Transition Economy Readjustment: A Trade-Shock Perspective

Examining the Impacts of the Collapse of Soviet Trade on Eastern Europe's Transition Economies

Abstract: To what extent is Hungary's recession between 1991 and 1996 driven by the costs of institutional adjustment following the collapse of the planned economy? Using a dynamic general equilibrium model with trade policy, price subsidies, and labor frictions, I build on prior work by Gorodnichenko, Mendoza, and Tesar (2012) to argue that the collapse of Soviet trade in 1991 induces a costly restructuring of Hungary's planned economy. I show that the estimated model closely matches the trajectory of consumption as seen in the data. Counterfactual experiments indicate that high wage rigidity, habit formation in consumption, and large oil price subsidies, together, go a long way in explaining the severity of Hungary's recession. The model highlights alternative policies resulting in a shortened and lessened severity.

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1 Introduction

Studying the sources of great depressions is of central interest in the macroeconomics literature. There are compelling reasons to believe that different causes of great depressions propagate differently throughout the economy and have disparate welfare impacts across populations. The work by Gorodnichenko, Mendoza, and Tesar (hereafter GMT) in "The Finnish Great Depression: From Russia with Love" [7] suggests a framework to examine great depressions driven by disruptions in trade relationships and presents a natural extension to consider the implications of the collapse in Soviet trade on Eastern European transition economies. My work extends the model and intuition of GMT to Hungary. Within the set of transition economies, Hungary was the most economically advanced and exhibited the greatest degree of economic liberalization [14]. Hungary is an interesting case study in crisis-management policy [5]. In 1995, Hungary faced a growing trade deficit, and policy responses included a large devaluation of currency, appreciation of the exchange rate, and maintaining nominal wage rigidity as a constraint on the growth of wages [19] [12].

In the case of Finland, GMT find that the collapse in Soviet trade propagated through the economy via a costly restructuring of the manufacturing sector from production of goods destined almost exclusively for the Soviet Union to production of goods for the world markets that required different capital and inputs. Firms that specialized in these largely Soviet goods faced a complicated adjustment and change to their production processes and had not previously competed directly with goods destined for the rest of the world. Such industries became essentially obsolete with the fall of the Soviet Union. The other mechanism was a sudden and persistent shock to the price of energy and raw materials. These two mechanisms are heavily interrelated in the case of Finland. The nature of trade agreements in the USSR incentivized Finnish production of goods necessary to the USSR through energy imports at an overvalued exchange rate. This relationship was mutually beneficial, but it was of high strategic importance for the Soviet Union due to Finland's international status as a Western democracy with access to Western technology and goods that was willing to engage in a trade relationship with the USSR. More information on the nature of Finnish-Soviet trade is given in the Finnish-Soviet Trade section.

The case study of Finland is interesting when considering the experience of Eastern Europe's other transition economies in the same time period. Most of the Soviet Union's other trading partners had Communist systems that also collapsed around the time that the Soviet Union did. Therefore, the macroeconomic aggregates and data from this time period reflect both the effects of the transition from a command to a market economy and the impacts of the collapse in Soviet trade. Isolating the effects of the Soviet trade collapse from the general transition effects has been an econometric challenge as these effects are highly confounded. The study of Finland is compelling because Finland did not face transition effects as a market-based Westernized economy. The comparison of the case of Finland to the case of other transition economies in Eastern Europe provides compelling research questions. How can the trends in the 1990s in Eastern Europe be decomposed into transition effects and trade effects? To what extent does the composition of the prior trade matter in terms of restructuring the manufacturing sector and redirection of exports? How do prices impact the rate and nature of this trade collapse both in terms of sticky wages and inflation? I will explore these questions via a panel of Eastern European transition economies that vary in the relevant attributes and apply a version of GMT's model to capture some of these dynamics.

Hungary is a strong candidate country for such answering such questions and extracting comparisons between Finland and other transition economies. Hungary's economic history in the late 20th century has distinguishing characteristics from other transition economies, particularly relating to a series of economic reforms launched in 1968 called the New Economic Mechanism (NEM). One notable aspect of the NEM was a change in price setting. Prior to 1968, prices were fixed by the state and were highly rigid as a result. A new price system was developed with three categories of prices: fixed, limited, and free. Limited prices were allowed to fluctuate within an interval defined by the state. The price type classification for each good was roughly based on intermediate and final goods. For example, materials and some intermediate goods were typically classified into fixed price categories to provide price stability for common inputs to production, while final goods were typically classified into more flexible prices. Moreover, Hungary was extremely trade dependent, particularly on the Soviet Union, throughout the latter half of the century, and faced inflation in the 1980s. This set of historical circumstances and policies provides an interesting alternative to Finland in a number of dimensions [4]. Furthermore, Hungary's central statistical office has somewhat richer economic data than other countries in the region.

To reconcile the set of circumstances that differentiate Hungary from Finland, I calibrate an augmented version of GMT's Finland model with an exchange-rate driven trade policy to target Hungary's consumption series. This trade policy shows up in the price of traded goods and captures a distortionary price-setting mechanism. The calibrated model successfully matches the trajectory of consumption in Hungary throughout the post-1991 collapse and transition period. In particular, my calibration reflects the gradual decline in the transition period of consumption and matches the trough at 1993. Additionally, I use my calibration to generate a decomposition of the collapse in output into contributions by spending components. Using counterfactual experiments, I isolate the impact of pre-collapse alternative policies on the subsequent recession and conclude that the presence of high wage rigidity severely constrains macroeconomic adjustment and recovery.

The remainder of the paper proceeds as follows. Section 2 situates Hungary's economic policy in historical context. Section 3 describes the data and section 4 gives a literature review. In section 5, I present a theoretical model of a small open economy with four sectors. Section 6 describes and evaluates the calibration. Section 7 discusses the results of the preferred model and counterfactual experiments to evaluate policies. Section 8 concludes.

2 Background Information

Macroeconomic and sector-level indicators in the panel of countries studied by GMT exhibit different trends, fluctuations and timing of economic turning points. Notwithstanding, figures 1 and 2 motivate a consideration of the 1990s recessions as induced by the shock to trade in response to the collapse of the Soviet Union. In particular, figure 2 features both Finland and Cuba. The path of GDP per capita in both countries looks identical to the remainder of the panel. This is noteworthy because Finland was never a planned economy and therefore avoided a transition between economic systems, while the case of Cuba is interesting because its planned economy continues to the present day. Thus, Cuba did not face institutional adjustment in this period. On the other hand, Eastern European transition economies, Finland, and Cuba are all strong trading partners of the USSR. All of these countries were members of the Soviet-sponsored trading bloc known as the Council for Mutual Economic Assistance (CMEA).[1] The common pattern in the timing and severity of the recessions experienced in each of these countries is compelling and suggests that the collapse of the Soviet Union may be a joint cause of each of these recessions.

Several graphs of relevant series are included below. From Figure 1, Finland's higher level of development and wealth becomes clear. The levels of GDP per capita are not identical per se in the rest of the panel, but they are substantially closer to each other than to Finland. Moreover, figure 2, which shows GDP per capita normalized to 100 in 1990, indicates that Poland's growth path differs from other countries in the panel. This reflects Poland's stronger growth in the 1990-2000 period, which perhaps is a result of its earlier market transition in the 1980s. Bulgaria is also notable for its slight deviation from trend in the period between 1996 and 2002, when GDP per capita actually declined. The remaining countries exhibit a common pattern of a decline in GDP per capita between 1990 and 1993, with a return to the 1990 levels of GDP by 1996.

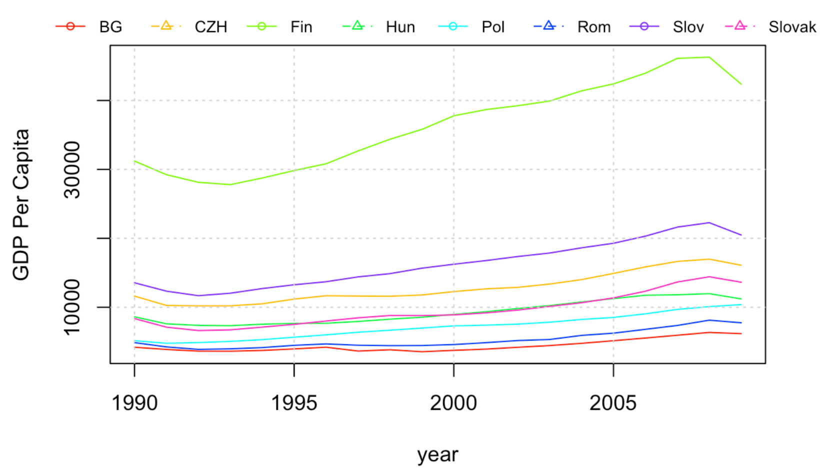


Figure 1: GDP per capita in levels across the panel of countries

[1]Finland is technically an observer-level member of CMEA, but its government is given full trading and economic privileges as a member. The status as an observer limits Finland's influence on the trade-policy setting side, but it does not exclude it from the trade relationship benefits a full member would receive.

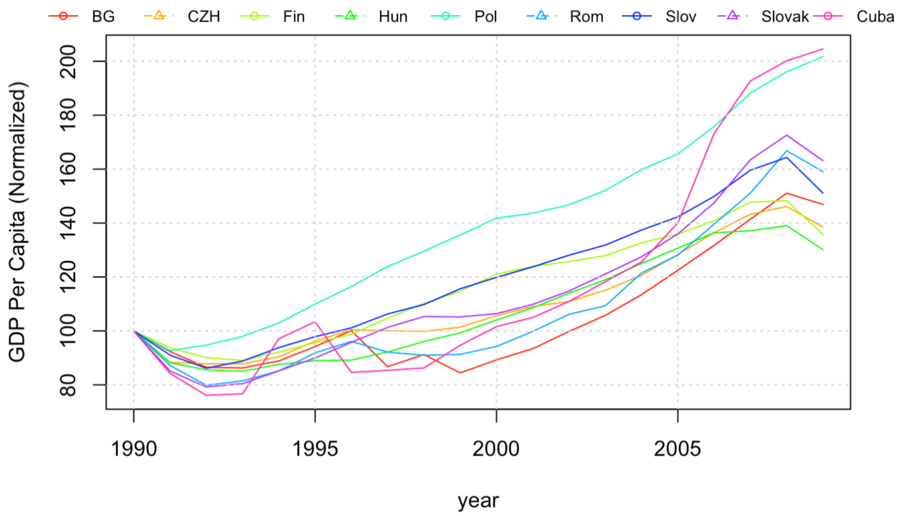


Figure 2: normalized GDP per capita across the panel of countries

Several Eastern European countries had large informal and black-market sectors of the economy under the Communist system, particularly to fill demand for Western goods that were not available. Current estimates of the size of the informal economy vary by country but average about 30% of official GDP, which suggests that the informal sector should be included to accurately capture all relevant sectors. As a point of contrast, the informal economy is not estimated to be a large factor in Finland.

There are also interesting patterns of import prices in the relevant countries. As seen in Figure 3, Finland's import prices sharply declined throughout 1985 and remained low until 1988 when they began to rise again. The period of sharply rising import prices corresponds with the Soviet Collapse. On the other hand, prices in Poland and Hungary exhibit more consistent patterns of increasing import price indices. In the time series of the import price index for Finland, Hungary, and Poland, Poland's time series has not been seasonally adjusted.

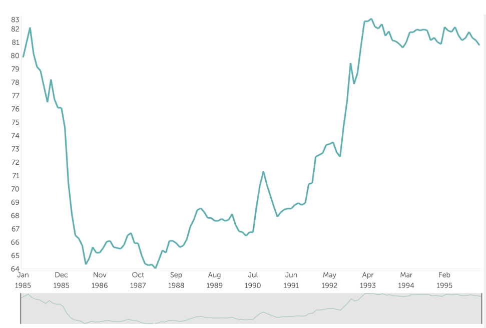


Figure 3: Finland Import Price Index, measured quarterly

2.1 Finnish-Soviet Trade

Finnish-Soviet trade has its origins in the Paasikivi-Kekkonen Doctrine, which is a broad foreign policy position that established Finland as an independent, democratic, and capitalist country with a strong economic relationship to the Soviet Union. Agreements within this time period, including the Treaty of Friendship, Cooperation, and Mutual Assistance, established a scientific and technological relationship between the two countries. Finland and the USSR generally agreed to circulate knowledge and research, as well as participate in scientific exchanges. The 1955 Treaty on Scientific and Technological Cooperation was the first such agreement between a capitalist and socialist country. It is clear that the USSR reaped enormous benefits from its trade and economic relationship with Finland, and this relationship motivates the favorable trade agreement for Finland. [17]

Finnish-Soviet trade was characterized by a oil for manufactures structure, which created a buffer for both countries against the volatility in the price in oil. As oil prices increased, Finland expanded production and shifted resources into sectors specific to USSR exports in order to meet the increased costs of energy. This style of agreement meant that Finland's exports to the USSR were determined by the price of energy and thus prior shocks to export demand can be thought of as exogenous to Finland's decisions. Baseline agreements for trade volumes were determined by five-year agreements between the USSR and Finland.

The critical component of Finnish-Soviet trade was a distorted terms of trade. As such, micro and survey data of managers suggests that trade to the Soviet Union was considered lucrative due to low risk and high profits, and obtaining export licenses was an important role of trade associations. Kajaste (1992) estimates [10] that Soviet exports included a 9.5% markup compared to exports in other markets [10]. Other estimates suggest a potentially larger markup. More specifically, Finnish manufacturers gained a premium on exports to the USSR, while oil importers received a discount on imported oil. A consideration of the evolution of this terms of trade distortion is a key component of the trade collapse story. Both absolute prices at the port for imports and exports and evidence of those distortions at the retail level will be of relevance to the model and empirical work. In any case, prior to the collapse of the Soviet trade channel, the Finnish economy was subsidized by oil prices that carried at least a 10% discount.[13] On the flip side, these trade manufactures were highly specialized to the needs of the Soviet Union, and thus post-collapse redirection of trade at a discount relative to the pre-collapse period was not possible for most products.

2.2 A Model of Trade-Induced Great Depressions

Conesa, Kehoe, and Ruhl (2007) [11] estimate a neoclassical growth model to decompose output changes into labor input changes, capital input changes, and changes in efficiency (TFP). They conclude that changes in TFP and an increase in both labor income and consumption taxes during 1989-1994 severely depressed labor hours and drove the contraction of output in the same time period. They conclude that the Finnish depression was the result of poor internal policy rather than external trade shocks. Notably, they do not examine the effects of the collapse in Soviet trade and take shocks to TFP as being exogenous.

Under the framework of Soviet-exclusive exports, this assumptions seems somewhat problematic. Firms that were granted rights to export to the Soviet Union were disproportionately impacted by the collapse in trade because their products became nearly worthless under the post-Soviet regime. Such firms had to reorient production to a global market with appropriately-valued goods. It is plausible that some capital was specific to the Soviet goods, and therefore could not be used efficiently to produce alternative goods. Therefore, the capital would become more efficient, changing the marginal rate of technical substitution between labor and capital. This change is therefore not exogenous and would factor into the TFP shocks of the Conesa, Kehoe, and Ruhl. [11]

2.3 Hungarian-CMEA Trade

Prior to 1989, Hungarian trade can be largely divided into two categories of approximately equal weight, namely trade within OECD area and trade within the Council for Mutual Economic Assistance (CMEA) area. Within the OECD area, trade was organized under convertible currencies; accordingly, pricing and quantities are determined in accordance with world market prices. Trade within the CMEA area was settled in the transferable rouble, according to a system of pricing and delivery outlined in the Pricing and the Transferable Rouble section.

The trade patterns and economic interdependence between the Soviet Union and Hungary has been characterized by historians as a reverse colonial model [15]. Data on product patterns traded between Hungary and each of these areas shows substantial differences in Hungary's role within both trade blocks. With the OECD area, Hungary's trade patterns resemble those of a developing country, while within the CMEA area, Hungary's product movements are characteristic of a highly industrialized nation. [9]. In this sense, the metropole (the Soviet Union) exchanged raw materials for finished goods from its sphere of influence (the colonies), which is the opposite of a traditional colonial relationship. This pattern of trade makes Soviet trade relationships particularly interesting in an international political economy context. [16]

Table 1: Production and Imports of Energy 1976-1981

	1976	1977	1978	1979	1980	1981
Production	2,142	2,191	2,198	2,027	2,031	2,024
Imports	8,785	8.538	9,960	9,638	8.336	7,754
Of Which from USSR	7,725	7,716	8,497	8,476	7,500	7,280

Notes: Looks at the classification of crude oil production, imports, and Soviet imports

As can be seen from Table 1, the overwhelming majority of Hungarian crude oil (and particularly imported crude oil) comes from the USSR.[6]

The divergence in trade motivates the division of Hungary's economy into four distinct sectors, two of which handle Western trade and one that handles CMEA trade. Because of the Soviet Union's abundance of resources and raw materials, over two-thirds of Soviet exports to Hungary were raw materials, while over two-thirds of Hungary's respective exports were finished products. A more detailed discussion of the products and industries in each direction of trade can be found in the appendix.

Prior to the collapse of the Soviet Union, Hungarian-Soviet trade was conducted according to a system of bilateral quotas determined years in advance. As discussed in the introduction, Hungary's New Economic Mechanism reform of 1968 introduced limited independence from state control for firms. However, the firm and mostly symbiotic pattern of trade established prior to the 1968 reform meant that the most profitable operations were production for the Soviet Union. Hungarian industries around processing chemicals and metallury from the Soviet Union as well as engineering firms producing exports specialized for Soviet export remained profitable and relatively secure. In this setting, the reform of 1968 changed production of Hungarian firms from a government prescription to a clear-cut choice on behalf of the firms, but it did not alter trade flows.

A breakdown in the composition of Hungarian exports to convertible currency areas is given in the figure below. This chart gives an indication of the types of exports Hungary produced for the West as opposed to the types of exports produced for the USSR. In particular, the post-1991 Hungarian exports feature relatively more intermediate goods, whereas Soviet trade for Hungary occurs in manufactured goods.

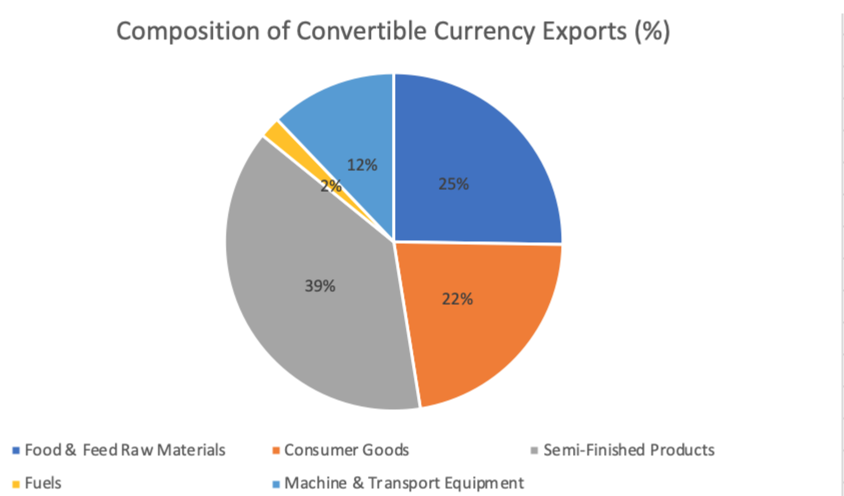


Figure 4: Composition of Hungary's exports by shares 1991

The rigidity of this system in response to Hungarian governmental reforms indicates the potential negative shock of the collapse in this Hungarian-Soviet trade. First, Hungarian firms based investment and profit maximization on the supposed rigidity and security of the Soviet Union as a source of demand for these products. Because these products were specialized for Soviet use, Hungarian manufactures were not offered on world markets, and therefore world prices were not considered and improvements to quality control were not undertaken. Furthermore, industries that relied on Soviet inputs also made investment decisions based on this existing supply chain. These factors in combination created vast exposure within the Hungarian economy on both the supply and demand side and motivates the exploration of the collapse in trade as a source of sharply negative output growth in Hungary in the 1990s.

2.4 Austria-Soviet Trade

Austria presents another case study of interest in identifying the role of the Soviet trade shock on macroeconomic performance. Although Austria was not a centrally planned economy, it's largest firms were nationalized following World War II, in part to protect them from Soviet takeover as war reparations. As a result, the government had an outsized role in the Austria economy through these large, state-owned companies, including VOEST Alpine, an important steel, auto, and railway company that traded primarily with the Soviet Union. In general, trade with the Soviet Union was concentrated in the state-owned firms, which resulted in a great deal of trade exposure in these firms that is not entirely captured by the share of Soviet trade in the overall economy. These firms underwent privatization beginning in the 1990s, and the transition effects from this privatization can be interpreted as transition effects independent of widespread institutional adjustment, as was present in communist Eastern Europe.

Thus, the inclusion of Austria provides a case study of a smaller and more concentrated shock to trade. Furthermore, high quality data at different levels of aggregation is available for Austria that is not available for Hungary. Trade prices with the Soviet Union were set in hard currency, rendering prices of traded goods closer to prevailing world market prices. The model of the Austrian economy will be calibrated according to the baseline GMT model described in the Model section of the paper.

2.5 Pricing and the Transferable Rouble

A central challenge in the identification of mechanisms and effects that can reproduce the negative output shock as a result of the collapse in Soviet trade is the absence of a unique exchange rate between transferable roubles and dollars. There is considerable discrepancy between various measures of the exchange rate, from the official intra-CMEA rate of .61 $\frac{TR}{\$}$ to the Polish cross rate of 4.52 $\frac{TR}{\$}$ (both 1990 values), and this type of discrepancy is a persistent feature of CMEA trade [21]. The imprecision of measuring this exchange rate is a key aspect that differentiates Hungarian-Soviet trade from Finnish-Soviet trade, and may present an interesting and novel decomposition of the aggregate Soviet collapse trade shock effect.

Pricing under the CMEA generally worked as follows, with some simplifications for the purposes of efficient modeling and notation. The discussion of pricing in CMEA trade follows Dani Rodrik's work on this topic closely [21]. The CMEA selected a world reference price, typically a five year moving average of world market prices, and converted the reference price to TR according to the official intra-CMEA rate, and this would constitute the common price, that would then be converted to national currencies under the relevant national exchange rates. In the case of imports of raw materials (primarily the domain of the Soviet Union), this scheme had the effect of smoothing temporary price shocks and reducing price volatility of raw materials, in particular oil. On the export side, CMEA finished goods produced for CMEA trade were generally of lower quality than Western analogues, so the set of world reference prices was extremely limited. This meant that reference prices were in practice negotiated in five-year terms and then exchanged according to the official CMEA rate as described previously.

From the perspective of the Hungarian household (also the sole owner of the firm), the change to world market prices after the collapse of CMEA trade impacted imports and exports in two distinct ways. On the one hand, the transition from five-year moving averages to single reference prices introduced greater volatility in pricing raw material imports. Despite cyclical variation in prices, over time, changes to the long-run trend of prices in the late 20th century are not likely to substantially alter the price of imports. On the other hand, the integration of CMEA markets with Western markets created an influx of high-quality Western produced goods in the CMEA area. Data from Oblath and Tarr (1991) [20] suggests that in comparison to Soviet Union exports, Hungarian products would have to be sold at a 44.9% discount to compete in Western markets. This market integration essentially rendered most Hungarian export manufactures obsolete, as the Western products were sold at similar or lower prices as a result of decades of total factor productivity (TFP) and returns to scale improvements. Data in figure 5 shows a comparison of TFP over time Hungary. Accordingly, the volume of exports sold declined precipitously in the post-1991 period resulting in substantial loss of income.

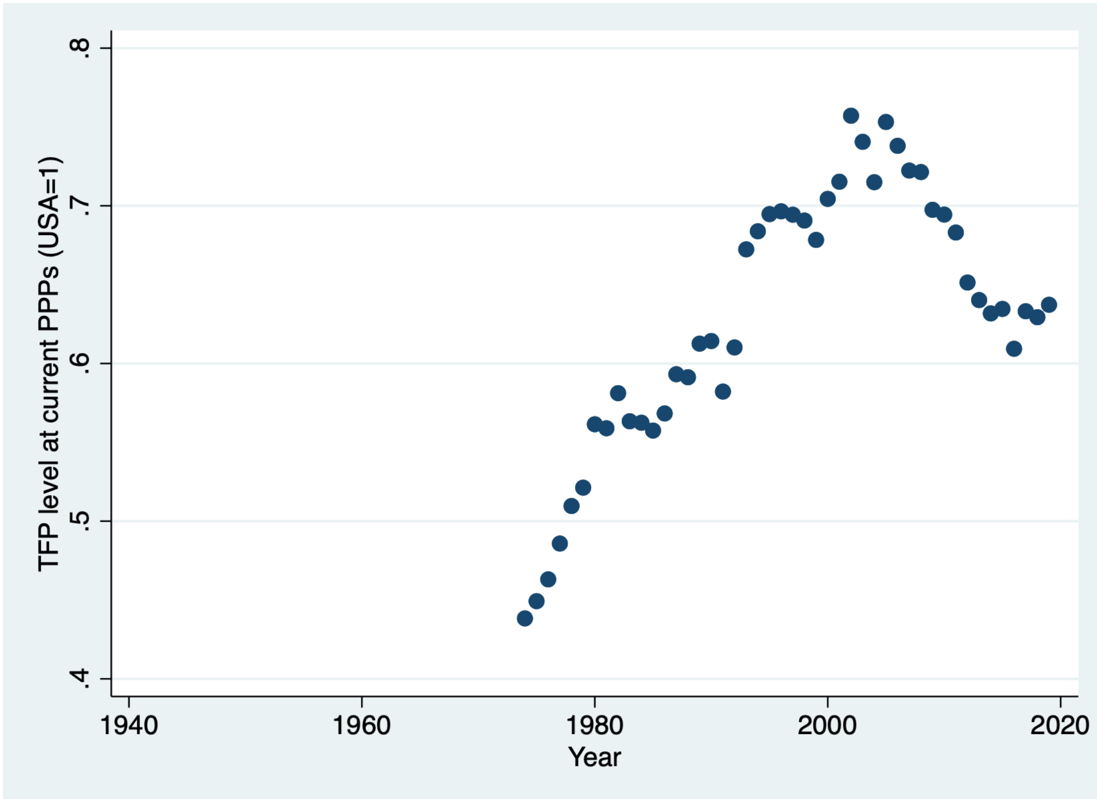


Figure 5: Hungary's measured TFP values

2.6 Implicit Import Subsidies and Export Taxes

The ideas and algebraic identities in this subsection closely follow the results of Rodrik (1992), but the application to the GMT model is my own.

The discrepancy between the official intra-CMEA transferable rouble exchange rate and the exchange rates of national currencies within the CMEA area with the transferable rouble is mathematically equivalent to an implicit import subsidy and export tax within the CMEA sector [1]. In the model outlined in section 4 of this paper, this corresponds to sector 2 of the economy, namely CMEA trade. For that reason, I use p_{2m} and p_{2x} to denote the import and export price of the CMEA good respectively. The endogenous price p_{2t} that shows up in the model is a representative good with an aggregated price of the import, export, and domestic prices.

The following series of equations defines import and export prices, as well as terms of trade, in terms of the various exchange rates of interest.

$$p_{2m} = p^*_{2m} \left(\frac{e^I_{R\$}}{e_{R\$}} \right) e_\$ \tag{1}$$

$$p_{2x} = p^*_{2x} \left(\frac{e^I_{R\$}}{e_{R\$}} \right) e_\$ \tag{2}$$

$$TOT = \frac{p_{2x}}{p_{2m}} = \frac{p^*_{2x}}{p^*_{2m}} \tag{3}$$

where p^*_{2m} is the world reference price of the import, p^*_{2x} is the world reference price of the export, $e^I_{R\$}$ is the official exchange rate ($TR/\$$), $e_{R\$}$ is the national cross rate ($TR/\$$), $e_\$$ is the national exchange rate (national currency/\$), and e_R is the rate between domestic currency and the transferable rouble (National currency/TR). Importantly, $e_{R\$}$ is not observed; it is obtained by dividing $e_\$$ by e_R.

The following series of equations defines import and export prices, as well as terms of trade under a unified interest rate that excludes the transferable rouble as a middleman currency.

$$p'_{2m} = p'^*_{2m} e_\$ \tag{4}$$

$$p'_{2x} = p'^*_{2x} e_\$ \tag{5}$$

$$TOT' = \frac{p'_{2x}}{p'_{2m}} = \frac{p'^*_{2x}}{p'^*_{2m}} \tag{6}$$

where the primes indicate post-1991 values.

In the case of Hungary (and the remainder of the CMEA area), the ratio $\frac{e^I_{R\$}}{e_{R\$}} < 1$. Thus, both p_{2m} and p_{2x} are lower than they would be in the absence of the differing exchange rates (i.e. if $\frac{e^I_{R\$}}{e_{R\$}} = 1$ instead). When comparing equations (1)-(3) with (4)-(6) and the knowledge that $\frac{e^I_{R\$}}{e_{R\$}} < 1$, it is clear that the discrepancy in exchange rates distorts the prices Hungarians face on imports and the price they receive on exports, and that the distortion is analytically equivalent to an import subsidy/export tax. Calculations by Rodrik based on exchange rate data indicate that the ad valorem rate of this implicit subsidy, given by $\frac{e^I_{R\$}}{e_{R\$}} - 1$, is 277% in Hungary in 1990. An import subsidy of this size is deeply relevant to understanding the mechanisms of how a trade shock propagates through the macroeconomy. This subsidy is incorporated into the theoretical model and calibration of Hungary.

3 Data

Data on economic aggregates comes from OECD's Statistics Database. These series are used to motivate cross-country comparisons and structural changes. Data on exports by destination comes from OECD's STAN bilateral trade database. These series give the value of trade between any home country and its major trading partners disaggregated by sector. This data is used to compute shares for the Soviet and Non-Soviet sectors. GMT suggest a list of industries to distinguish Soviet and non-Soviet sectors, and historical research suggests that the same sectors are largely appropriate for Hungary. I use the following industries (the GMT industries) to generate information on the Soviet and non-Soviet sectors:

- Chemicals and Chemical Products
- Coke, Refined Petroleum Products and Nuclear Fuel
- Rubber and Plastics Products

- Other Non-Metallic Mineral Products
- Basic Metals
- Fabricated Metal Products
- Textiles, Textile Products, Leather and Footwear
- Wood and Products of Wood and Cork
- Pulp, Paper, Paper Products, Printing and Publishing
- Basic Metals and Fabricated Metal Products
- Office, Accounting and Computing Machinery
- Electrical Machinery and Apparatus, not elsewhere classified
- Radio, Television and Communication Equipment
- Medical, Precision, and Optical Instruments
- Motor Vehicles, Trailers and Semi-Trailers
- Other Transport Equipment
- Manufacturing not elsewhere classified; Recycling
- Electricity, Gas and Water Supply

Energy data is scraped from Finnish Statistical Yearbooks (1993). Hungary's Central Statistical Office has a time series on the electricity balance broken down by origin and destination. The same office has a series of final energy consumption by industry. Annual daily time use series based on microdata are also provided by the Hungarian Central Statistical Office. This information is used to determine leisure and labor hours. Other consumption and labor data is taken from the IMF's IFS database, OECD's Statistical Division, and the Hungarian Central Statistical Office.

Obtaining accurate and comprehensive data on the state of the economy is a significant challenge in Eastern Europe during this time period. As a first stage, data was infrequently collected and is not readily available. Furthermore, the overvaluation of exports to the Soviet Union and artificially high prices during the Communist period make data on output and its components unreliable. The sudden downward shock to the levels of output during the market transition in part reflects more accurate prices and in part reflects actual decreases in output. Thus, meaningful comparisons under the two regimes are challenging.

3.1 Hungarian Data

Hungarian Data comes from the OECD's Structural Analysis Database (hereafter: STAN) and the Penn World Tables. Specifically, I use sectoral data on employment, value added, labor hours, output, investment (gross fixed capital formation), and wage bill from OECD's STAN database. Consumption data by sector is based on an input-output table from 1989 combined with Finland's consumption series from 1976-1991 [2].

Data for many of Hungary's series is not available prior to 1992, and these are constructed based on a penalized (ridge) regression of Finland, West Germany (Germany after 1991), and Austria's respective series with additional controls included as necessary to estimate the series. The ridge regression is chosen because the trajectories of the time series inputs are highly correlated, and therefore a standard OLS regression is not appropriate. I also repeat the data generation with an OLS regression on only the Finnish and Austria series to generate data for Hungary. I interpret the results from these two exercises as bounds on the true effect of the collapse in Soviet trade on Hungary. The exposure of Finland, Hungary, and Austria to Soviet trade varies; Finland was most exposed and Hungary was least exposed, based on historical narrative and trade data. The results of each of these exercises are presented in the appendix. More information on the specific controls used for each series can be found in the data section of the appendix.

I use Ridge (penalized) regression to estimate the following linear regression model and generate Hungarian data prior to 1992:

$$H_t = w_0 + w_1 F_t + w_2 A_t + w_3 G_t$$

where the $\vec{w}$ is the ridge estimate of the set of coefficients that approximates the available Hungarian data. For all data series except Employment, data is available in Hungary for all years after 1992, and the ridge regression is fit based on the the years 1992-2002. For the employment series, Hungarian data is consistently available only after 1995, and thus the ridge regression is fit based on 1995-2002. After the ridge estimate is generate, I use the vector of coefficients $\vec{w}$ to fill in the estimated Hungarian time series from 1976-1991. Ridge is a shrinkage method and its estimator is given by:

$$\hat{w} = \min_{w \in R^4} \left[(y - \mathbf{X}w)^T (y - \mathbf{X}w) + \lambda ||w||^2 \right]$$

In explicit form:

$$\hat{w} = (\mathbf{X}^T \mathbf{X} + \lambda \mathbf{I})^{-1} \mathbf{X}^T y$$

I use ridge regression to shrink the size of coefficients in the regressions to generate Hungarian data. This is particularly relevant on the w_0 term, which tended to be very large relative to the other coefficients in an OLS regression. Figure 12 shows a prototypical result of the ridge regression and all of the time series (excluding employment), wherein the years 1976-1990 feature a steady rise with a slight slowdown between 1980-1990 and then a crash from 1990-1992, followed by a recovery. Most importantly, all of the ridge regressions exhibit the characteristic U-shaped behavior of transition economies between 1990 and 1996.

Penalty terms for each ridge regression are set to be as small as possible while still generating positive values for all points in the simulated series. Because the model results and calibration are based on percentage differences between consecutive years, scaling the coefficients of the regression does not change the pattern of the time series. Increasing the penalty term on any of these series greatly shrinks the y-intercept and somewhat shrinks the w_1 and w_3 coefficients, or those on Austria and Finland. In all of the regression estimates, the coefficients on Austria and Finland are of similar magnitude, while the coefficient for Germany is of much smaller magnitude. This is consistent with the historical narrative that Hungary is somewhere between Austria and Finland in terms of exposure to Soviet trade and accordingly experiences a depression that sits in the middle of these two cases. The low values of the coefficients on Germany may suggest that Germany in this model serves as a type of time/European fixed effect[2]. Figures 13 and 14 show the results of changing the value of the penalty term. The penalty in Figure 13 is a third of the penalty size in Figure 14, and the estimated drop in value added between 1990 and 1992 are 41 and 48 percent respectively. This again suggests that the predicted drop in outcome variables is not substantially changed as a result of the changes in the size of the penalty term. Code to generate each of these estimates is given and the penalty term can be freely changed.

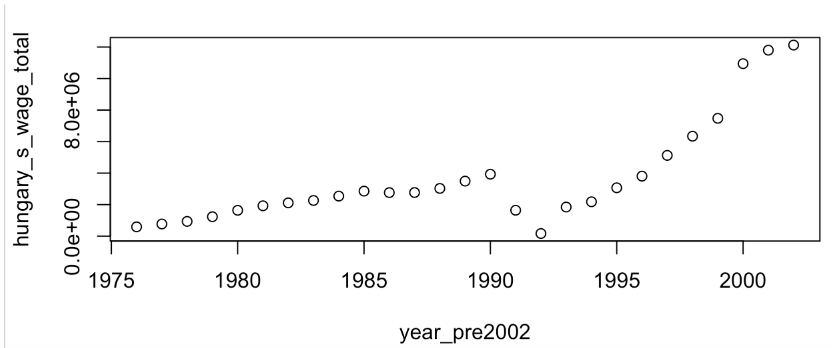


Figure 6: Ridge Regression Results (Soviet-Sector Wages)

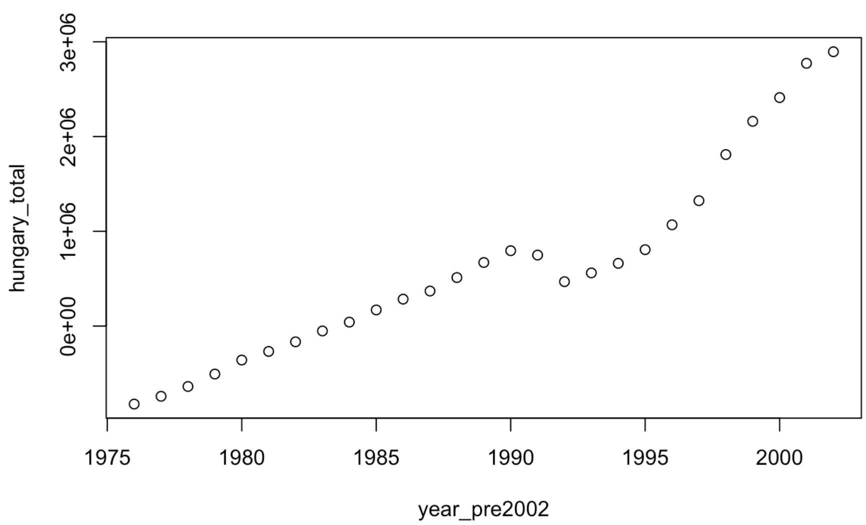


Figure 7: Ridge Results (Soviet-Sector Value Added)-Smaller Penalty

[2]When I conducted a LASSO regression of the same series, the German coefficients quickly shrink to 0, suggesting that the German data is not a strong predictor for the Hungarian data.

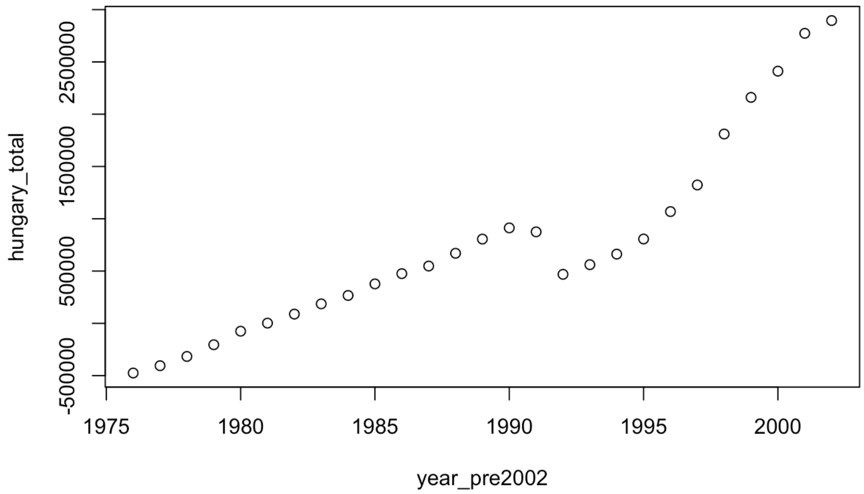


Figure 8: Ridge Results (Soviet-Sector Value Added)-Larger Penalty

3.2 Constructing the Soviet Sector

A model of Hungary's economy is calibrated based on the pure split of production into Soviet, non-Soviet, and service industries. The industries listed above in the data section are taken to be the Soviet sector. Any further partitioning of the industries into Soviet and non-Soviet components is infeasible given data constraints. A more realistic partition of the industries would yield a more accurate decomposition of the sectoral response to the trade shock into a Soviet-sector response, a non-soviet traded sector response, and a service response. A more interesting examination of the response may come from a comparison of the service sector with the two traded sectors. In particular, this comparison in response to a trade shock would isolate the trade response from general equilibrium effects of a recession.

4 Model

GMT model the Finnish economy as a small open economy with four sectors.[7] I follow their model closely to construct the Hungarian analogue. Sector 1 is the non-Soviet sector that produces a traded good consumed at home and sold abroad in western markets. Sector 2 is the CMEA sector that produces a good that can be consumed at home or sold exclusively within the CMEA area in transferable roubles. Export licensing within sector 2 is granted by Hungarian government contracts. Sector 3 is services and is therefore a non-trading sector. Sector four is consumption of a Western import good.

4.1 Environment

4.1.1 Households

The representative household chooses a lifetime plan for consumption and labor allocations to maximize $U \equiv \sum_{t=0}^{\infty} \beta^t U(G_t, L_{1t}, L_{2t}, L_{3t})$ where G is a CES consumption aggregator over four consumption goods and L_{jt} for j = 1, 2, 3 is the labor supplied to each sector in each period. The consumption aggregator is given by $G_t = \{\zeta_1 C_{1t}^{\rho_C} + \zeta_2 C_{2t}^{\rho_C} + \zeta_3 C_{3t}^{\rho_C} + \zeta_4 C_{4t}^{\rho_C}\}^{1/\rho_C}$, where $\frac{1}{1-\rho_C}$ is the elasticity of substitution of consumption, ζ_j are the weights in the consumption aggregator, and C_{jt} are the consumption of the goods produced by sectors j = 1,2,3. C_{4t} is the consumption of the Western import good.

Following Greenwood, Hercowitz, and Huffman (1988) [8], the period utility function is given by $U(G_t, L_{1t}, L_{2t}, L_{3t}) = \frac{1}{1-\sigma}(G_t - \frac{\chi_1}{\nu_1+1}L_{1t}^{\nu_1+1} - \frac{\chi_2}{\nu_2+1}L_{2t}^{\nu_2+1} - \frac{\chi_3}{\nu_3+1}L_{3t}^{\nu_3+1})^{(1-\sigma)}$, where $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution. Total employment is given by $L_t = L_{1t}+L_{2t}+L_{3t}$. Wages do not equalize in general across sectors because of the differences in disutility from working. More precise relationships between the endogenous variables are given in the solving the household problem section.

I assume that households own domestic firms and face the following budget constraint:

$$w_{1t}L_{1t} + w_{2t}L_{2t} + w_{2t}L_{2t} + (q_{1t} + d_{1t})K_{1,t-1} + (q_{2t} + d_{2t})K_{2,t-1} + (q_{3t} + d_{3t})K_{3,t-1} + R_t B_t = B_{t+1} + q_{1t}K_{1,t} + q_{2t}K_{2,t} + q_{3t}K_{3,t} + C_{1t} + p_{2t}C_{2t} + p_{3t}C_{3t} + p_{4t}C_{4t} \tag{7}$$

where w_j is the wage in sector j = 1,2,3, B_t is a one-period bond traded on international markets at the gross world interest rate of R_t, q_j is the price of capital in sector j and d_j is the dividend on capital in sector j. Prices are normalized to 1 based on the sector 1 good.

4.1.2 Firms

Firms in all sectors use inputs of capital (K), labor (L), and energy (E) to produce. The representative firm in each industry selects the distribution of inputs that maximizes profits. The representative firm faces the following problem:

$$\max_{K_{jt},L_{jt},E_{jt}} \quad \sum_{t=0}^{\infty} \frac{1}{\prod_{s=0}^{t} R_s} \left(p_{jt}Q_{jt} - p_j^E E_{jt} - w_{jt}L_{jt} - p_{jt}\left(K_{jt} - (1-\delta)K_{j,t-1}\right) - p_{jt}\frac{\phi_j}{2}\left(\frac{K_{jt}}{K_{jt-1}} - 1\right)^2 K_{jt-1} \right) \tag{8}$$

where δ is the rate of depreciation of the capital stock. ϕ is a capital adjustment cost coefficient, and p_{jt} is the relative price of goods in sector j (relative to the price of good 1) and p_t^E is the relative price of energy.

Production functions are given by $Q_{jt} = min\left(a_{jE}E_{jt}, \left(\alpha_{jK}K_{j,t-1}^{\rho_p} + \alpha_{jL}L_{jt}^{\rho_p}\right)^{\frac{\gamma_j}{\rho_p}}\right\}$ for j = 1, 2,3 and a_{jE} is the energy-sector requirement for sector j, $\frac{1}{1-\rho}$ is the elasticity of substitution between capital and labor, α_{jK}, α_{jL} are weights in the capital-labor aggregator and γ_j measures returns to scale in sector j. I assume that energy and value-added are perfect complements because substitution away from energy is not possible in the relevant timescale. In the Leontief production function's optimal solution, $a_{jE}E_{jt} = Q_{jt}$.

Value added is defined as $Y_{jt} = p_{jt}Q_{jt} - p_t^E E_{jt} = (p_{jt} - \frac{p_t^E}{a_{jE}})Q_{jt}$ and the value-added function is given by $Y_{jt} = F_j(K_{jj,t-1}, L_{jt}, p_{jt}, p_t^E)$. Using first-order conditions, the shadow prices of capital and dividend are given by:

$$q_{jt} = p_{jt}\left(1 + \phi_j\left(\frac{I_{jt}}{K_{j,t-1}} - \delta\right)\right)$$

$$d_{jt} = MPK_{j,t+1} - \delta q_{j,t+1} + p_{j,t+1}\phi_j\left(\frac{I_j, t+1}{K_{jt}} - \delta\right)\frac{I_{j,t+1}}{K_{jt}}$$

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

4.1.3 Market-Clearing Conditions

In sector 1, output is consumed and invested in sector 1 or exported to the rest of the world (non-CMEA) such that

$$Q_{1t} - C_{1t} - I_{1t} - X_{1t} = 0 \tag{9}$$

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^*, purchased at a world relative price p^*, and for imports of good C_4 purchased at world relative price p_{4t}. Hence, the non-CMEA balance of trade can be defined as follows:

$$TB_t = X_{1t} - p_t^* M_t^* - p_{4t} - C_{4t} = B_{t+1} - R_t B_t \tag{10}$$

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

$$Q_{2t} - C_{2t} - I_{2t} - X_{2t} = 0 \tag{11}$$

where X_{2t} measures exports to the USSR. To capture the quota system of Hungarian-Soviet trade, we assume that trade with the Soviet Union is balanced at all times. Hence, the Soviet trade balance is:

$$p_{2t}X_{2t} - p_t^s M_t^s = 0 \tag{12}$$

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 are set by five-year agreements between Hungary and the USSR.

I assume that Hungary produces no energy domestically and energy is not storable so that imports of energy are equal to domestic consumption of energy:

$$M_t^* + M_t^s - (E_{1t} + E_{2t} + E_{3t}) = 0 \tag{13}$$

In sector 3, since goods are nontradable, domestic production equals domestic absorption:

$$Q_{3t} - C_{3t} - I_{3t} = 0 \tag{14}$$

The equation that determines the evolution of wages in each sector is discussed in the next section.

4.1.4 Wage Rigidity

Finland has one of the highest rates of union membership and an extensive history of wages being determined by collective bargaining. The Finnish government is also heavily involved in wage negotiations and there is a well-documented literature on the trajectory and changes to Finnish wages prior to and after the 1990s. In particular, there is a decline in the proportion of GDP that is wages that appears to be persistent and driven primarily by declines in the nominal rigidity of the service sector. Figure A2 shows this pattern from 1948 to 1997. The sharp decline in the wage share of GDP coincides with the time period under consideration.

The changes in nominal wage rigidity vary by sector, as shown in the figure 7, which suggests that in the initial collapse and recovery period (1991-1994), nominal wage rigidity was high, while in the period directly after, nominal wage rigidity declined across all sectors in Finland.

Similarly,the high level of nominal wage rigidity in Hungary motivates the question of how this great depression would have propagated throughout in the absence of this strong wage rigidity.

Thinking about different ways to model this wage rigidity may also be interesting and lead to different conclusions. GMT considers the evolution of wage equation as a convex combination of previous period sector-specific wages and the reservation wage that comes out of the household labor supply of sector j in each regime t. The wages evolve according to the following formula:

$$w_{jt} = \theta_j w_{j,t-1} + (1 - \theta_j) w_{jt}^D \tag{15}$$

where θ_j governs the sector-specific wage stickiness. The results of Tavares [22] and the information of figure 9/Table 7.1 suggest that there is variable nominal wage rigidity across sectors and therefore sector-specific parameter values are warranted. Finland's system of ex-ante wage negotiations suggests that labor market clearing happens by changing the labor allocation rather than changes in the wage. Countries with different traditions of wage adjustment, especially as it relates to the timing of wage adjustments in response to macroeconomic shocks, may exhibit different patterns of adjustment. A variance decomposition in the factors that drive wage adjustments will need to be conducted to change the functional form of the wage evolution equation. Following devaluing of currency and the overall function of centrally planned economy banks as instruments of government policy rather than profit-earning institutions, Hungarian banks were not concerned with assessing credit-worthiness of firms, but rather with monitoring economic activity and compliance with five-year plans. Thus, in Hungary, firms trading with the CMEA area faced "soft" budget constraints that essentially incentivized perpetual wage growth regardless of macroeconomic conditions and changes in productivity. The uniqueness of centrally-planned credit systems with respect to wages is a critical difference between Finland's organized system of union wage negotiations and Hungary's more flexible system.

Table 7.1. The amount of nominal wage rigidities (averages over several years).

	Manual manufacturing	Non-manual manufacturing	Services
1986-1990	0.00	0.11	..
1991-1993 (1992-1994)	0.00	0.52	0.89
1994- (1995-)	0.00	0.18	0.14

Notes: Averages for services are from the years 1992-1994 and from the years 1995-2001.

Figure 9: Finland Nominal Wage Rigidity Averages

4.2 Competitive Equilibrium

A recursive competitive equilibrium in this economy is defined as the intertemporal sequence of allocations $\{L_{1t}, L_{2t}, L_{3t}, C_{1t}, C_{2t}, C_{3t}, C_{4t}, I_{1t}, I_{2t}, I_{3t}, Y_{1t}, Y_{2t}, Y_{3t}, E_{1t}, E_{2t}, E_{3t}, q_{1t}, q_{2t}, q_{3t}, Q_{1t}, Q_{2t}, Q_{3t}, M_t^*$ 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, the representative firm's problem, and satisfy the market clearing conditions given the initial conditions and allocations $\{K_{10}, K_{20}, K_{30},$ $w_{10}, w_{20}, w_{30}\}$ and intertemporal sequence of exogenous variables $\{p_t^E, M_t^S, p_{4t}, R_t\}_{t=0}^{\infty}$. The analysis focuses on equilibria that start from initial conditions that match Hungary's economy just before the collapse of the Soviet Union with the sequence of exogenous variables calibrated to reflect the sudden changes in the prices of energy and collapse of the second sector. Determining these initial conditions includes an element of uncertainty. As discussed previously in the data section, data that comes from this region in this time period is incomplete and may potentially have significant measurement error. One significant source of measurement error is the sizeable informal economy, which will be discussed in the next section. Adding the informal sector as an option for the households will add insights into how this measurement error impacts the initial conditions and how this in turn impacts the model.

4.2.1 Solving the Household Problem

In this section, I derive the solution of the household for given prices and exogenous variables. The representative household chooses a lifetime plan for consumption and labor allocations to maximize $U \equiv \sum_{t=0}^{\infty} \beta^t U(G_t, L_{1t}, L_{2t}, L_{3t})$ where G is a CES consumption aggregator over four consumption goods and L_{jt} for j = 1,2, 3 is the labor supplied to each sector in each period. The consumption aggregator is given by $G_t = \{\zeta_1 C_{1t}^{\rho_C} + \zeta_2 C_{2t}^{\rho_C} + \zeta_3 C_{3t}^{\rho_C} + \zeta_4 C_{4t}^{\rho_C}\}^{1/\rho_C}$ and the period utility function is given by $U(G_t, L_{1t}, L_{2t}, L_{3t}) = \frac{1}{1-\sigma}(G_t - \frac{\chi_1}{\nu_1+1} L_{1t}^{\nu_1+1} - \frac{\chi_2}{\nu_2+1} L_{2t}^{\nu_2+1} - \frac{\chi_3}{\nu_3+1} L_{3t}^{\nu_3+1})^{(1-\sigma)}$.

The household budget constraint in each period t is given by:

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

Though the model is in infinite periods, I explicitly solve in two periods for characterizing equations between endogenous variables. Without loss of generality, I select the first two periods t=1 and t=2.

Setting up the two-period Lagrangean, I get:

$$L(c_{11}, c_{21}, c_{31}, c_{41}, L_{11}, L_{21}, L_{31}) = U(G_1, L_{11}, L_{21}, L_{31}) + \beta U(G_2, L_{12}, L_{22}, L_{32}) + \lambda\{B_{t+1} + q_{1t}K_{1,t} + q_{2t}K_{2,t}$$
$$+q_{3t}K_{3,t} + C_{1t} + p_{2t}C_{2t} + p_{3t}C_{3t} + p_{4t}C_{4t} - [w_{1t}L_{1t} + w_{2t}L_{2t} + w_{2t}L_{2t}$$
$$+(q_{1t} + d_{1t})K_{1,t-1} + (q_{2t} + d_{2t})K_{2,t-1} + (q_{3t} + d_{3t})K_{3,t-1} + R_tB_t\}$$

Taking the first order conditions and setting them equal to 0, I get:

$$a_1 \left(\zeta_2 c_{21}^{\zeta_2 - 1} c_{11}^{\zeta_1} c_{31}^{\zeta_3} c_{41}^{1-\zeta_1-\zeta_2-\zeta_3} \right) + p_{21}\lambda = 0$$

$$a_1 \left(\zeta_3 c_{31}^{\zeta_3 - 1} c_{11}^{\zeta_1} c_{21}^{\zeta_2} c_{41}^{1-\zeta_1-\zeta_2-\zeta_3} \right) + p_{31}\lambda = 0$$

$$a_1 \left(\zeta_4 c_{41}^{\zeta_1-\zeta_2-\zeta_3} c_{11}^{\zeta_1} c_{21}^{\zeta_2} c_{31}^{\zeta_3} \right) + p_{41}\lambda = 0$$

$$a_1 \left(\zeta_1 c_{11}^{\zeta_1 - 1} c_{21}^{\zeta_2} c_{31}^{\zeta_3} c_{41}^{1-\zeta_1-\zeta_2-\zeta_3} \right) + \lambda = 0$$

$$a_1 \left(-\chi_1 L_{11}^{\nu} \right) - \lambda w_{11} = 0$$

$$a_1 \left(-\chi_2 L_{21}^{\nu} \right) - \lambda w_{21} = 0$$

$$a_1 \left(-\chi_3 L_{31}^{\nu} \right) - \lambda w_{31} = 0$$

where a_t is $(G_0 - \frac{\chi_1}{\nu+1} L_{1t}^{\nu+1} - \frac{\chi_2}{\nu+1} L_{2t}^{\nu+1} - \frac{\chi_3}{\nu+1} L_{3t}^{\nu+1})^{-\sigma}$

Setting the equations equal to each other by solving for lambda and rearranging, I get:

$$\frac{L_{11}}{L_{21}} = \left(\frac{\chi_2}{\chi_1}\right)^{\frac{1}{\nu}} \left(\frac{w_{11}}{w_{21}}\right)^{\frac{1}{\nu}} \tag{16}$$

$$\frac{L_{11}}{L_{31}} = \left(\frac{\chi_3}{\chi_1}\right)^{\frac{1}{\nu}} \left(\frac{w_{11}}{w_{31}}\right)^{\frac{1}{\nu}} \tag{17}$$

$$\frac{L_{21}}{L_{31}} = \left(\frac{\chi_3}{\chi_2}\right)^{\frac{1}{\nu}} \left(\frac{w_{21}}{w_{31}}\right)^{\frac{1}{\nu}} \tag{18}$$

$$\chi_1 L_{11}^{\nu} \left(\frac{p_{21}}{w_{11}}\right) = \frac{\partial G_1}{\partial C_{21}} \tag{19}$$

$$\chi_1 L_{11}^{\nu} \left(\frac{p_{31}}{w_{11}}\right) = \frac{\partial G_1}{\partial C_{31}} \tag{20}$$

$$\chi_1 L_{11}^{\nu} \left(\frac{p_{41}}{w_{11}}\right) = \frac{\partial G_1}{\partial C_{41}} \tag{21}$$

Because p_{11} is the numeraire, I can rewrite equations 19-21 as:

$$\frac{\chi_1 L_{11}{}^{\nu}}{w_{11}}\left(\frac{p_{21}}{p_{11}}\right) = \frac{\partial C_1}{\partial C_{21}}$$
$$\frac{\chi_1 L_{11}{}^{\nu}}{w_{11}}\left(\frac{p_{31}}{p_{11}}\right) = \frac{\partial C_1}{\partial C_{31}}$$
$$\frac{\chi_1 L_{11}{}^{\nu}}{w_{11}}\left(\frac{p_{41}}{p_{11}}\right) = \frac{\partial C_1}{\partial C_{41}}$$

The same first-order conditions apply in period 2. Intertemporal relationships can be backed out using the following equation:

$$\frac{\partial G_1}{\partial C_{21}} = \beta\left(\frac{p_{21}}{p_{22}}\right)\left(\frac{a_2}{a_1}\right)\frac{\partial G_2}{\partial C_{22}}$$

4.3 Competitive Equilibrium with Price Subsidies

Similar to the baseline model (section 4.2), Sector 1 is the non-Soviet sector, Sector 2 is the CMEA sector, Sector 3 is services, and Sector 4 is consumption of a Western import good. To incorporate the role of the transferable rouble in the pre-collapse trading relationship, I consider a world with Hungary and the Soviet Union as individual governments in a currency union with a trade policy of taxes and subsides. The policy parameter, or the amount of the subsidy/tax is given by s, is set exogenously, but it is time-varying. A formal description of the equivalence between the trade policy and the transferable rouble pricing scheme is given in the Implicit Import Subsidy section of the paper.

The revenue from the trade policy is returned to consumers via a lump-sum transfer denoted by ψ. In the case of a positive value of s, the export tax inflates the marginal cost to the firms producing export goods and the import subsidy deflates the marginal cost to consumers purchasing import goods. This distortionary policy changes the consumption patterns of consumers by inducing greater consumption of imported goods and fewer exports.

The pricing scheme also introduces the role of exchange rates between the Hungarian forint and the US dollar, which is the assumed currency for transactions involving the West, namely sectors 1 and 4. I treat these transactions as if they go through the exchange rate. After 1991, all transactions occur in dollars and the policy parameter is set equal to 0.

4.3.1 Households

The representative household chooses a lifetime plan for consumption and labor allocations to maximize $U \equiv \sum_{t=0}^{\infty} \beta^t U(G_t, L_{1t}, L_{2t}, L_{3t})$ where G is a CES consumption aggregator over four consumption goods and L_{jt} for j = 1,2, 3 is the labor supplied to each sector in each period. The consumption aggregator is given by $G_t = \{\zeta_1 C_{1t}^{\rho_C} + \zeta_2 C_{2t}^{\rho_C} + \zeta_3 C_{3t}^{\rho_C} + \zeta_4 C_{4t}^{\rho_C}\}^{1/\rho_C}$, where $\frac{1}{1-\rho_C}$ is the elasticity of substitution of consumption, ζ_j are the weights in the consumption aggregator, and C_{jt} are the consumption of the goods produced by sectors j = 1,2,3. C_{4t} is the consumption of the Western import good.

Following Greenwood, Hercowitz, and Huffman (1988) [8], the period utility function is given by $U(G_t, L_{1t}, L_{2t}, L_{3t}) = \frac{1}{1-\sigma}(G_t - \frac{\chi_1}{\nu_1+1}L_{1t}^{\nu_1+1} - \frac{\chi_2}{\nu_2+1}L_{2t}^{\nu_2+1} - \frac{\chi_3}{\nu_3+1}L_{3t}^{\nu_3+1})^{(1-\sigma)}$, where $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution. Total employment is given by $L_t = L_{1t}+L_{2t}+L_{3t}$. Wages do not equalize in general across sectors because of the differences in disutility from working. More precise relationships between the endogenous variables are given in the solving the household problem section.

I assume that households own domestic firms and face the following budget constraint:

$$w_{1t}L_{1t} + w_{2t}L_{2t} + w_{2t}L_{2t} + (q_{1t} + d_{1t})K_{1,t-1} + (q_{2t} + d_{2t})K_{2,t-1} + (q_{3t} + d_{3t})K_{3,t-1} + R_tB_t = B_{t+1} + q_{1t}K_{1,t} + q_{2t}K_{2,t} + q_{3t}K_{3,t} + C_{1t} + \frac{1}{(1+s_t)}p_{2t}C_{2t} + p_{3t}C_{3t} + p_{4t}C_{4t} + \psi \tag{22}$$

where w_j is the wage in sector j = 1,2,3, B_t is a one-period bond traded on international markets at the gross world interest rate of R_t, q_j is the price of capital in sector j, d_j is the dividend on capital in sector j, s is the trade policy parameter, and ψ is the common transfer from the trade policy. Prices are normalized to 1 based on the sector 1 good.

4.3.2 Firms

Firms in all sectors use inputs of capital (K), labor (L), and energy (E) to produce. The representative firm in each industry selects the distribution of inputs that maximizes profits. The representative firm faces the following problem:

$$\max_{K_{jt},L_{jt},E_{jt}} \quad \sum_{t=0}^{\infty} \frac{1}{\prod_{s=0}^{t} R_s} \left(p_{jt}^{*}Q_{jt} - p_j^E E_{jt} - w_{jt}L_{jt} - p_{jt}\left(K_{jt} - (1-\delta)K_{j,t-1}\right) - p_{jt}\frac{\phi_j}{2}\left(\frac{K_{jt}}{K_{jt-1}} - 1\right)^2 K_{jt-1}\right) \tag{23}$$

where δ is the rate of depreciation of the capital stock. ϕ is a capital adjustment cost coefficient, and p_{jt} is the relative price of goods in sector j (relative to the price of good 1) and p_t^E is the relative price of energy. The price of the sector 2 export good is augmented by $(1 + s_t)$.

Production functions are given by $Q_{jt} = min\left(a_{jE}E_{jt}, \left(\alpha_{jK}K_{j,t-1}^{\rho_p} + \alpha_{jL}L_{jt}^{\rho_p}\right)^{\frac{\gamma_j}{\rho_p}}\right\}$ for j = 1,2,3 and a_{jE} is the energy-sector requirement for sector j, $\frac{1}{1-\rho}$ is the elasticity of substitution between capital and labor, α_{jK}, α_{jL} are weights in the capital-labor aggregator and γ_j measures returns to scale in sector j. I assume that energy and value-added are perfect complements because substitution away from energy is not possible in the relevant timescale. In the Leontif production function's optimal solution, $a_{jE}E_{jt} = Q_{jt}$.

Value added is defined as $Y_{jt} = p_{jt}Q_{jt} - p_t^E E_{jt} = (p_{jt} - \frac{p_t^E}{a_{jE}})Q_{jt}$ and the value-added function is given by $Y_{jt} = F_j(K_{jj,t-1}, L_{jt}, p_{jt}, p_t^E)$. Using first-order conditions, the shadow prices of capital and dividend are given by:

$$q_{jt} = p_{jt}\left(1 + \phi_j\left(\frac{I_{jt}}{K_{j,t-1}} - \delta\right)\right)$$

$$d_{jt} = MPK_{j,t+1} - \delta q_{j,t+1} + p_{j,t+1}\phi_j\left(\frac{I_j, t+1}{K_{jt}} - \delta\right)\frac{I_{j,t+1}}{K_{jt}}$$

where $MPK_{j,t+1} = \frac{\partial Y_{j,t+1}}{\partial K_{jt}}$ is the marginal product of capital. Again, the price of good 2 is augmented by $(1 + s_t)$.

4.3.3 Market-Clearing Conditions

In sector 1, output is consumed and invested in within sector 1 or exported to the rest of the world (non-CMEA) such that

$$Q_{1t} - C_{1t} - I_{1t} - X_{1t} = 0 \tag{24}$$

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^*, purchased at a world relative price p^*, and for imports of good C_4 purchased at world relative price p_{4t}. Hence, the non-CMEA balance of trade can be defined as follows:

$$TB_t = X_{1t} - p_t^* M_t^* - p_{4t} - C_{4t} = B_{t+1} - R_t B_t \tag{25}$$

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

$$Q_{2t} - C_{2t} - I_{2t} - X_{2t} = 0 \tag{26}$$

where X_{2t} measures exports to the USSR. To capture the quota system of Hungarian-Soviet trade, we assume that trade with the Soviet Union is balanced at all times. Hence, the Soviet trade balance is:

$$(1 + s_t)p_{2t}X_{2t} - p_t^{su} M_t^{su} = 0 \tag{27}$$

where p_t^{su} is the barter price of energy contracted with the Soviet Union for a quantity M_t^{su} of energy imports. The values of p_t^{su} and M_t^{su} are fixed, since they are set by five-year agreements between Hungary and the USSR.

I assume that Hungary produces no energy domestically and energy is not storable so that imports of energy are equal to domestic consumption of energy:

$$M_t^* + M_t^s - (E_{1t} + E_{2t} + E_{3t}) = 0 \tag{28}$$

In sector 3, since goods are nontradable, domestic production equals domestic absorption:

$$Q_{3t} - C_{3t} - I_{3t} = 0 \tag{29}$$

The equation that determines the evolution of wages in each sector is as in the baseline case.

$$w_{jt} = \theta_j w_{j,t-1} + (1 - \theta_j) w_{jt}^D \tag{30}$$

where θ_j governs the sector-specific wage stickiness.

4.3.4 Equilibrium

A recursive competitive equilibrium in this economy is defined as the intertemporal sequence of allocations $\{L_{1t}, L_{2t}, L_{3t}, C_{1t}, C_{2t}, C_{3t}, C_{4t}, I_{1t}, I_{2t}, I_{3t}, Y_{1t}, Y_{2t}, Y_{3t}, E_{1t}, E_{2t}, E_{3t}, q_{1t}, q_{2t}, q_{3t}, Q_{1t}, Q_{2t}, Q_{3t}, M_t^*$ and prices $\{p_{2t}, p_{3t}, w_{1t}, w_{2t}, w_{3t}, q_{1t}, q_{2t}, q_{3t}, \Psi\}_{t=0}^{\infty}$ that solve the household's problem, the representative firm's problem, and satisfy the market clearing conditions given the initial conditions and allocations $\{K_{10}, K_{20}, K_{30}, w_{10}, w_{20}, w_{30}\}$ and intertemporal sequence of exogenous variables $\{s_t, p_t^E, M_t^S, p_{4t}, R_t\}_{t=0}^{\infty}$. The endogenous variable Ψ is the total revenue from the trade policy, and is given by $(1+s)Q_{2t}$, where Q_{2t} is the production of goods in sector 2 for export to the Soviet Union.

The analysis focuses on equilibria that start from initial conditions that match Hungary's economy just before the collapse of the Soviet Union with the sequence of exogenous variables calibrated to reflect the sudden changes in the prices of energy and collapse of the second sector. The exogenous trade policy values are set based on Dani Rodrik's estimates for five-year intervals, as described in the import subsidy section. Determining the initial conditions includes an element of uncertainty. As discussed previously in the data section, data that comes from Hungary in this time period is incomplete and may potentially have significant measurement error. In some cases, data series are completely missing prior to 1991, and in these cases, series are generated via regressions on the same series in other countries.

4.3.5 Solving the Household Problem

In this section, I derive the solution of the household for given prices and exogenous variables. The representative household chooses a lifetime plan for consumption and labor allocations to maximize $U \equiv \sum_{t=0}^{\infty} \beta^t U(G_t, L_{1t}, L_{2t}, L_{3t})$ where G is a CES consumption aggregator over four consumption goods and L_{jt} for j = 1,2, 3 is the labor supplied to each sector in each period. The consumption aggregator is given by $G_t = \{\zeta_1 C_{1t}^{\rho_C} + \zeta_2 C_{2t}^{\rho_C} + \zeta_3 C_{3t}^{\rho_C} + \zeta_4 C_{4t}^{\rho_C}\}^{1/\rho_C}$ and the period utility function is given by $U(G_t, L_{1t}, L_{2t}, L_{3t}) = \frac{1}{1-\sigma}(G_t - \frac{\chi_1}{\nu_1+1} L_{1t}^{\nu_1+1} - \frac{\chi_2}{\nu_2+1} L_{2t}^{\nu_2+1} - \frac{\chi_3}{\nu_3+1} L_{3t}^{\nu_3+1})^{(1-\sigma)}$.

The household budget constraint in each period t is given by:

$$w_{1t}L_{1t} + w_{2t}L_{2t} + w_{2t}L_{2t} + (q_{1t}+d_{1t})K_{1,t-1} + (q_{2t}+d_{2t})K_{2,t-1} + (q_{3t}+d_{3t})K_{3,t-1} + R_tB_t = B_{t+1} + q_{1t}K_{1,t} + q_{2t}K_{2,t} + q_{3t}K_{3,t} + C_{1t} + \frac{1}{(1+s_t)}p_{2t}C_{2t} + p_{3t}C_{3t} + p_{4t}C_{4t}$$

Though the model is in infinite periods, I explicitly solve in two periods for characterizing equations between endogenous variables. Without loss of generality, I select the first two periods t=1 and t=2.

Setting up the two-period Lagrangean, I get:

$$L(c_{11}, c_{21}, c_{31}, c_{41}, L_{11}, L_{21}, L_{31}) = U(G_1, L_{11}, L_{21}, L_{31}) + \beta U(G_2, L_{12}, L_{22}, L_{32}) + \lambda\{B_{t+1} + q_{1t}K_{1,t} + q_{2t}K_{2,t} + q_{3t}K_{3,t} + C_{1t} + \frac{1}{(1+s_t)}p_{2t}C_{2t} + p_{3t}C_{3t} + p_{4t}C_{4t} - [w_{1t}L_{1t} + w_{2t}L_{2t} + w_{2t}L_{2t} + (q_{1t}+d_{1t})K_{1,t-1} + (q_{2t}+d_{2t})K_{2,t-1} + (q_{3t}+d_{3t})K_{3,t-1} + R_tB_t\}$$

Taking first order conditions and setting them equal to zero, I get:

$$a_1\left(\zeta_2 c_{21}^{\zeta_2-1}c_{11}^{\zeta_1}c_{31}^{\zeta_3}c_{41}^{1-\zeta_1-\zeta_2-\zeta_3}\right)+\frac{1}{(1+s_t)}p_{21}\lambda=0$$

$$a_1\left(\zeta_3 c_{31}^{\zeta_3-1}c_{11}^{\zeta_1}c_{21}^{\zeta_2}c_{41}^{1-\zeta_1-\zeta_2-\zeta_3}\right)+p_{31}\lambda=0$$

$$a_1\left(\zeta_4 c_{41}^{\zeta_1-\zeta_2-\zeta_3}c_{11}^{\zeta_1}c_{21}^{\zeta_2}c_{31}^{\zeta_3}\right)+p_{41}\lambda=0$$

$$a_1\left(\zeta_1 c_{11}^{\zeta_1-1}c_{21}^{\zeta_2}c_{31}^{\zeta_3}c_{41}^{1-\zeta_1-\zeta_2-\zeta_3}\right)+\lambda=0$$

$$a_1\left(-\chi_1 L_{11}^{\nu}\right)-\lambda w_{11}=0$$

$$a_1\left(-\chi_2 L_{21}^{\nu}\right)-\lambda w_{21}=0$$

$$a_1\left(-\chi_3 L_{31}^{\nu}\right)-\lambda w_{31}=0$$

where a_1 is $(G_0-\frac{\chi_1}{\nu+1}L_{1t}^{\nu+1}-\frac{\chi_2}{\nu+1}L_{2t}^{\nu+1}-\frac{\chi_3}{\nu+1}L_{3t}^{\nu+1})^{-\sigma}$

Setting the equations equal to each other by solving for lambda and rearranging, I get:

$$\frac{L_{11}}{L_{21}}=\left(\frac{\chi_2}{\chi_1}\right)^{\frac{1}{\nu}}\left(\frac{w_{11}}{w_{22}}\right)^{\frac{1}{\nu}} \tag{31}$$

$$\chi_1 L_{11}^{\nu}\left(\frac{p_{21}}{(1+s_t)w_{11}}\right)=\frac{\partial C_1}{\partial C_{21}} \tag{32}$$

Because p_{11} is the numeraire, I can rewrite as:

$$\frac{\chi_1 L_{11}}{w_{11}}^{\nu}\left(\frac{p_{21}}{(1+s_t)p_{11}}\right)=\frac{\partial C_1}{\partial C_{21}}$$

The same first-order conditions apply in period 2 and other relationships are as in period 1, with augmenting of price 2. Intertemporal relationships can be backed out using the following equation:

$$\frac{\partial G_1}{\partial C_{21}}=\beta\left(\frac{p_{21}}{p_{22}}\right)\left(\frac{1+s_2}{1+s_1}\right)\left(\frac{a_2}{a_1}\right)\frac{\partial G_2}{\partial C_{22}}$$

5 Calibration

To select between specifications of the model parameters, I target model performance with respect to the consumption series. Targeting the moments of consumption presents a number of advantages relative to other series. Firstly, data is reported across two regimes for Hungary: the pre-collapse planned economy and the post-collapse market economy. As compared to investment, employment, and wages, consumption is more likely similar between the two regimes. In other words, a recession-driven change in the composition of consumption spending is driven by large changes in prices rather than a change in preferences or evolving expectations about the future. Furthermore, given this relative consistency in the composition of consumption, measurement errors are comparable temporally.

Historical accounts, migration data, and public perception support the idea that the trough of the 1990s recession was in 1993. In particular, gross output in Hungary in 1993 was 42% lower than it was in 1989, lower than every other year [3]. All other outcome variables reach a trough prior to 1993. At the same time, the recession is driven by consumption across model specifications, which suggests that the response of consumption is a key component to the Soviet collapse-induced recession.
footnoteResults of model specifications that do not target consumption are presented in the appendix This delay in the complete response of consumption to the trade shock suggests a high degree of consumption smoothing and habit formation amongst households. It is likely that households faced severe liquidity constraints in response to the Soviet collapse and initially responded by reducing investment spending. The unexpected nature of the collapse combined with uncertainty in the terms of the political-economic restructuring. Thus, household expectations evolved as conditions changed. As the recession deepened and persisted, that liquidity constraint tightened and forced a larger response of consumption.

The consumption response presents a clearer pattern after 1991. The figures below contrast the response of consumption and investment. The consumption deviation from trend exhibits a clear change in trend after 1990 that persists to 2004, while the pattern of investment indicates a sharp temporary decline in 1990 that is on path to revert to trend by 1998.[3] Furthermore, the pre-collapse pattern of investment shows large periodic deviations from trend (i.e. the business cycles), which is consistent with the idea that investment is a more volatile component of spending. A comparison of the pre-collapse trends in consumption and investment suggests that the large deviation from trend post-1991 in consumption is more significant and indicative of a change in economic behavior than the investment pattern.

[3]Extending the data series would likely extend the trend

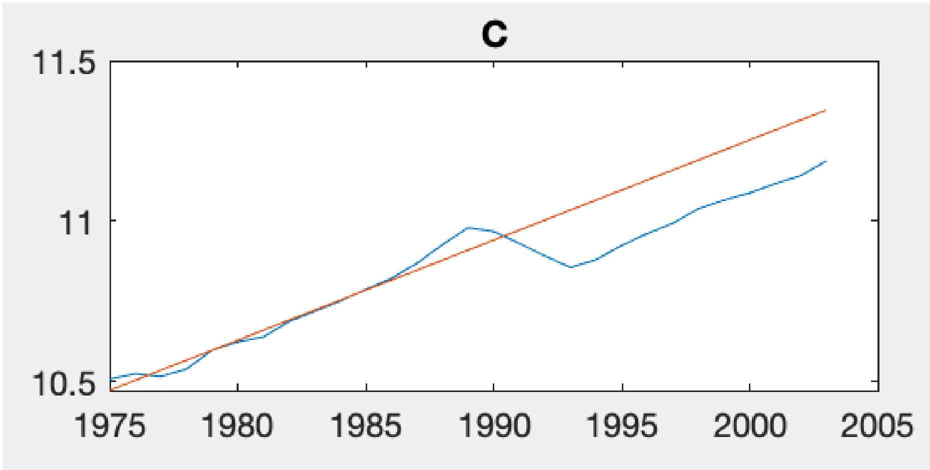


Figure 10: Percent deviation from trend in consumption

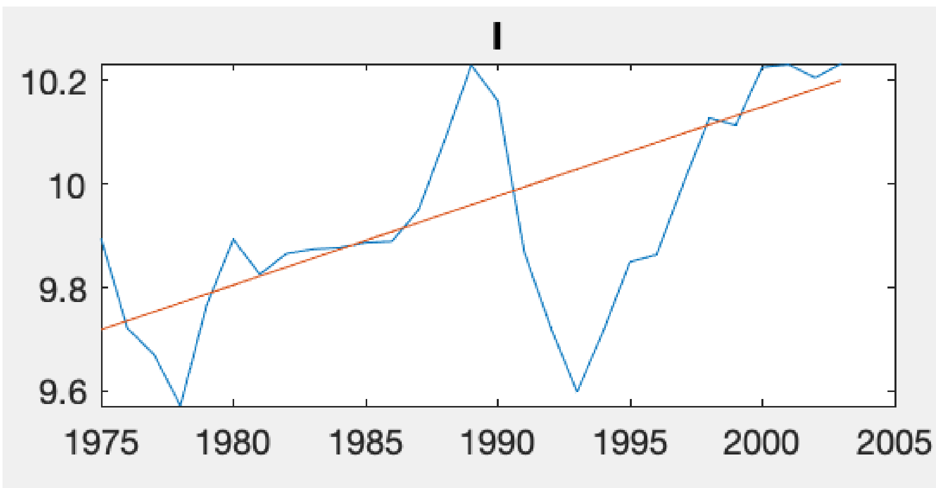


Figure 11: Percent deviation from trend in investment

It is relevant to consider how the preferred model changes when consumption is targeted. Calibrating with respect to consumption requires matching the lagged response to the recession, which placed greater emphasis on the persistence parameters of the model. In particular, habit formation in consumption and wage rigidity are critical to match the behavior of the consumption series. Choosing to target an alternative outcome variable would shift the emphasis from these two parameters to a different set of parameters. This means that a focus on targeting consumption may place disproportionate emphasis on the timing of the response to the shock.

5.1 Calibration Strategy

The model is calibrated at quarterly frequency. The discount factor is set at .97 (i.e. a 3% discount rate) because output per capita grew at approximately 2% per year in Finland throughout the 1980s, consistent with the real interest rate of approximately 10.72% in the same time period [2]. Consistent with GMT, I use an intertemporal elasticity of substitution of $\sigma^{-1} = .5$ and I set elasticity of labor at $\nu = 1$. Because I assume Cobb-Douglas preferences in consumption, I set the weights on the consumption goods $\zeta_1, \zeta_2, \zeta_3, \zeta_4$ according to their average share of consumption over all years. This calculation yields $\zeta_1 = .17$, $\zeta_2 = .2$, $\zeta_3 = .47$, and $\zeta_4 = 1 - \zeta_1 - \zeta_2 - \zeta_3 = .16$. Depreciation is set to achieve a 10% annual depreciation rate. Wage rigidity is set at $\theta = .96$ in all 3 sectors of production to reflect the high levels of wage rigidity in Hungary as a feature of the planned economy.[9] Furthermore, the lack of movement or deviation from trend in the wage series is consistent with a high level of wage rigidity in Hungary. In the counterfactual experiments section, I present results under alternative values for θ, including varying the wage rigidity across sectors. The value of the import-tax export subsidy comes from estimates by Rodrik (1992).[21]

6 Results

6.1 Benchmark Hungarian Calibration Results

Because the calibration strategy targets model performance in matching the moments of the consumption series, I present three preferred specifications. I consider a baseline model with shocks to the interest rate, a model that includes large adjustment costs, and a model with a large shock to the price of oil.

6.1.1 Model with Adjustment Costs Included

My preferred specification considers an economy with adjustment costs included. In particular, this model includes larger adjustment costs, specifically quadratic investment adjustment costs ($\psi = 0.5$), quadratic labor adjustment costs ($\lambda = 1$). It also incorporates unequal consumption habit formation (highest habit formation in the Soviet sector), high wage rigidity, and a 15% Soviet oil subsidy. I present a specification with inequality of habit formation that is highest in the Soviet sector because these goods face the highest price change in response to the collapse of the Soviet Union. Imposing a larger coefficient on habit formation on the Soviet sector suggests a greater adjustment cost on the part of households.

As shown in table 2, the model with adjustment costs included somewhat resembles the model with interest rate shocks both in terms of the initial severity and in terms of the 7 year outcome. In terms of the consumption series, the adjustment cost model understates the initial severity of the recession relative to the interest rate shock model, but overstates the long-term severity of the recession. The predicted lack of reversion to trend of the consumption series in this model is particularly remarkable and highlights the role of the habit formation parameter in determining the trajectory of consumption. The larger capital adjustment costs also likely tighten the liquidity constraint of households both in the short and long run. As partial owners of firms, households incorporate the higher capital adjustment costs into their budget constraints. This increased cost shows up as an income effect of reduced potential consumption spending.

Beyond small differences in temporal severity predicted by the two models, the commonalities in the near-full recovery of investment suggests that adjustment costs and shocks to the interest rate propagate similarly throughout the macroeconomy in general equilibrium. This suggests that the increased interest rates can proxy and replicate the effects of the adjustment costs from a planned to a market economy. This is interesting because interest rate increases are typically indicative of increased uncertainty in the future value of money, while adjustment costs reflect uncertainty in institutional structures and expectations. As seen in the figure below, the two models behave similarly across a number of outcome variables and generate similar predictions about the deviations from trend.

Table 2: Adjustment Costs Model Decomposition

	Trough	After 7 years
Consumption	-12.89	-10.53
Investment	-7.01	-2.223
Net Exports	-1.159	-.03015
Government Spending	2.039	1.14

Notes: Values are percentages relative to the old steady state (i.e. a world in which the Soviet Union does not collapse)

6.1.2 Baseline Model with Interest Rate Shocks

This specification features the baseline model (parameters as given in the calilbration section with two interest rate shocks of 2% each in 1991 and 1993. Table 3 indicates the model's predicted percentage deviation from steady state for each of the components of GDP both at the trough and 7 years after the collapse of the Soviet Union. The model specification with interest rate shocks indicates a below-trend deviation of approximately 15% from steady state for consumption and over 11% for investment at the trough. By 7 years after the collapse, an approximately 9% deviation from trend in the consumption persists, while investment substantially recovers but remains at 2.7% below the previous steady-state level. The results of this model specification indicate that consumption is impacted by the collapse in trade long-term. The persistence in the pattern of consumption results from a combination of the increased prices of imported goods and the large habit formation on the part of Hungarian households. The relative recovery of investment may indicate a transformation in expectations by businesses and households in response to the post-Soviet economic order.

The predicted behavior of net exports and government spending is interesting in this model. In particular, net exports are above the pre-collapse steady state level at the trough of the recession, but fall to a below-trend level after 7 years. The predicted initial response of net exports to the collapse is consistent with a pattern of trade reorientation with OECD countries. Convertible currency exports increased from 17.9% to 21% of total sales between the first half of 1990 and the first half of 1991 [2]. The increased export demand from OECD countries was especially concentrated in non-electric machinery, metal products, chemicals, and food. On the other hand, the decline of Eastern European markets adversely impacted exports of pharmaceuticals, textiles, and electrical appliances. Government spending is above trend at the trough and remains somewhat above trend 7 years after the collapse. This is consistent with evidence of increased government spending on the part of Hungary in an effort to reduce the economic shock of the transition.[18].

Table 3: Interest Rate Shock Decomposition

	Trough	After 7 years
Consumption	-15.06	-8.959
Investment	-11.28	-2.744
Net Exports	2.331	-2.001
Government Spending	3.447	1.197

Notes: Values are percentages relative to the old steady state (i.e. a world in which the Soviet Union does not collapse)

6.1.3 Large Oil Price Shock Model

I also present a model that features a larger shock to the price of oil. In other words, this model has a greater discount on the price of Soviet oil relative to the prevailing world price than the other preferred specifications. This model is instructive in isolating the effect of the shock to the price of oil to the recession. This specification considers a 25% subsidy on oil imported from the Soviet Union, while the other specifications feature a 15% subsidy.

As seen in table 4, this model predicts a less acute and persistent recession than the other two preferred specifications. In particular, all GDP components revert to trend after 7 years, which suggests that the economy is able to fully adjust to a higher oil price. This model's results are consistent with the environmental economics literature, which indicates that the elasticity of demand with respect to oil is low. This indicates that the remaining factors of production adjust in response to a change in the price of oil and that this adjustment is not persistent. The predicted near-complete recovery of the economy in response to a large oil price shock is interesting because of the Leontief production function. Energy requirements are assumed to be complementary to the other inputs to production, which implies that the costs of production simply increase in this specification. This model is interesting also because the shock is one time, which may partially explain the lack of persistence.

Table 4: Large Oil Price Shock Decomposition

	Trough	After 7 years
Consumption	-8.594	-0.963
Investment	-3.15	-0.3149
Net Exports	-0.427	-0.08596
Government Spending	1.581	0.03548

Notes: Values are percentages relative to the old steady state (i.e. a world in which the Soviet Union does not collapse)

Figures 12, 13, and 14 show results of the Hungarian calibration exercise for the consumption, wage, and net exports series. The light blue dotted line indicates the interest rate shock model, the dark blue dotted line indicates the adjustment costs model, while the pink and blue dotted line indicates the model with a large oil price shock. The gray area indicates a 90% confidence interval of the deviation from trend in the data.

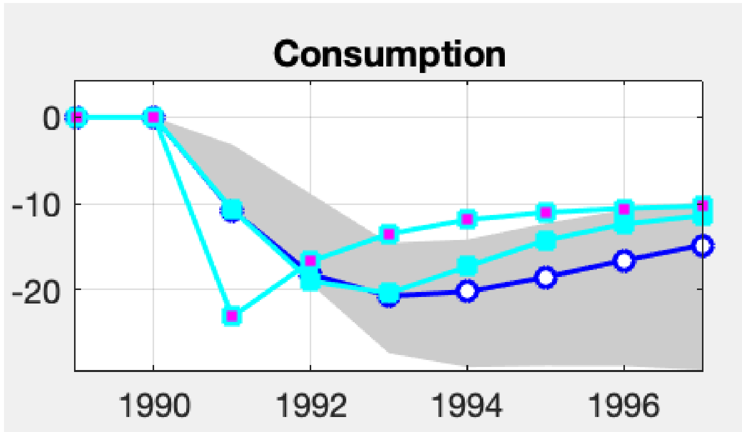


Figure 12: Calibration Results: Consumption

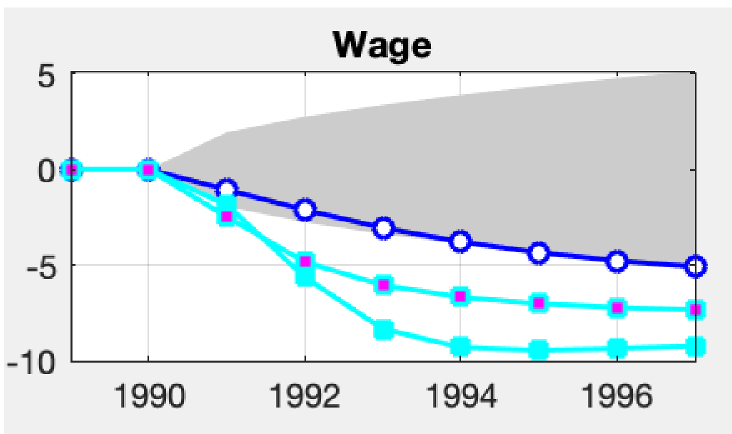


Figure 13: Calibration Results: Wages

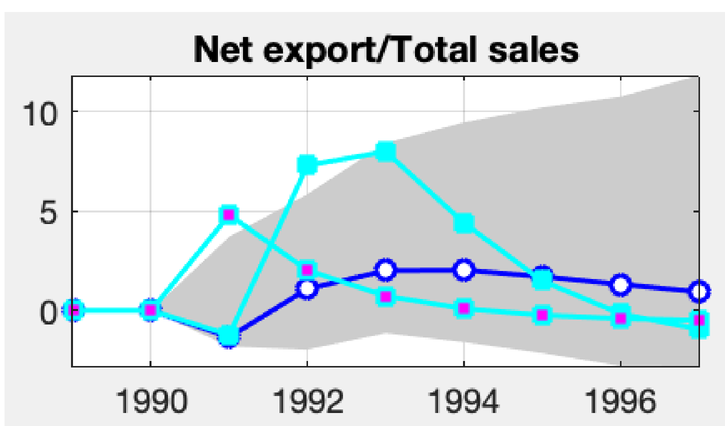


Figure 14: Calibration Results: Net Exports

The figures show the predicted deviations from trend in each series based on each specification. As seen in figures, the specification that considers adjustment costs provides the closest fit to the 90% confidence interval of the data (the gray path). The trajectory of the baseline model with interest rate shocks performs similarly with respect to matching the trend in the consumption series, but it does not explain the pattern in wages or exports as well. On the other hand, figure 12 provides a visualization of the increased short-term recession severity predicted by a large shock to the price of oil. Taken together, the figures and predicted trend suggest an equivalence between interest rate shocks and considering adjustment costs. This equivalence is consistent with economic theory, which tells us that increased adjustment costs as a result of a new political-economic system result in increased uncertainty about future expectations and that these increased adjustment costs behave similar to shocks in the interest rate, at least on the consumption side.

6.2 Counterfactual Experiments

In this section, I conduct simulation experiments using the parameters of the structural model to understand the relative contribution of each macroeconomic factor in explaining the timing and severity of the recession.

I focus on three policy alternatives and their impact on the severity and timing of the recession: lower wage rigidity, a lower distortionary price subsidy, and a lower oil price shock.

Table 5: Wage Rigidity Sensitivity

	$\theta = .99$		$\theta = .95$	
Component	Trough	7 years	Trough	7 years
Consumption	-12.89	-10.53	-6.609	-4.872
Investment	-7.01	-2.223	-4.854	-1.495
Net Exports	-1.159	-.3015	-1.564	-0.3995
Government Spending	2.039	1.14	0.2159	0.1439

Notes: Compares the effect of lowering wage rigidity on the recession using the all adjustment costs model

Lowering the wage rigidity from $\theta = .99$ to $\theta = .95$ lowers the trough of the consumption series from an almost 13% decline relative to steady state to a 6.6% decline. Changing the wage rigidity also decreases the 7-year severity of the recession. In terms of the investment series, the severity of the recession is approximately halved by the decline in wage rigidity. From the perspective of the firm, a lower coefficient on wage rigidity loosens a constraint of the firm's optimization problem and allows the firm to adjust wages and employment in response to macroeconomic conditions. A high level of wage rigidity may introduce a temporary distortion where labor is not paid at its marginal product due to preexisting labor contracts. High wage rigidity may result in higher unemployment as firms are constrained in adjusting wages but are relatively less constrained in hiring decisions. Thus, to the extent that the transition and adjustment is non-instantaneous, high wage rigidity imposes additional constraints on the firm, thereby prolonging the recession. Implicitly, the high wage rigidity means that adjustment to the collapse in trade happened through the channel of increased unemployment rather than a combination of unemployment and lower wages.

Table 6: Distortionary Trade Policy Sensitivity

	$\tau = .5$		$\tau = 1$	
Component	Trough	7 years	Trough	7 years
Consumption	-15.06	-8.959	-16.04	-9.291
Investment	-11.28	-2.744	-10.74	-2.57
Net Exports	2.331	-2.001	2.202	-1.922
Government Spending	3.447	1.197	4.185	1.319

Notes: Compares the effect of a 50% trade policy parameter with a 100% trade policy parameter

I also conduct an experiment to isolate the effects of the dual system of exchange rates with respect to the transferable rouble in Hungary. As discussed in the import subsidy-export tax section, the dual system of exchange rates of Hungarian Forints and transferable rouble used by Hungary is equivalent to a trade policy of import subsidies and export taxes. Increasing the trade policy parameter within the Soviet economic sphere from a 50% to 100% trade policy does not substantially change the simulated estimates of the deviations from the previous steady state. The removal of the trade policy after 1991 acts similarly to any price increase. In this case, only the Soviet sector is impacted by the removal of the trade policy. This increased price most likely induces both a substitution and income effect for the household. In response to higher prices in the Soviet-sector, the household effectively has less purchasing power. Thus, the household may substitute away from the relatively more expensive Soviet-sector goods in response to the elimination of the subsidy. In light of this trade policy, habit persistence in consumption is very interesting because households experience disutility from changing consumption patterns but also from higher prices.

On the other hand, taxes on exports have also been eliminated with the ending of this policy. Thus, households see larger profit margins on Soviet export industries as a result of the elimination of the policy. Because trade is more or less balanced in the pre-collapse period within the Soviet bloc, formally eliminating the trade policy perhaps suggests a distributional effect rather than an overall effect. Interestingly, the model with the large distortionary trade policy exhibits the same pattern of net exports as the baseline model with oil shocks, in that net exports initially increased in response to the shock and are below trend after 7 years.

Table 7: Oil Price Shock Sensitivity

	$p_E = .1$		$p_E = .25$	
Component	Trough	7 years	Trough	7 years
Consumption	-12.89	-10.53	-16.04	-13.52
Investment	-7.01	-2.223	-8.894	-3.083
Net Exports	-1.159	-.3015	-1.133	-0.1519
Government Spending	2.039	1.14	2.355	1.352

Notes: Compares the effect of a 10% oil subsidy with a 25% subsidy on Soviet oil

I conduct an experiment to examine the difference in outcomes following the collapse of a 10% oil subsidy and a 25% oil subsidy. Isolating the effect of the oil price subsidy in a computational experiment isolates the portion of the collapse due to the elimination of the oil price subsidy. Removing the oil subsidy on Soviet oil acts like a shock to technology, in that the price of an important input to production increases dramatically and therefore directly increases the cost of production. Production, especially in the short run, is inelastic in response to oil prices. In this counterfactual experiment, the policy to reduce the subsidy received on oil is motivated by historical evidence that Cuba switched oil suppliers from Soviet Union to Venezuela and experienced substantial growth. This suggests that a portfolio of producers can reduce risk, particularly in the severity and persistence of a recession.

I also consider a counterfactual experiment that changes the discount rate.

Table 8: Discount Rate Sensitivity

	$\beta = .97$		$\beta = .99$	
Component	Trough	7 years	Trough	7 years
Consumption	-9.307	-6.325	-14.11	-9.36
Investment	-3.376	-1.593	-5.855	-2.882
Net Exports	-0.1867	-0.9913	0.2891	-0.4892
Government Spending	0.9208	-0.02514	1.965	0.6307

Notes: Compares the effect of a 3% discount rate with a 1% discount rate

The purpose of this counterfactual experiment is to indicate the role that the value of the future plays in contributing to the severity of a recession. It is consistent with economic intuition that a world that more highly values the future experiences a deeper recession both at the trough and after 7 years. Situating the collapse of the Soviet Union as a massive shock to the geopolitical world order, the discount rate to an extent reflects beliefs about the future. A full consideration of the political economic reality makes this counterfactual experiment interesting because the policy suggestion from this seems to be that encouraging a lower valuation of the future can reduce the severity of a recession.

7 Conclusion

The breakup of the Soviet Union serves as a unique natural experiment in which the timing of the shock is well-known, but was relatively unpredictable in advance. Furthermore, the wide range of Soviet satellite states allows for a fascinating comparison of post-collapse policies and trade reorientation. The natural question is how long does it take for plants, firms and institutions to adapt to new economic circumstances? The rate of technology adaptation and substitution toward labor clearly matters in thinking about the timing of recovery. This work revisits the sources and drivers of the Hungarian recession of the 1990s by incorporating several key features of Hungary's trade with the Soviet Union into a structural model and calibrating the parameters of the structural model to match the behavior of the consumption series.

Counterfactual experiments suggest that lowering wage rigidity, perhaps through weaker terms of labor contracts is associated with a substantially less severe acute and long-term recession. My experiments also suggest that reducing the incidence of shocks to the price of oil reduces the severity of recessions. Of course, shocks to the price of oil are not control variables of the policymaker, but the set of trading partners is a control variable. For a non-oil producing country, trade with a diversified set of oil producers is critical to alleviating the transition costs associated with large changes to the price of oil. Reducing the extent of distortionary trade policy is not associated with substantial changes to trajectory of the recession in this model. This suggests that the relevant margins of sensitivity may be much larger than what I simulated. This small effect of the trade policy may also indicate that the extent of changes to the price of imported and exported goods outside the Soviet industry was substantially larger in magnitude than the within-CMEA trade policy.

7.1 Future Directions of Research

The reorientation of production from Soviet-exclusive exports to globally competitive products is a process common to all of Eastern Europe's transition economies. A central point of interest is the transition of an economy from a highly distorted set of prices to world market prices, and the associated impact on output. Implicit in an examination of pricing reforms is the role of the transferable rouble in sustaining a trade relationship within the CMEA area. This has general applicability with respect to the role of other non-convertible currencies in trade partnerships (for example China).

A key component of the Hungarian and Eastern European recessions is distributional. In particular, the mechanisms of privatization both generated and preserved substantial inequality. The severity of inflation and higher import prices in Hungary clearly had differential impacts across the income distribution. To that end, moving beyond the representative agent model and adding heterogeneity to the households will illuminate another dimension to the recession. Adding heterogeneity to the households in terms of low and high productivity workers can provide more insight into the winners and losers from the reorientation of trade. Moreover, Eastern Europe's planned economies featured a high degree of industrial concentration. In Hungary in 1990, 1.1% of companies accounted for 62.7% of net industrial sales [2]. The industrial concentration is particularly start in exports, partially as a result of a highly regulated system of obtaining export licenses from Hungary pre-1990. The collapse of Soviet trade and the planned economy greatly reduced the degree of industrial concentration in Hungary. This change in the industrial organization and environment indicates that adding heterogeneity to firms may also highlight the importance of fixed pricing.

Working with the specific factors model will be instructive as to the transition process in the initial years after the collapse. One direction of particular interest (though impractical given data constraints) is further examination of Cuba's economy after the collapse of the Soviet Union. From the 1960s, Cuba is a member of the Soviet Union's Council on Mutual Economic Assistance and received most favored nation status from the Soviet Union. In particular, Cuba benefited tremendously from highly subsidized and regular imports of oil from the Soviet Union. There is strong evidence of Cuba's re-export of subsidized Soviet oil to the rest of the world and that this scheme accounted for a substantial portion of Cuba's GDP. Calibrating a model of trade reorientation with respect to Cuba would isolate the effects of the trade collapse itself in the setting of a planned economy.

8 Appendix

8.1 Additional Tables and Figures

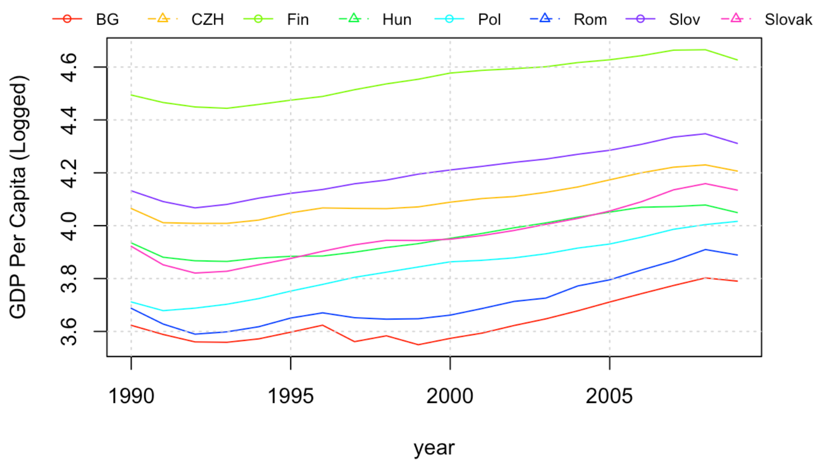


Figure 15: log GDP per capita across the panel of countries

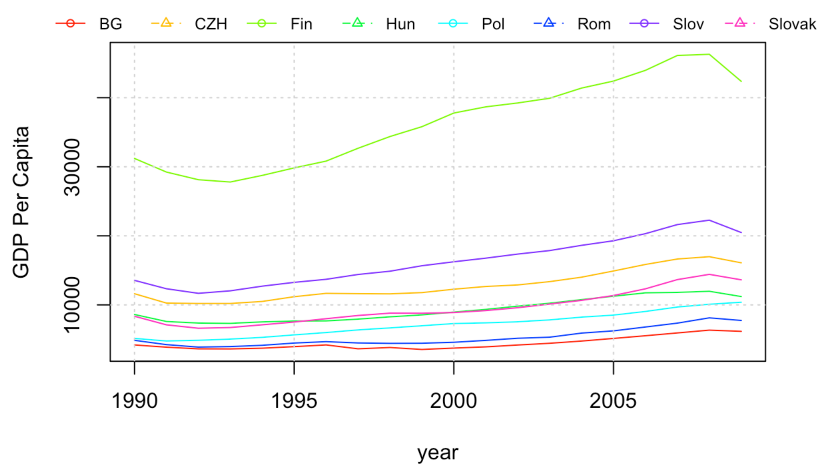


Figure 16: GDP per capita in levels across the panel of countries

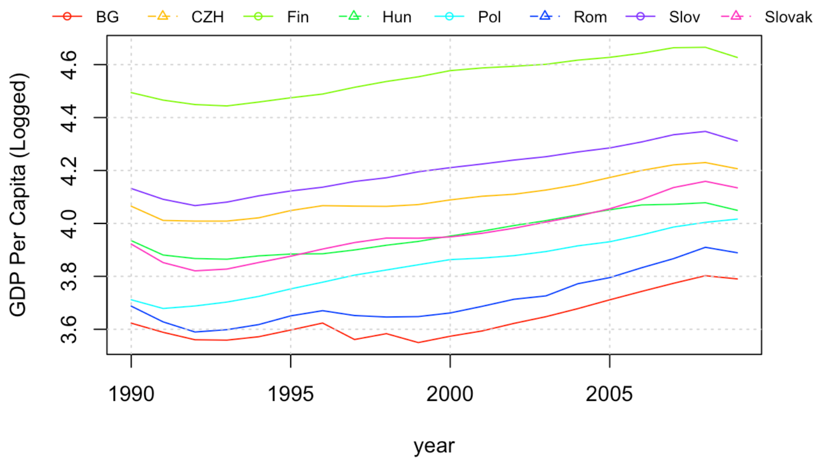


Figure 17: log GDP per capita across the panel of countries

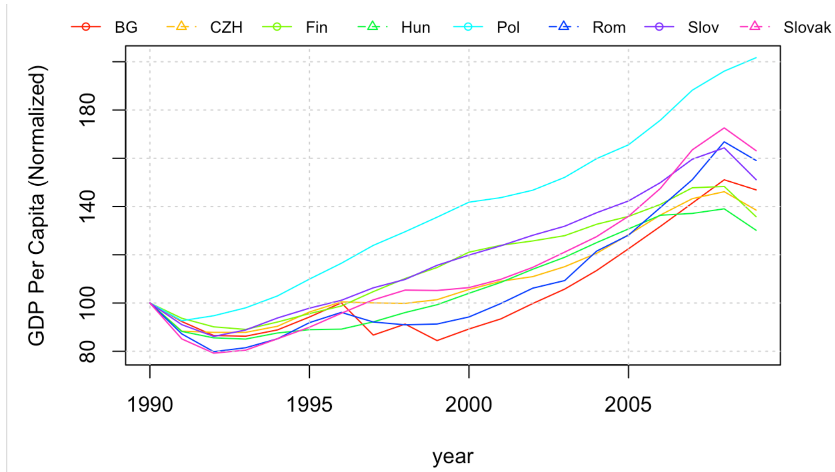


Figure 18: normalized GDP per capita across the panel of countries

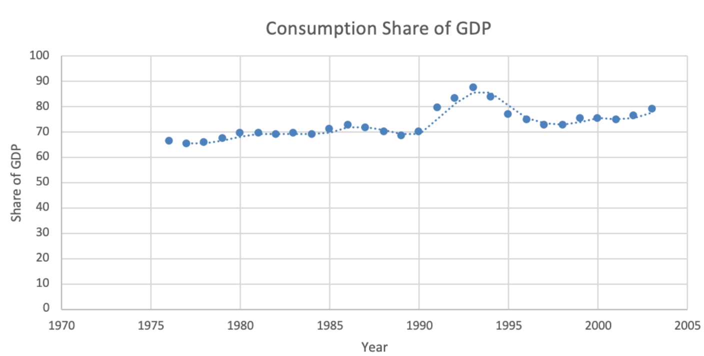


Figure 19: Consumption Share of Hungarian GDP

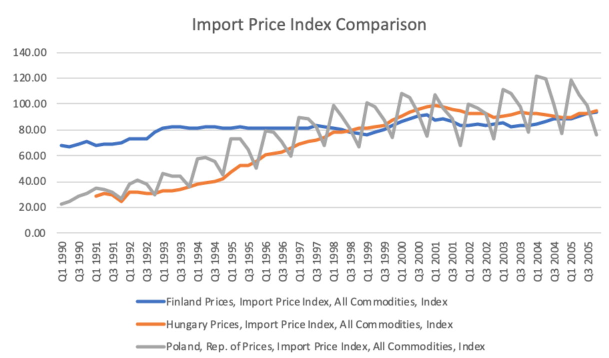


Figure 20: Import Price Index Comparison, measured quarterly

Figure A2. The share of wages and salaries of the GDP, 1948-1997 (Source: National Accounts).[20]

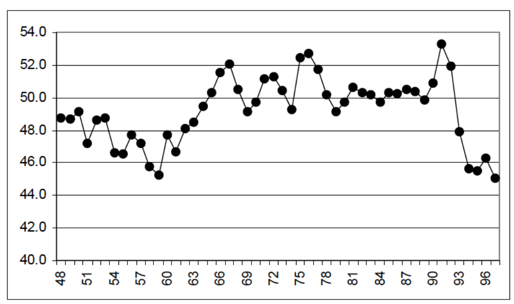


Figure 21: Finland Wage Share of GDP

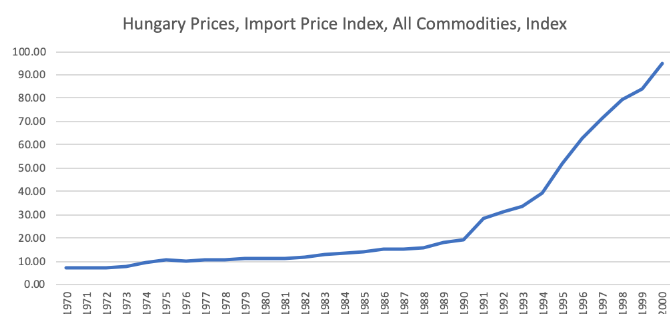


Figure 22: Hungary's import price index

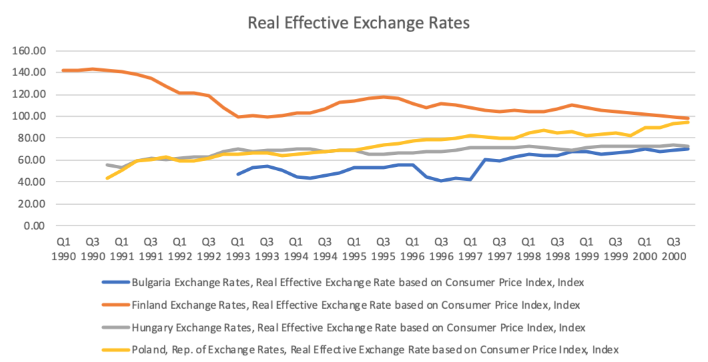


Figure 23: Hungary's import price index

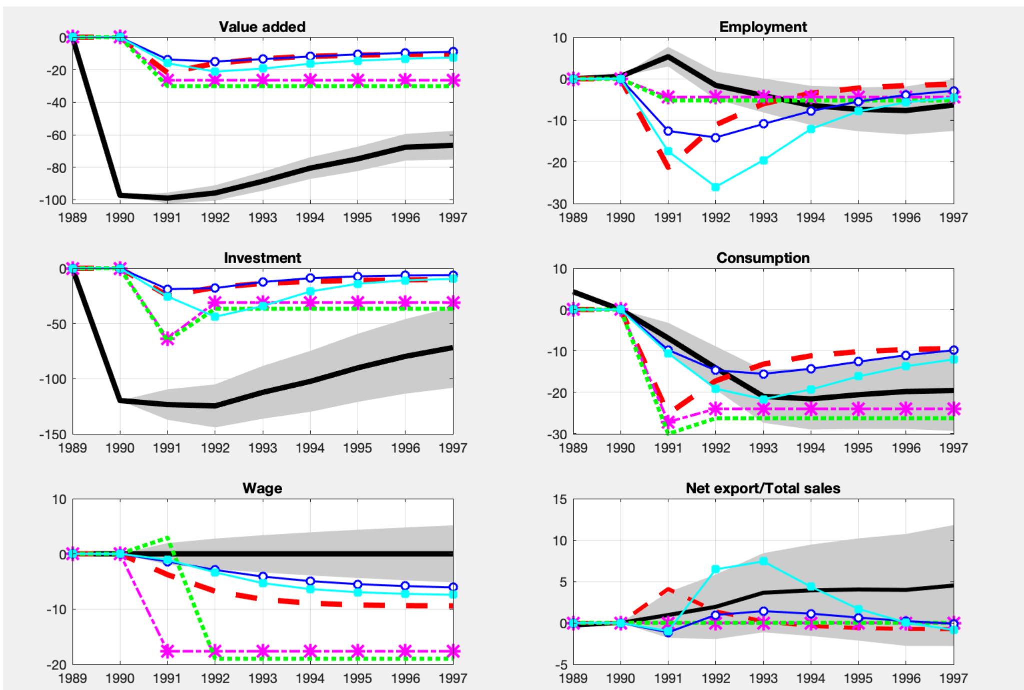


Figure 24: Hungary Sectoral Calibration Results

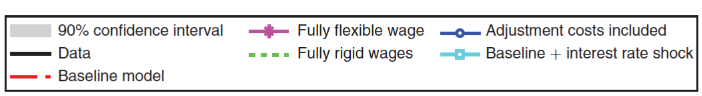


Figure 25: Model Legend

8.2 Austrian Calibration

The Austrian calibration is instructive in a consideration of a more limited scale of trade reorientation due to a smaller trade exposure to the Soviet Union than Hungary or Finland.

Working with Austrian data and calibration of the Austrian model is a first-stage attempt to capture these differences, as the Austrian restructuring was heavily concentrated in a few large firms. The Austrian case provides additional insights into the timing of the shock. The figures shown below plot percent deviations from trend in the Austrian data and simulated model series.

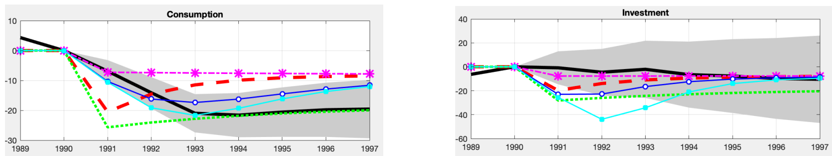


Figure 26: Percent deviation from trend

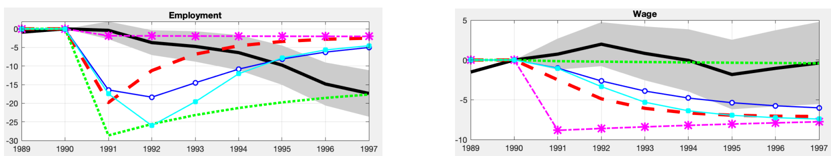
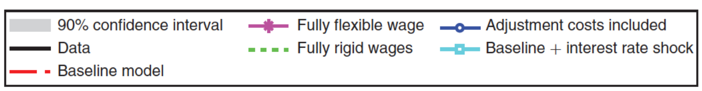


Figure 27: Percent deviation from trend



The figures above plot actual and simulated responses for key macroeconomic variables measured as percent deviations from the pre-collapse steady state. The model with fully rigid wages (the green dotted line) captures the 20% drop in consumption and the small drop in investment. This version of the model also captures the relatively flat trajectory of wages over this time period. This may provide evidence of the rigidity of wages in Austria.

The flat trend of investment in the data is one of the more interesting features. In the model, the recovery of investment reflects the fact that given our functional form assumptions and calibrated parameters, the investment share of output does not respond to changes in prices. This suggests that utilization of Austrian capital does not require the raw inputs that the Soviet Union provided, as the increase in prices of Soviet imports would result in an increase in prices for utilizing capital. Thus, investment was not the channel through which a persistent decline in output was operating and therefore the investment environment was not fundamentally changed by the collapse in the Soviet trade relationship. Because Austrian trade with the Soviet Union was primarily focused in a small number of large firms, preliminary analysis of the Austrian case indicates that a shock to trade largely does not impact investment under this kind of industrial organization.

8.3 Competitive Equilibrium with Informality

The IZA has extensive work on the composition and size of the informal sector of the economy. In the case of Europe, there are fairly large regional discrepancies. In particular, informal labor sectors are smallest in the Nordic countries, including Finland and Sweden. On the other hand, the informal sector in Central and Eastern Europe (CEE) is fairly large, and IZA estimates that anywhere from 14% to 27% of the workforce is employed informally. The composition of the informal and formal labor forces are not identical across demographic characteristics and attributes. The informal workforce is generally more rural, younger, and less educated. Furthermore, there are seasonal swings toward informality. In other words, informal employment is not a permanent or exclusive status, and a large portion of the population reports at least some informal employment. This trend is present even under the previously Communist regimes in Eastern Europe. Quantifying how the presence of informality changes the impact of the Soviet trade collapse is of interest, both because this informality is necessary to fully match the economic conditions in CEE but also because the informal industry presents another alternative for consumers. The inclusion of the informal sector will change the decisions of the consumers.

In the presence of informality, the representative household chooses a lifetime plan for consumption and labor allocations to maximize $U \equiv \sum_{t=0}^{\infty} \beta^t U(G_t, L_{ft}, L_{it}, L_{2t}, L_{3t})$ where G is a CES consumption aggregator over four consumption goods and L_{jt} for j = 2, 3 is the labor supplied to each sector in each period. L_{ft} and L_{it} are the formal and informal labor supplied to the non-Soviet sector respectively. I assume that informal labor occurs via the non-Soviet sector only because licenses to export to the Soviet Union were tightly regulated and penalties for violating these licenses were sufficiently high to disincentivize informal activity. Additionally, the potential for wages paid in convertible currencies was a strong incentive for informal labor. The consumption aggregator is given by $G_t = \{\zeta_1 C_{1t}^{\rho_C} + \zeta_2 C_{2t}^{\rho_C} + \zeta_3 C_{3t}^{\rho_C} + \zeta_4 C_{4t}^{\rho_C}\}^{1/\rho_C}$, where $\frac{1}{1-\rho_C}$ is the elasticity of substitution of consumption, ζ_j are the weights in the consumption aggregator, and C_{jt} are the consumption of the goods produced by sectors j = 1,2,3. C_{4t} is the consumption of the Western import good.

Following Greenwood, Hercowitz, and Huffman (1988) [8], the period utility function is given by $U(G_t, L_{1t}, L_{2t}, L_{3t}) = \frac{1}{1-\sigma}(G_t - \frac{\chi_1}{\nu_1+1} L_{1t}^{\nu_1+1} - \frac{\chi_2}{\nu_2+1} L_{2t}^{\nu_2+1} - \frac{\chi_3}{\nu_3+1} L_{3t}^{\nu_3+1})^{(1-\sigma)}$, where $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution. Total employment is given by $L_t = L_{it} + L_{ft} + L_{2t} + L_{3t}$ and $L_{1t} = L_{it} + L_{ft}$. Though there are presumably differences in benefits from working formally as opposed to informally, I assume for simplicity that consumers do not differentiate between formal and informal employment in their utility function conditional on wages. In other words, formal and informal labor is substitutable. Wages do not equalize in general across sectors. If the representative agent chooses frictionless allocation of labor across sectors, including the informal sector, wages do equalize, absent the nominal rigidities.

I assume that households own domestic firms and face the following budget constraint:

$$\begin{aligned} w_{it}L_{it} + w_{ft}L_{ft} + w_{2t}L_{2t} + w_{2t}L_{2t} + (q_{1t} + d_{1t})K_{1,t-1} + (q_{2t} + d_{2t})K_{2,t-1} + (q_{3t} + d_{3t})K_{3,t-1} + R_tB_t = \\ B_{t+1} + q_{1t}K_{1,t} + q_{2t}K_{2,t} + q_{3t}K_{3,t} + C_{1t} + p_{2t}C_{2t} + p_{3t}C_{3t} + p_{4t}C_{4t} \end{aligned} \tag{33}$$

where w_j is the wage in sector j = 1,2,3, B_t is a one-period bond traded on international markets at the gross world interest rate of R_t, q_j is the price of capital in sector j and d_j is the dividend on capital in sector j. Prices are normalized to 1 based on the sector 1 good. Wages do equalize between the formal and informal workforce of sector 1.

8.4 Measuring the Size of the Informal Economy

Medina and Schneider [16] (2018) undertake a comprehensive survey to estimate the size of the informal economy in all IMF member countries using various estimation techniques. On a basic level, the size of the informal economy is negatively correlated with the probability of detection (magnitude of fines associated with being detected) and positively correlated with the opportunity cost of working formally. These opportunity costs include the level of taxation and regulation, including the stringency of labor laws such as minimum wage and maximum hours/safety standards. On the supply side, the opportunity for workers to work formally or informally also contribute to the size of the informal sector.

The most commonly used method to identify the size of the informal economy is the National Aggregates Discrepancy Approach, which essentially examines and classifies non-observed economic activity according to a well-defined procedure. In recent years, micro approaches using microdata have become the preferred method.

Another approach to measure the size of the informal economy uses survey data from representative samples of the population. This method carries the usual concerns with bias, such as under-reporting given the potential illegality of the activity, but has the potential to more closely identify heterogeneity amongst individuals or specific groups. For example, the informal economy may be meaningfully different across the services sector and the manufacturing sector, and survey data allows for closer identification. Similar microdata approaches rely on surveys of managers.

The newest approach to measuring the informal economy is via indicator variable methods. The most obvious such method is the difference between national expenditure and income. The transaction approach follows the same logic. Under Fischer's equation, money*velocity = prices * transactions. Assuming a constant relationship between prices and transactions and total output, Price*transactions = c(Official GDP + shadow economy), where $c \in \mathbb{R}$. Equalizing this and Fisher's equation, money*velocity = c(official GDP + shadow economy). The supply of money and official GDP estimates are generally available, and the velocity of money is estimable. Under the assumption of a known constant proportion c, the size of the shadow economy can be estimated for all other years in the sample. This method involves strong assumptions on the constant proportion of the shadow economy.

Finally, a more complex MIMIC procedure examines the potential inputs to the size of the shadow economy and then uses a structural equation modeling approach can be a useful confirmation tool. Selecting a method to estimate the size of the shadow economy will be a secondary topic of interest.

Medina and Schneider [16] estimate the size of the shadow economy in Poland and Hungary to be 22.2% and 22.4% of GDP. Finland's shadow economy is estimated to be 11.5% of GDP. The size of this difference may be sufficiently large to drive changes in household labor decisions in the post-Soviet period.

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