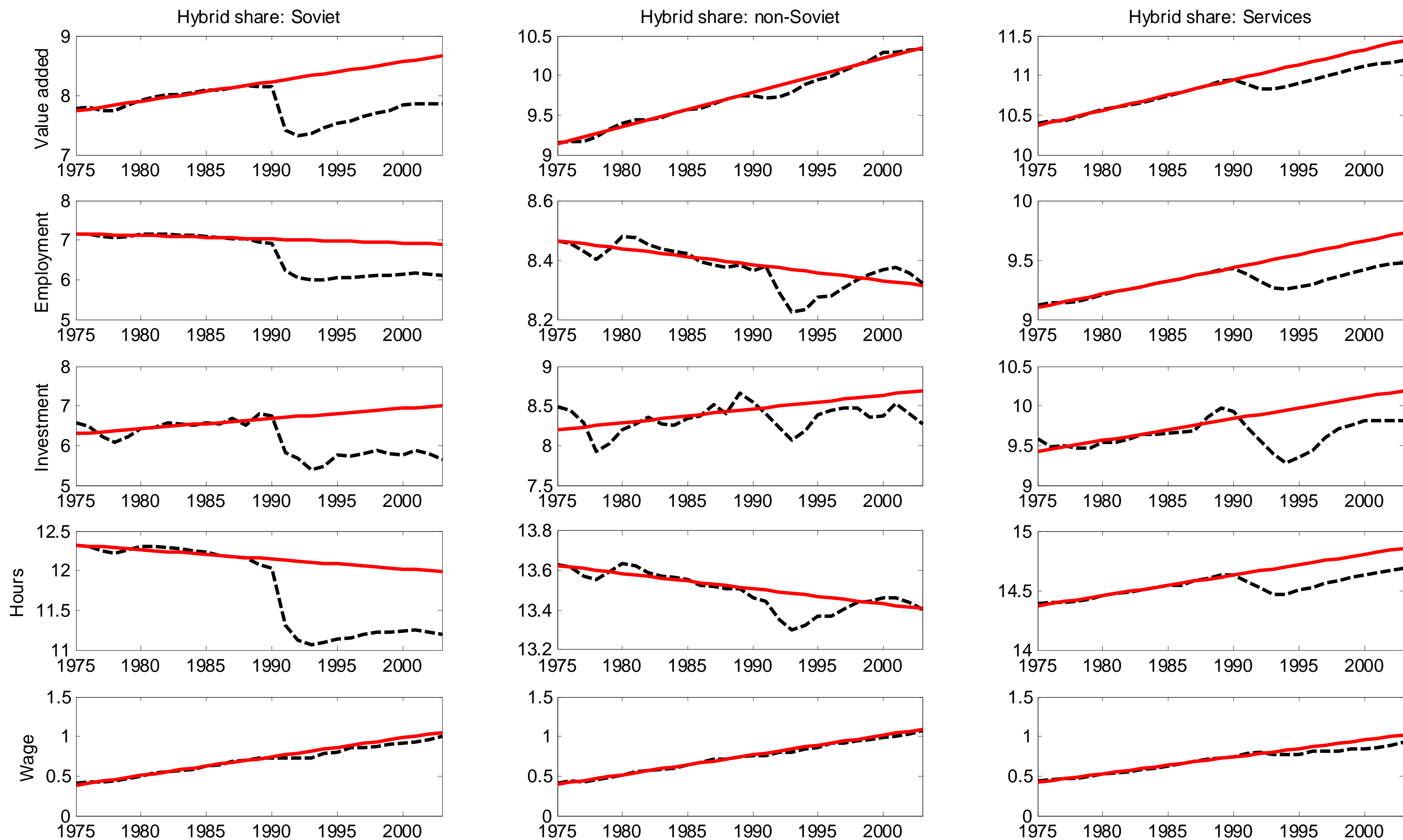






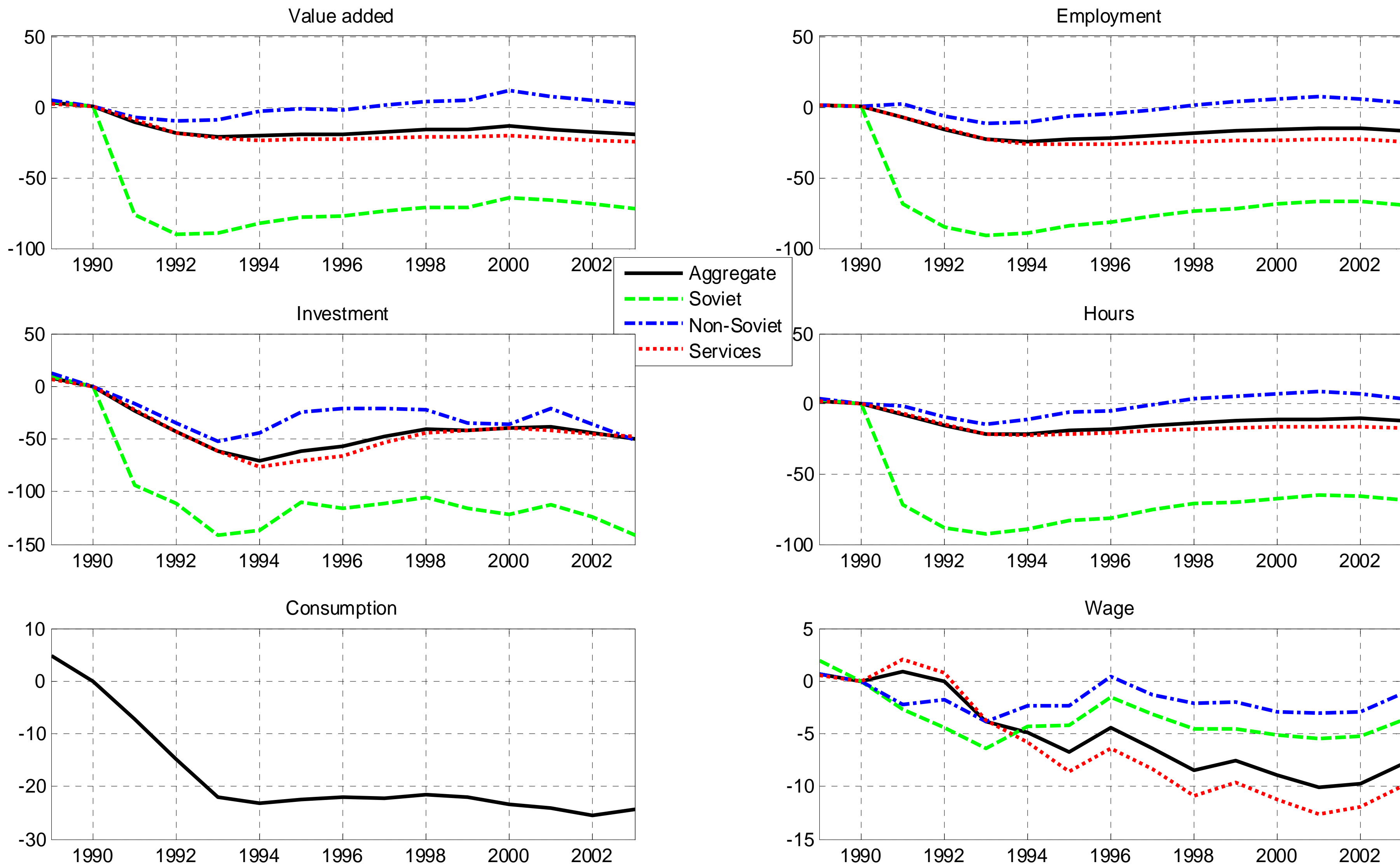
Note: The figure reports logs of real value added, real investment, real consumption, hours, and real wages. Solid line is time trend estimated on 1975-1989 data. Broken line is actual series.

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: percent 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: Sensitivity analysis

In a more general specification of the model we allow for habit formation in consumption and adjustment costs in labor and investment. Specifically, the household optimization problem has a more general utility function $U \equiv \sum_{t=0}^{\infty} \beta^t U(G_t, L_{1t}, L_{2t} L_{3t})$ where $G_t = (\xi_1 \bar{C}_{1t}^{\rho_C} + \xi_2 \bar{C}_{2t}^{\rho_C} + \xi_3 \bar{C}_{3t}^{\rho_C} + \xi_4 \bar{C}_{4t}^{\rho_C})^{1/\rho_C}$ is the CES consumption aggregator, and $\bar{C}_{jt} = \frac{1}{1-h} C_{jt} - \frac{h}{1-h} C_{j,t-1}$ is is the habit-adjusted consumption for good j, and parameter h describes habit in consumption.

We also consider an alternative functional form for the labor supply for different sectors. In particular, we examine how the choice of ρ_L, which controls the elasticity of substitution of labor supply across sectors, affects impulse responses:

$$U(G_t, L_{1t}, L_{2t} L_{3t}) = \frac{1}{1-\sigma} \left(G_t - \frac{\chi}{1+\eta} \left\{ \sum_{j=1}^{3} \omega_j L_{jt}^{\rho_L} \right\}^{\frac{1+\eta}{\rho_L}} \right)^{1-\sigma} .$$

In the firm's profit maximization problem, our generalization amounts to the following modification in the objective function

$$\sum_{t=0}^{\infty} \frac{1}{\prod_{s=0}^{t} R_s} \Bigg(p_{jt} Q_{jt} - p_t^E E_{jt} - w_{jt} L_{jt} - p_{jt} \left\{ K_{jt} - (1-\delta) K_{j,t-1} + \frac{\phi}{2} \left[\frac{K_{jt}}{K_{j,t-1}} - 1 \right]^2 K_{j,t-1} + \frac{\psi}{2} \left[\frac{I_{jt}}{I_{j,t-1}} - 1 \right]^2 I_{j,t-1} + \frac{\lambda}{2} \left[\frac{L_{jt}}{L_{j,t-1}} - 1 \right]^2 L_{j,t-1} \right\} \Bigg),$$

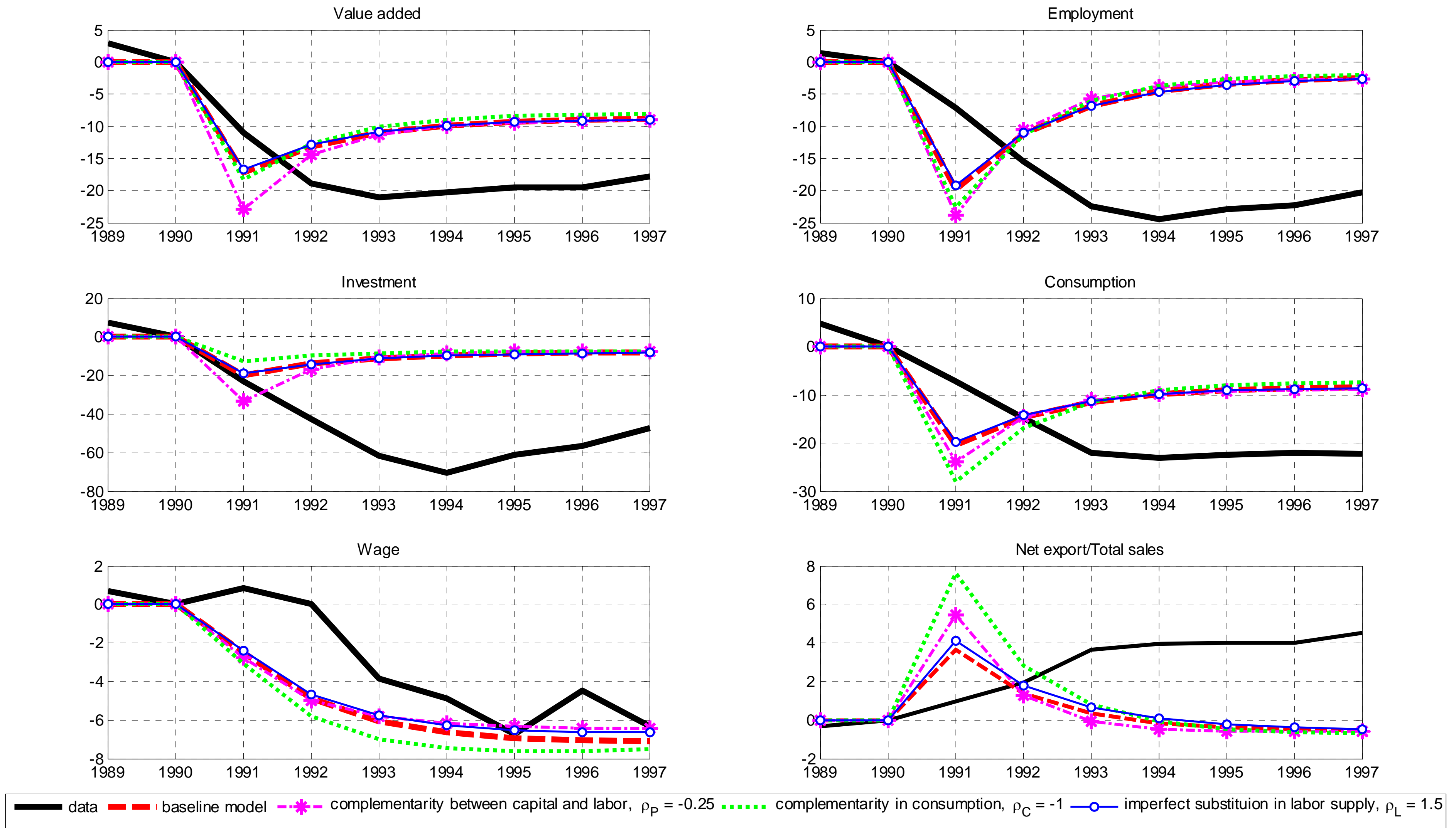
where parameters ϕ, ψ, λ are adjustment cost coefficients on capital, investment and labor respectively. All adjustment costs are quadratic. We also consider a CES aggregator for value added so that the production function in sector j is given by

$$Q_{jt} = \min \left\{ a_{jE} E_{jt}, \left(\alpha_{Lj} L_{jt}^{\rho_P} + (1 - \alpha_{Lj}) K_{j,t-1}^{\rho_P} \right)^{1/\rho_P} \right\}.$$

We assume small to moderate adjustment costs in labor: $\lambda = 1$. 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: $\psi = 0.5$. 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 0.9. We take an intermediate value of habit persistence and set $h = 0.8$.

In the figure below, we show the sensitivity of impulse responses to using alternative assumptions about functional forms.

Macroeconomic aggregates: Effects of adjustment costs and habit formation, percent deviations from trend.



Notes: The figures plot percent deviations from trend. Scenario "complementarity between capital and labor" assumes CES aggregator for value added in all sectors with elasticity of substitution between capital and labor equal to 0.8. Scenario "complementarity in consumption" assumes CES aggregator for consumption where the elasticity of substitution is 0.5. Scenario "imperfect substitution in labor supply" assumes that the elasticity of substitution across sectoral labor supplies for disutility of labor supply is -2.

Appendix D: Wage bargaining agreements.

Year	Agreement	Period of validity	Increase effective from	General Increase %	General Increase p/hour	Minimum and low-pay increase %	Average increase (industry workers) %	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	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		1.7	

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