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Financial factors in the boom-bust episode in Finland in the late 1980s and early 1990s

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Hanna Freystätter

Financial factors in the boom-bust episode in Finland in the late 1980s and early 1990s

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Financial factors in the boom-bust episode in Finland in the late 1980s and early 1990s

Bank of Finland Research
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Abstract

This paper proposes a framework for studying the boom and bust in Finland in the late 1980s and early 1990s. We develop a small open economy DSGE model with balance sheet-constrained firms à la BGG and calibrate it to the Finnish economy. We use the model to simulate three events that are claimed to have played a key role in the Finnish boom-bust episode and compare the model outcome with actual Finnish data. Firstly, we assess in our DSGE framework the role of financial market deregulation in the 1980s in the boom that preceded the crises. Secondly, we use our model to evaluate the negative impact of the collapse of Soviet-Finnish trade at the beginning of 1991. Thirdly, we investigate the effect of the collapse of the fixed exchange rate regime in September 1992. We conclude that financial frictions combined with the shocks that hit the Finnish economy are able to produce a boom and a severe depression similar to the one observed in Finland in the late 1980s and early 1990s. A key finding is the crucial role played by the financial accelerator mechanism in the ability of the model to mimic the response of the Finnish economy to the shocks it encountered. A key contribution is the incorporating unconventional shocks into the model: domestic financial market shocks to capture the deregulation of the financial market; a capital obsolescence shock to model the sudden redundancy of Soviet-oriented manufacturing; and a shock from the international financial market, a country borrowing premium shock, to capture the collapse of the fixed exchange rate regime.

Keywords: depression, Finland, financial factors, DSGE models

JEL classification numbers: E27, E32, E44

Rahoitustekijöiden merkitys Suomen 1980-luvun lopun talouden ylikuumenemisessa ja 1990-luvun alun lamassa

Suomen Pankin keskustelualoitteita 1/2011

Hanna Freystätter
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tässä työssä rakennetaan mallikehikko, jonka avulla voidaan tutkia Suomen talouden ylikuumenemista 1980-luvun lopulla sekä 1990-luvun alun lamaa. Työssä rakennetaan moderni dynaaminen makromalli, jossa on taserajoitteisia yrityksiä, kuten BGG-rahoitusakseleraattorimallissa, ja kalibroidaan malli Suomen talouteen sopivaksi. Mallilla simuloidaan kolmea tapahtumaa, joita pidetään keskeisinä Suomen talouden ylikuumenemisen ja laman kannalta. Tulemia verrataan Suomea koskeviin tilastotietoihin. Ensimmäisessä simulaatiossa arvioidaan rahoitusmarkkinoiden vapauttamisen merkitystä 1980-luvun lopun talouden ylikuumenemisessa. Toisessa simulaatiossa mallin avulla arvioidaan vuoden 1991 alun Suomen Neuvostoliiton-kaupan romahduksen epäsuotuisaa merkitystä. Kolmannessa simulaatiossa tutkitaan syyskuussa 1992 nähdyn kiinteän valuuttakurssiregiimin romahduksen vaikutuksia. Keskeinen tutkimustulos on rahoitusakseleraattorimekanismin suuri merkitys siltä kannalta, kuinka hyvin malli kykenee toistamaan sokkien Suomen talouteen aiheuttamat vaikutukset. Työn keskeinen kontribuutio on epätavanomaisten sokkien tuominen malliin: kotimaiset rahoitusmarkkinasokit kuvaavat rahoitusmarkkinoiden vapauttamista, pääoman taloudelliseen merkitykseen kohdistuva sokki kuvaa Neuvostoliiton-kauppaan suuntautuneen pääomankannan muuttumista tarpeettomaksi sekä maapreemiosokki kuvaa valuuttakurssiregiimin romahdusta.

Avainsanat: lama, Suomi, rahoitustekijät, DSGE mallit

JEL-luokittelu: E27, E32, E44

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1 Introduction

Finland experienced an economic boom at the end of 1980s that was followed by a deep depression in the beginning of 1990s with protracted and persistent decline in output and investment. Finland's real GDP peaked at around 6 per cent above trend in the beginning of 1990 and fell to -5 per cent below trend in 1993: an overall contraction of about -11 per cent within about 3 years. The behaviour of private investment was even more dramatic: an investment boom of 20 per cent above trend in 1989 was followed by a collapse of -15 per cent below trend by 1993: an overall contraction of about -35 per cent within 4 years. The severity of the depression gives Finland a place among the 'Big Five' postwar rich country large-scale financial crises identified by Reinhart and Rogoff (2008).

In this paper, we address the boom-bust period in Finland by focusing on the behaviour of private investment and on financial factors behind the large and persistent deviations of private investment from its trend. We show how financial factors combined with the shocks that hit the Finnish economy produced first a boom that was followed by a severe depression.

This paper proposes a framework for studying both the boom late 1980s and the bust early 1990s in Finland. To this end, we construct a small open economy DSGE model with financial frictions in the form of BGG (Bernanke, Gertler and Gilchrist, 1999) financial accelerator. A key contribution is to incorporate 'unconventional' shocks into the model to capture and evaluate the role played by three key events of the episode: financial market deregulation in the 1980s, the collapse of Soviet-Finnish trade in 1991 and the collapse of the fixed exchange rate regime in 1992. We calibrate the model to the Finnish economy and compare model outcome with actual Finnish data.

Our analysis assigns an essential role to the balance sheet constrained firms a la Bernanke, Gertler and Gilchrist (1999) in capturing the magnitude and persistence observed in investment and output data during the Finnish boom-bust cycle.The BGG financial accelerator links the balance sheet conditions of the firms to real activity via an external finance premium that depends inversely on the strength of the borrower balance sheets. In our model framework, we show how financial factors, either boosting or depressing economic activity, contributed first to the boom and later to the severity of the crises and to the slow recovery. Absent credit market frictions, the initiating disturbances would have resulted only in a mild upturn or downturn.

Furthermore, we argue that the shocks that hit Finland were greatly amplified since they hit the firm balance sheets. The result was sharp and persistent changes in the firm risk premia affecting firms' abilities to invest and thus leading to large and persistent swings of investment first above and later below its trend. We conclude that the shocks that hit the Finnish economy combined with financial frictions are able to produce a boom and a severe depression, matching key salient features of the actual boom-bust experienced in Finland.

The greater part of the financial deregulation process in Finland was carried out in the second half of the 1980s.[1] The deregulation process resulted in an exceptionally rapid growth in bank lending and an overheating of the economy. In our model framework, we produce a boom similar to the one observed in Finland late 1980s by modeling financial market deregulation as shocks from the domestic financial market lowering the cost of credit. Our model framework enables us thus to study formally the informal notion that financial market deregulation in the 1980s was at the core of the overheating of the economy.

In the beginning of 1991, the collapse of Soviet-Finnish trade and the sudden redundancy of Soviet-oriented manufacturing wiped out part of the economically valuable capital from the economy and resulted in a dramatic weakening of firm balance sheets. In this paper, we argue that the collapse of Soviet-Finnish trade is best understood as a capital obsolescence shock reducing the value of capital in the firm balance sheets as opposed to a conventional trade shock. Here we draw on Gertler and Karadi (2009) who introduce a capital obsolescence shock into their model to capture the subprime crises that wiped out part of the value of intermediary sector balance sheets in the US as the value of the subprime related assets collapsed. We illustrate in our model framework how the capital obsolescence shock combined with balance sheet constrained firms leads to a severe downturn similar to the one experienced in Finland.

The collapse of the Soviet-Finnish trade was followed by the collapse of the fixed exchange rate regime in September 1992 and a depreciation of the currency. Despite the depreciation of the real exchange rate and a pickup in net trade, investment contracted further and output remained depressed for several years.We illustrate in our model the role played by financial factors after the collapse of the fixed exchange rate regime. We argue that the indebtedness of the entrepreneurial sector in Finland and the fact that part of the loans were denominated in foreign currency resulted in a persistent decline in investent and a slow recovery of the economy despite an increase in net trade due to improved competitiveness.

The collapse of the Soviet-Finnish trade has been studied by Gorodnichenko et al (2009) in a dynamic general equilibrium model that describes the Soviet-Finnish trade linkages in great detail. Gorodnichenko et al (2009) treat the collapse of Soviet trade as a large exogenous trade shock and conclude that their model is able to match the aggregate dynamics reasonably well. The key mechanism that amplifies the initial shock in their model is rigid real wages. However, their model is not able to produce a drop in investment of similar magnitude and persistence as observed in the Finnish data. In this paper, we show that our model captures the effects and the magnitude of the collapse of Soviet trade more accurately by modeling it as a capital obsolescence shock and combining this shock with balance sheet constrained firms.

Furthermore, Gorodnichenko et al (2009) are silent about the collapse of the exchange rate regime in August 1992. In this paper, we study the effects of the collapse of the fixed exchange rate regime and illustrate the role of

[1] Economic developments in Finland from 1970s to the end of 1990s are described, for example, in Korhonen (2010).

firm indebtedness in the severity of the crises and the slow recovery. Similar analysis is done by Gertler, Gilchrist and Natalucci (2003) who study the collapse of the fixed exchange rate regime in Korea in an open economy DSGE framework similar to the one in this paper. Gertler et al (2003) focus on the role of the exchange rate regime in a model with the financial accelerator and illustrate the response of the economy to a collapse of the fixed exchange rate regime with all firm debt either in domestic currency or in foreign currency. In this paper, we show that even if only a relatively small fraction of the firm debt is denominated in foreign currency, this has a quantitatively significant downward effect on the economy offsetting part of the positive net trade effect from a real exchange rate depreciation.

Another view of the Finnish depression is offered by Conesa et al (2007)who attribute the depression to a sharp fall in total factor productivity in 1989–1992 and argue that adverse labour tax shocks played also an important role. However, financial factors do not play a role in their approach.

Our key contribution is that, in contrast to the previous studies on the Finnish crises, our DSGE model allows us to examine both the boom and the bust in the same model framework. For example, Gorodnichenko et al (2009) ignore the boom that preceded the crises. Honkapohja and Koskela (1999), on the other hand, offer an explanation both to the boom and to the bust, and emphasize the role of financial factors in the boom-bust cycle. Our paper complements their analysis by providing a DSGE model framework for studying both qualitatively as well as quantitatively the boom-bust cycle and the role of financial factors in it. Our conclusions are, however, not similar. Honkapohja and Koskela (1999) treat the collapse of Soviet-Finnish trade as a trade shock and argue that it accounts for only a fraction of the decline in output. Instead, they emphasize the negative effect from defending the fixed exchange rate regime with high interest rates and then the exchange rate shock after the collapse of the fixed exchange rate regime. In our model simulation, we take into account the fact that the Soviet-Finnish trade collapsed during the fixed exghange rate regime so that the nominal interest rate and the nominal exchange rate were not able to respond to the adverse shock from the collapse of Soviet-Finnish trade.

The paper proceeds as follows: In Section 2, we present the model framework. Section 3 discusses the parameter calibration. In Section 4, we present the results of our three boom-bust experiments: financial market deregulation, the collapse of Soviet-Finnish trade and the collapse of the fixed exchange rate regime. The model responses are then compared with the actual data. Section 4 concludes.

2 The model

In this section, we describe our small open economy DSGE model that builds on Gertler, Gilchrist and Natalucci (2003) and Freystätter (2010). The model incorporates a version of financial frictions proposed by Bernanke, Gertler and Gilchrist (1999), BGG from now on. The BGG financial accelerator mechanism

introduces a balance sheet constraint on the entrepreneurs' ability to obtain finance: entrepreneurs pay an external finance premium that depends inversely on their net worth. In our model, entrepreneurs are allowed to borrow both in domestic and foreign currency to finance the capital used in the production process. In addition to the financial frictions, the model incorporates nominal and real rigidities, such as habit formation, flow investment adjustment costs, variable capital utilization rate, export inertia, and Calvo-style nominal price rigidities at retail sector.

In addition to the commonly used supply and demand shocks, the economy is subject to financial market shocks stemming from domestic and foreign financial markets. Furthermore, a key addition to the model is a disturbance to the quality of capital, following Gertler and Karadi (2009). In our model, the capital obsolescence shock affects the balance sheets of the non-financial firms, as opposed to the financial intermediary sector balance sheet in Gertler and Karadi (2009). We argue that these 'unconventional' shocks in conjunction with the financial accelerator provide us with a model environment suitable for analyzing the boom-bust episode in Finland.

The economy consists of households, a production sector, a central bank and a foreign sector. As in BGG, the production sector consists of entrepreneurs, capital producers and monopolistically competitive retailers. Foreign behaviour is modelled as exogenous.

2.1 Households

2.1.1 Preferences

Households work, save and consume domestic and foreign tradable goods. The representative household's expected life-time utility is given by

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t U \left(e_t \log \left[c_t^i - b c_{t-1} \right] + \eta \log(1 - h_t) \right) \tag{2.1}$$

where c_t denotes consumption, and $(1 - h_t)$ is leisure. $\beta \in (0, 1)$ is the discount factor. Parameter b measures the degree of external habit formation in consumption. Thus, the utility of household i depends positively on the difference between the current level of individual consumption c_t^i and the lagged economy-wide consumption level c_{t-1} and negatively on the number of hours worked, h_t. η is the weight on leisure in the utility function. e_t is a preference shock. The preference shock follows a first-order autoregressive process given in log-linearized form by

$$\log e_t = \rho_e \log(e_{t-1}) + \epsilon_{et} \tag{2.2}$$

where ϵ_{et} is an uncorrelated and normally distributed innovation with zero mean and standard deviation σ_e, and ρ_e is an autoregressive coefficient.

In the open economy model, the consumption good c_t is a composite of tradable goods. Each household consumes domestically produced goods as

well as imported goods, which are supplied by domestic firms and importing firms, respectively. The following CES index defines household preferences over home goods c_t^H and foreign goods c_t^F

$$c_t = \left[(\omega)^{\frac{1}{\rho}}(c_t^H)^{\frac{\rho-1}{\rho}} + (1-\omega)^{\frac{1}{\rho}}(c_t^F)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \tag{2.3}$$

where c_t^H is produced by domestic monopolistically competitive retailers and c_t^F are imported foreign goods sold by retailers of foreign goods. ω is the share of domestic goods in the consumption composite. The intratemporal elasticity of substitution between domestic and foreign goods ρ captures the sensitivity of the consumption allocation between home and foreign goods with respect to the relative price of home and foreign goods.

The corresponding consumer price index, P_t is given by

$$P_t = \left[(\omega)(p_t^H)^{1-\rho} + (1-\omega)(p_t^F)^{\frac{1}{\rho}}\right]^{\frac{1}{1-\rho}} \tag{2.4}$$

2.1.2 Budget constraint

The budget constraint of the representative household is as follows

$$c_t = \frac{W_t}{P_t}h_t + \frac{\Omega_t}{P_t} - \frac{B_{t+1} - R_{t-1}B_t}{P_t} - \frac{s_t B_{t+1}^* - s_t \Gamma_t R_{t-1}^* B_t^*}{P_t} \tag{2.5}$$

where c_t is real consumption, W_t/P_t is real wage, h_t is labour hours, and Ω_t represents the dividend payments from the retailers.

Households can save in domestic bonds B_t and foreign bonds B_t^*. The foreign and the domestic gross nominal interest rates are respectively denoted by R_t and R_t^*.The effective gross interest rate at which the agent can borrow or lend on the international asset market is given by $\Gamma_t R_t^*$ and it depends on the foreign interest rate R^* and a country-specific borrowing premium Γ_t. Following Schmitt-Grohe and Uribe (2003), we assume a premium on the foreign bond holdings to ensure a well-defined steady state in the model. The country borrowing premium depends on the real aggregate net foreign asset position of the domestic households and a country borrowing premium shock

$$\Gamma_t = \exp(-\kappa(a_t - \bar{a}) + \epsilon_{\Gamma t}) \tag{2.6}$$

where $a_t \equiv s_t B_t^*/P_t$ is the real net foreign indebtedness in home currency (s_t is the nominal exchange rate), $\bar{a}_t$ is the steady state level of real foreign indebtedness and κ is the elasticity of the borrowing premium with respect to the net foreign indebtedness. κ is set close to zero so that it makes the real net foreign assets a_t revert to steady state following a shock but does not have a marked impact on the short run dynamics of the model. The country

borrowing premium depends also on an exogenous shock $\epsilon_{\Gamma t}$ that is assumed to follow an AR(1) process given in log-linearized form below

$$\epsilon_{\Gamma t} = \rho_{\Gamma}\epsilon_{\Gamma t-1} + \epsilon_{\Gamma\Gamma t} \tag{2.7}$$

where ρ_{Γ} is an autoregressive coefficient and $\epsilon_{\Gamma\Gamma t}$ is an uncorrelated and normally distributed innovation with zero mean and a standard deviation σ_{Γ}. The country borrowing premium shock is introduced to model sudden capital outflows, as in Gertler, Gilchrist and Natalucci (2003).

2.1.3 First-order conditions

The equations below present the optimality conditions for the household's optimization problem

$$\frac{e_t}{c_t - bc_{t-1}} = \lambda_t \tag{2.8}$$

where λ_t is the Lagrangian multiplier associated with the budget constraint.

The labour supply is given by

$$\frac{\eta}{1 - h_t} = \lambda_t w_t \tag{2.9}$$

which equates the marginal cost of supplying labour to the marginal utility of consumption generated by the corresponding increase in labour income.

The intertemporal decision for optimal holdings of bonds is given by

$$\frac{\lambda_t}{R_t} = \beta E_t \left(\frac{\lambda_{t+1}}{\pi_{t+1}}\right) \tag{2.10}$$

where $\pi_{t+1} = P_{t+1}/P_t$.

The optimal allocation of consumption between home and foreign goods is given by

$$\frac{c_t^H}{c_t^F} = \frac{\omega}{1-\omega}\left(\frac{p_t^H}{p_t^F}\right)^{-\rho} \tag{2.11}$$

The optimality condition governing the choice of foreign bonds combined with (2.10) yields the following uncovered interest rate parity (UIP) condition

$$E_t\{\frac{\lambda_{t+1}}{\pi_{t+1}}\left[R_t - \frac{s_{t+1}}{s_t}\Gamma_t R_t^*\right]\} = 0 \tag{2.12}$$

In a small open economy model with flexible exchange rate, the uncovered interest rate parity condition is an arbitrage condition pinning down expected exchange rate changes. In a fixed exchange rate regime, the domestic nominal interest rate R_t is determined by the exogenous foreign interest rate R_t^* and the endogenous country borrowing premium Γ_t. The exogenous foreign variables are discussed in Section 2.3.

2.2 Production sector

The production sector consists of entrepreneurs, capital producers and retailers. In this section, we first focus on the competitive entrepreneurs who produce a wholesale good. The wholesale good is sold to domestic retailers who repackage it and sell it to domestic and foreign consumers and to capital producers. Capital producers carry out the production of capital goods.

The entrepreneurs borrow to finance the acquisition of capital needed in the production of the wholesale good. We allow for foreign currency denominated debt. Furthermore, we introduce a stochastic factor, a capital obsolescence shock, that affects the gross return on capital and capital accumulation. In Gertler and Karadi (2009), this shock captures a feature of the recent financial crises where financial instruments turned out to be worse than thought of which hit the intermediary balance sheets. Here, the shock affects the non-financial entrepreneurs' balance sheets.

2.2.1 Entrepreneurs

The entrepreneurs produce a wholesale product with the following production technology

$$Y_t = (U_t K_t)^{\alpha} (A_t h_t)^{(1-\alpha)} \tag{2.13}$$

where capital services $U_t K_t$ are the product of the capital stock K_t and the utilization rate of capital U_t. h_t denotes hours of work and α denotes the share of capital in the production function. A_t is a neutral technology shock. It is assumed to follow a stationary first-order autoregressive process

$$\log A_t = (1 - \rho_A) \log(A) + \rho_A \log(A_{t-1}) + \epsilon_{At} \tag{2.14}$$

where ρ_A is an autoregressive coefficient and $A > 0$ is a constant. The error term ϵ_{At} is normally distributed with zero mean and standard deviation σ_A.

The entrepreneur's decision problem is as follows: The firm chooses the capital stock K_{t+1}, labour demand h_{t+1} and capacity utilization rate U_{t+1} to produce output Y_{t+1}.The firm's earnings in $t+1$ consist of the value of output and the value of its capital stock left over after deducting financing and labour costs.

$$\max E_t \beta \Lambda_{t,t+1} [P^h_{t+1} Y_{t+1} + (q_{t+1} - \delta(U_{t+1})) x_{t+1} K_{t+1} \tag{2.15}$$

$$- f_{t+1} q_t K_{t+1} - \frac{W_{t+1}}{P_{t+1}} h_{t+1}] \tag{2.16}$$

$$+ \xi_{t+1} [(U_{t+1} K_{t+1})^{\alpha} (A_{t+1} h_{t+1})^{(1-\alpha)} - Y_{t+1}] \tag{2.17}$$

$\beta \Lambda_{t,t+1}$ is the firm's stochastic discount factor where $\Lambda_{t,t+1} \equiv \lambda_{t+1}/\lambda_t$.The wholesale product Y_{t+1} is sold to domestic good retailers at competetive

markets for a price $P^h_{t+1} = \xi_{t+1}$, where $\xi_{t+1} > 0$ is the Lagrangian multiplier associated with production function (2.13) and denotes the real marginal cost.

After production in period $t+1$ the firm can either sell its capital stock for the real market price of capital q_{t+1} or keep it for production next period.We assume that the replacement cost of capital is unity so that the value of units of capital left over is given by $(q_{t+1} - \delta(U_{t+1}))x_{t+1}K_{t+1}$. Following Gertler and Karadi (2009) we assume that the quality of capital is affected by an exogeous factor x_{t+1}, a capital obsolescence shock. This is an aggregate shock that affects the gross return on capital and the accumulation of aggregate capital stock in the economy.

Financing costs $f_{t+1}q_tK_{t+1}$ consist of the overall cost of external finance f_{t+1} (that in optimum equals the return on capital) and the value of acquired capital q_tK_{t+1} needed to produce the wholesale good. Labour costs consist of the real wage W_{t+1}/P_{t+1} and hours worked h_{t+1}.

Entrepreneurs choose an optimal level of utilization of capital as well as capital and labour inputs. The optimality condition for the capital stock K_{t+1} is

$$E_t\beta\Lambda_{t,t+1}f_{t+1} = E_t[\beta\Lambda_{t,t+1}\frac{\xi_{t+1}\alpha(Y_{t+1}/K_{t+1}) + (q_{t+1} - \delta(U_{t+1}))x_{t+1}}{q_t}] \quad (2.18)$$

In optimum, the discounted overall cost of capital must equal the discounted return, given by the right hand side of the equation.The expected marginal return on capital consists of the real marginal product of capital (the first term) and a capital gain due to fluctuations in asset prices q_t. Moreover, the capital gain is affected by endogenous depreciation and the exogenous disturbance to the quality of capital. The capital obsolescence shock is an aggregate shock to the gross return on capital.

The entrepreneur chooses its labour demand as follows

$$\frac{W_{t+1}}{P_{t+1}} = \xi_{t+1}(1-\alpha)\frac{Y_{t+1}}{h_{t+1}} \quad (2.19)$$

The optimality condition for capital utilization $U_{t+1}$is

$$\delta'(U_{t+1})x_{t+1}K_{t+1} = \frac{\xi_{t+1}\alpha Y_{t+1}}{U_{t+1}} \quad (2.20)$$

We assume that increases in the utilization rate of capital are costly because higher utilization rates imply faster depreciation rates. When selecting an optimal rate of utilization, firms must weigh the benefits of greater output against the costs of greater depreciation. In optimum, the marginal cost of a higher rate of utilization is equated to the marginal gain from a higher utilization.

We follow Baxter and Farr (2001) and assume that the depreciation function is the following convex function of the utilization rate.

$$\delta(U_t) = \delta + \frac{m}{1+\xi^u}(U_t)^{1+\xi^u} \quad (2.21)$$

$$with\ \delta, m, \xi^u > 0 \tag{2.22}$$

The finance of capital is divided between net worth and debt, as shown in the accounting identity below. The purchase of capital $q_t K_{t+1}$, where q_t is the real price of the capital, is financed partly by net worth n_{t+1} and partly by borrowing B^f_{t+1}

$$q_t K_{t+1} = \frac{B^f_{t+1}}{P_t} + n_{t+1} \tag{2.23}$$

In this paper, we assume that borrowing can be either in domestic or foreign currency. B^f_{t+1} denotes the amount borrowed in domestic currency. Foreign debt in domestic currency is given by $\frac{s_{t+1}B^{f*}_{t+1}}{P_t}$ where s_{t+1} is the nominal exchange rate. In both cases the amount borrowed (whether in domestic or foreign currency) is determined by $q_t K_{t+1} - n_{t+1}$.

At the end of period t entrepreneurs sell old capital to capital producers and pay off debt (the loan contract lasts for one period only). After that we see the entrepreneur's net worth for period $t+1$. Net worth n_{t+1} is the equity of the firm, ie the gross value of capital net of debt.

The entrepreneur's demand for capital depends on the expected marginal return and the expected marginal financing cost $E_t f_{t+1}$. The expected rate of return on capital is given by equation (2.18). The demand for capital should satisfy the optimality condition which states that the real return on capital is equal to the real cost on external funds. For an entrepreneur who is not fully self-financed, in equilibrium the expected return to capital will be equated to the marginal cost of external finance.

The entrepreneur's overall cost of external finance depends on the gross external finance premium $G(\cdot)$ and the gross real opportunity cost of funds. The gross opportunity cost of funds is, in case of domestic debt, the domestic real interest rate and, in case of foreign debt, the real effective foreign interest rate multiplied by the expected change in the nominal exchange rate. Γ_t is a country borrowing premium.

If the debt is in domestic currency, the cost of external finance is given by

$$E_t f^d_{t+1} = E_t[G(\cdot)\frac{R_t}{\pi_{t+1}}] \tag{2.24}$$

In case of foreign currency denominated debt, the overall cost of external finance is given by

$$E_t f^f_{t+1} = E_t[G(\cdot)\frac{\Gamma_t R^*_t}{\pi_{t+1}}\frac{s_{t+1}}{s_t}] \tag{2.25}$$

In equilibrium, the uncovered interest rate parity condition (see equation 2.12 equalizes these costs. However, the response of external finance costs to a shock depends on whether the debt is in domestic or foreign currency.

The external finance premium $G(\cdot)$ is the difference between the cost of external funds and the opportunity cost of internal funds (the risk-free real

interest rate). The presence of BGG financial frictions implies that the external finance premium varies inversely with the the aggregate financial condition of entrepreneurs, as measured by the ratio of net worth to the gross value of capital $\frac{n_{t+1}}{q_t K_{t+1}}$. Furthermore, we assume that the external finance premium also depends on an exogenous financial disturbance ϵ_{ft}.

$$G_t(\cdot) = G(\frac{n_{t+1}}{q_t K_{t+1}}; \epsilon_{ft}), \quad G\prime(\cdot) < 0, G(1) = 1 \tag{2.26}$$

The financial accelerator mechanism thus relates the external finance premium negatively to the strength of entrepreneurs' balance sheets.[2] The size of the external finance premium varies endogenously due to changes in the entrepreneurial sector leverage ratio and exogenously due to the shock process ϵ_{ft}. We refer to this shock as a credit supply shock, as in Gilchrist et al (2009). This is a financial disturbance that captures exogenous disturbances in domestic financial intermediation. It is a shock that increases or decreases the external finance premium to a level different from the one warranted by current economic conditions. The credit supply shock is assumed to follow an AR(1) process given in log-linearized form below

$$\epsilon_{ft} = \rho_f \epsilon_{ft-1} + \epsilon_{fft} \tag{2.27}$$

where ρ_f is an autoregressive coefficient vector and ϵ_{fft} is an uncorrelated and normally distributed innovation with zero mean and a standard deviation σ_f.

The log-linearized external finance premium is given by

$$\hat{G}_t = \psi(\hat{q}_t + \hat{K}_{t+1} - \hat{n}_{t+1}) + \hat{\epsilon}_{ft} \tag{2.28}$$

where variables with hats are in log-deviations from steady state, $\hat{x}_t = \log x_t - \log \bar{x}$.

We denote with ψ the elasticity of the risk premium to changes in the net worth-to-capital ratio, a measure of entrepreneurial financial health. This parameter could be interpreted as a summary statistic indicating how vulnerable the economy is to shocks affecting aggregate balance sheets.When the elasticity of external finance premium ψ is exactly equal to zero, the financial accelerator mechanism seizes to exist and there is no premium for the external finance of firms.

We allow for both domestic and foreign-currency denominated debt, by assuming a fixed share $(1- \omega^d)$ of debt denominated in foreign currency. With both domestic and foreign debt, the overall entrepreneurial sector cost of external finance $\hat{f}_{t+1}$evolves according to

[2]Due to asymmetric information between the the borrower and the lender, the lender charges the borrower a premium to cover the expected bankcruptcy cost. The specific form of $G_t(\cdot)$ depends on the primitive parameters of the costly state verification problem (see Bernanke et al, 1999, and Gertler, Gilchrist and Natalucci, 2003). The financial contract implies an external finance premium $G_t(\cdot)$ that depends on the entrepreneur's leverage ratio. The underlying parameter values determine the elasticity of the external finance premium with respect to firm leverage.

$$\hat{f}_{t+1} = \omega^d[\hat{R}_t - \hat{\pi}_{t+1} + \hat{G}_t] + (1-\omega^d)[\Gamma_t + R_t^* - \hat{\pi}_{t+1} + \hat{s}_{t+1} - \hat{s}_t + \hat{G}_t] \quad (2.29)$$

Movements in net worth affect the cost of capital via the external finance premium $\hat{G}_t$. Furthermore, is case of foreign currency denominated debt, movements in the nominal exchange rate have a direct impact on the cost of external finance.

The aggregate entrepreneurial net worth n_{t+1} evolves according to

$$E_t n_{t+1} = \nu_t V_t + (1-\nu_t) g_t \quad (2.30)$$

where V_t is the net worth of surviving entrepreneurs. Entrepreneurs are risk neutral. They have a finite planning horizon. The expected survival rate of entrepreneurs is ν_t which gives them an expected lifetime of $1/(1-\nu_t)$. A fraction $(1-\nu_t)$ of entrepreneurial financial wealth is destroyed exogenously each period. This is to ensure that entrepreneurs do not grow away from the financial constraint by accumulating enough wealth. The new entrepreneurs receive only a small transfer g_t from entrepreneurs who exit. As the number of entrepreneurs who exit is always balanced by the number that enter who have less net worth than those who exit, the greater the share of exiting entrepreneurs the smaller the aggregate net worth of the entrepreneurs.

We introduce a shock to the survival probability of entrepreneurs, a financial wealth shock, along the lines of Christiano et al (2007). In the log-linearized version of the model the parameter governing the survival probability of entrepreneurs takes the following form

$$\nu_t = \nu + \epsilon_{\nu t} \quad (2.31)$$

where $\epsilon_{\nu t}$ could be interpreted as a shock to the discount rate of entrepreneurs. It is an exogenous disturbance affecting the financial wealth in the hands of the entrepreneurs. Thus, the fraction of surviving entrepreneurs is itself subject to stochastic fluctuations $\epsilon_{\nu t}$, which is assumed to follow an AR(1) process given in log-linearized form below

$$\epsilon_{\nu t} = \rho_\nu \epsilon_{\nu t-1} + \epsilon_{\nu\nu t} \quad (2.32)$$

where $\rho_{\nu t}$ is an autoregressive coefficient vector and $\epsilon_{\nu\nu t}$ is an uncorrelated and normally distributed innovation with zero mean and a standard deviation σ_ν.

As Christiano et al (2007), we interpret the financial wealth shock as a way of describing exogenous movements in asset values. The financial wealth shock affects investment through the balance sheet by exogenously creating or destroying aggregate net worth of entrepreneurs.When a shock drives the survival probability up, the rate of desctruction of entrepreneurial wealth decreases, resembling a process of a stock market bubble building up. Entrepreneurs as a group have more wealth under their control. With more net worth, the need for external financing decreases and the demand for capital

increases. The entrepreneurs purchase more capital, which drives up its price and leads to a further increase in entrepreneurial net worth.

The net worth of surviving entrepreneurs evolves according to the following equation

$$V_t = f_t q_{t-1} K_t - E_{t-1} f_t (q_{t-1} K_t - n_t) \tag{2.33}$$

Let V_t denote the value of entrepreneurial capital net of borrowing costs carried over from previous period. f_t gives the real return on capital held in t. $E_{t-1} f_t$ is the cost of borrowing implied by the loan contract signed in time $t-1$. As in Christiano et al (2007) we assume that the debt contracts are in nominal terms (in BGG, 1999, the contract is specified in terms of the real interest rate). This assumption implies that an unanticipated increase in inflation decreases the real debt burden and thus increases net worth. This is the so called Fisher effect. Furthermore, movements in borrowing costs depend on the fraction of debt denominated in foreign currency. Thus, in our model, unanticipated changes in the nominal exchange rate affect net worth. An unexpected depreciation of the nominal exchange rate decreases net worth by increasing borrowing costs.

The evolution of net worth and the link from net worth to the real economy provides an endogenous propagation mechanism that amplifies the response of the economy to shocks. A shock that affects net worth negatively (positively) is able to initiate a bust (a boom). A shock that reduces the value of entrepreneur's value of capital net of borrowing costs cuts into their ability to borrow by increasing the external finance premium. The increase in the external finance premium amplifies the effect through an accelerator effect on investment and production. A shock that decreases net worth, produces a fall in investment.

In addition, it is important to notice that endogenous movements in asset prices have an impact on the real economy. In this model, the balance sheet of firms links the development of asset prices to the real economy. A shock that reduces the market value of capital q_t (ie, asset prices) decreases entrepreneurial net worth and produces a fall in investment. As a result, it is important to notice that fluctuations in the price of capital q_t may have significant effects on the leverage ratio and thus on the cost of funds.[3]

2.2.2 Capital Producers

The actual production of physical capital is carried out by capital-producing firms. Capital producers purchase final goods from domestic good retailers and use them as material input to produce investment goods i_t. They combine investment goods with the existing capital stock to produce new capital and sell capital to firms at the price q_t. We assume that the production of new capital involves flow investment adjustment costs.The objective of a capital producer is thus to choose the quantity of investment i_t to maximize the profits

[3] The effect of asset price q_t on net worth is greater than its effect on total assets. This implies that the leverage ratio moves countercyclically.

$$\max_i E_t \Sigma_{\tau=1}^{\infty} \Lambda_{t,\tau} \left[q_\tau i_\tau - (1 + f(\frac{i_\tau}{i_{\tau-1}}))i_\tau \right] \tag{2.34}$$

where $f(\frac{i_t}{i_{t-1}})i_t$ reflects physical adjustment costs, with $f(1) = f^{'}(1) = 0$ and $f^{''}(1) > 0$. Thus, the optimal condition is

$$q_t = 1 + f(\frac{i_t}{i_{t-1}}) + f'(\frac{i_t}{i_{t-1}})(\frac{i_t}{i_{t-1}}) - E_t \Lambda_{t,t+1} f'(\frac{i_{t+1}}{i_t})(\frac{i_{t+1}}{i_t})^2 \tag{2.35}$$

which is the standard Tobin's Q equation that relates the price of capital to marginal adjustment costs. In optimum, the price of capital goods is equal to the marginal cost of investment goods production. In the absence of capital adjustment costs, the price of capital is constant and equal to one. Capital adjustment costs slow down the response of investment to different shocks, which directly affects the price of capital. Therefore, capital adjustment costs allow the price of capital to vary, which contributes to the volatility of entrepreneurial net worth. We specify the investment adjustment costs as $\frac{\chi}{2}(\frac{i_t}{i_{t-1}} - 1)^2 i_t$.

The aggregate capital stock evolves according to

$$K_{t+1} = x_t[i_t + (1 - \delta(U_t))K_t] \tag{2.36}$$

As usual, the investment goods i_t are combined with the existing capital goods, $(1 - \delta(U_t))K_t$ to produce new capital goods, K_{t+1}. In addition, the effective quantity of capital in the economy also depends on the capital obsolescence shock which captures the stochastic depreciation of capital, as in Gertler and Kiyotaki (2009). The capital obsolescence shock is a disturbance that makes a part of the capital (used to produce goods that turn out obsolete) worthless.[4]

2.2.3 Retailers

The retail sector introduces nominal price rigidities into the model. There are two types of retailers in our open economy model: Domestic good retailers buy wholesale goods from domestic producers and foreign good retailers buy wholesale goods from abroad. Both domestic and foreign good retailers differentiate the wholesale goods slightly and engage in Calvo-style price-setting. The domestic final goods are sold to domestic and foreign consumers and to domestic capital producers in a monopolistically competitive market. The imported foreign goods are sold only to domestic consumers.

The probability of not being able to reoptimize the selling price is ϕ. Thus with probability ϕ the retailer must charge the price that was in effect in the

[4] Gertler and Kiyotaki (2009) motivate this disturbance by an example that assumes good specific capital. Each period a random fraction of goods become obsolete and are replaced by new goods. In that case, the capital used to produce obsolete goods is now worthless and the capital for the new goods is not fully on line.

preceeding period indexed by the steady state gross rate of inflation, π. With probability $(1-\phi)$ the retailer receives a signal to reoptimize and chooses price $p_t^H(j)$

The (aggregate) price of the domestic final good p_t^H is thus given by

$$p_t^H = [\phi(\pi p_{t-1}^H)^{1-\theta} + (1-\phi)(p_t^H(j))^{1-\theta}]^{\frac{1}{1-\theta}} \tag{2.37}$$

The solution of the domestic firms' price setting problems results in a Phillips-curve type relatioship between domestic inflation and real marginal cost ξ_t,

$$\hat{\pi}_t^H = \beta E_t \hat{\pi}_{t+1}^H + \frac{(1-\beta\phi)(1-\phi)}{\phi}\hat{\xi}_t \tag{2.38}$$

where variables with hats are in log-deviations from steady state, $\hat{x}_t = \log x_t - \log \bar{x}$.

The price setting problem of the foreign good retailers is analogous to that of the domestic good retailers. The foreign good retailers transform a homogenous foreign good into a differentiated import good, which they sell to the domestic households. Similarly to domestic good retailers, foreign good retailers operate under Calvo-style price-setting. We assume that retailers of domestic and foreign goods face the same degree of price rigidity ϕ. Foreign good retailers purchase foreign goods at world-market prices P_t^* which are set by their respective producers in their own currency. The law of one price holds at the wholesale level. By allowing for imperfect competition, we create a wedge between the wholesale and retail price of foreign goods and thus allow for incomplete exchange rate pass-through in import sector. The real marginal cost of acquiring foreign goods is $\xi_t^F = \frac{P_t^*}{P_t^F}$.

The price-setting problem of foreign good retailers results in a Phillips-curve relationship between import-price inflation and the corresponding real marginal cost.

$$\hat{\pi}_t^F = \beta E_t \hat{\pi}_{t+1}^F + \frac{(1-\beta\phi)(1-\phi)}{\phi}\hat{\xi}_t^F \tag{2.39}$$

In an open economy, CPI inflation is a composite of both the domestic and the foreign good inflation

$$\pi_t = (\pi_t^H)^{\omega}(\pi_t^F)^{(1-\omega)} \tag{2.40}$$

CPI inflation dynamics therefore depend on domestic driving forces as well as foreign factors.

2.3 Foreign behaviour

We assume that the foreign demand for the home tradable goods is

$$c_t^{H*} = [\left(\frac{p_t^H}{s_t P_t^*}\right)^{-\zeta} Y_t^*]^{\tau} (c_{t-1}^{H*})^{1-\tau} \tag{2.41}$$

It is a decreasing function of the relative price and an increasing function of foreign ouput. We assume that the export sector is pricing in producer's currency. The term $(c_{t-1}^{H*})^{1-\tau}$ represents inertia in foreign demand for domestic goods.

We assume that the foreign price level P_t^*, the foreign output Y_t^* and the foreign interest rate R_t^* are exogenous and each follow an AR(1) process given in log-linearized form below

$$x_t^* = \rho_{x^*} x_{t-1}^* + \epsilon_{x^* t} \tag{2.42}$$

where $x_t^* = \{P_t^*, Y_t^*, R_t^*\}$, ρ_{x^*} is an autoregressive coefficient vector and $\epsilon_{x^* t}$ is a vector of uncorrelated and normally distributed innovations with zero means and standard deviations σ_{x^*}.

2.4 Resource constraints

The production of the intermediate good firm is divided between consumption of domestic and foreign households and investment expeditures

$$Y_t = c_t^H + c_t^{H*} + i_t + f(\frac{i_t}{i_{t-1}})i_t \tag{2.43}$$

where $f(\frac{i_t}{i_{t-1}})i_t$ reflects physical adjustment costs.

2.5 Current account

The net foreign assets at the aggregate level evolve as follows

$$s_t B_{t+1}^* = p_t^H c_t^{H*} - s_t P_t^* c_t^F + s_t \Gamma_t R_{t-1}^* B_t^* \tag{2.44}$$

where B_{t+1}^* is the foreign net bond position, $p_t^H c_t^{H*}$ are the receipts from exports and $P_t^* c_t^F$ are the expenses on imports (the retailer only pays the marginal cost for imported wholesale goods and keeps the profit) and $\Gamma_t R_t^*$ is the country premium-adjusted gross nominal interest rate. We assume balanced trade in the steady state and normalize the steady state real exchange rate to unity. Notice that the net foreign asset position affects the endogenous country premium (see equation (2.6)).

2.6 Monetary policy

Monetary policy is conducted according to a Taylor-type rule with interest rate smoothing (expressed in log-linearized form)

$$\hat{R}_t = \rho^R \hat{R}_{t-1} + (1 - \rho^R)(\varrho_\pi \hat{\pi}_t + \varrho_y \hat{y}_t + \varrho_s \hat{s}_t) + \hat{\epsilon}_{Rt} \tag{2.45}$$

The policy maker is assumed to adjust the nominal interest rate $\hat{R}_t$ in response to deviations of lagged interest rates $\hat{R}_{t-1}$, CPI inflation $\hat{\pi}_t$, output $\hat{y}_t$ and nominal exchange rate $\hat{s}_t$ from their steady-state values. $\hat{\epsilon}_{Rt}$ is an exogenous shock to monetary policy normally distributed and with zero mean and standard deviation σ_R. The smoothing parameter ρ^Rmeasures the rate of interest rate inertia and lies between zero and one. ϱ_π, ϱ_y, and ϱ_s are the coefficients that measure the responses of monetary policy to deviations in inflation, output and nominal exchange rate.

3 Calibration

Tables 1 and 2 report the calibrated parameters along with the implied steady state values of some key variables. The choice of parameter values reflects our aim to capture the key features of the Finnish economy during 1980–1998.

The discount factor is set to 0.99 which corresponds to an annual real rate in steady state of 4 per cent. The steady state quarterly gross inflation rate is equal to 1.01, which matches the historical average over the period.We set ρ, the intratemporal elasticity of substitution for the consumption composite, at 1.5. The share of domestic goods in the consumption composite ω is 0.45. The share of home-produced consumption is resonably low to capture the high share of import-output and export-output ratios. We pick the relative utility weight on labour η to fix hours worked at one third of available time. The habit parameter b is set at 0.7.

The share of capital in the production function α is fixed at 0.45. We normalize the steady state utilization at unity and the steady state quarterly depreciation $\delta(U_{ss})$ is assigned a value of 0.05. This relatively high rate of steady state depreciation is needed to capture the high investment-output ratio in the economy at the time. This is important, as the study focuses on explaining investment fluctuations. For the same reason, the share of capital in production function is calibrated at a high level. The parameter ξ^u which represents the elasticity of marginal depreciation with respect to the utilization rate, is set equal to 1. Here, we follow Baxter and Farr (2001).

We fix the price rigidity parameter (the Calvo probability of not resetting optimally prices) ϕ to have prices fixed on average for a year. The parameter θ measuring the degree of monopoly power in the retail (both domestic and import) sector is set to be equal to 6 which implies a 20 per cent markup in the steady state.

The investment adjustment cost parameter χ is fixed at 4. The more costly it is to adjust investments the more volatile the price of capital and therefore

the more volatile the external finance premium as the price of capital has a direct effect on the net worth of firms.

With regard to the parameters of export demand, we set the price elasticity ζ equal to 1 and the share parameter τ equal to 0.25. This implies a relatively high degree of inertia in export demand. We fix the elasticity of the country borrowing premium with respect to net foreign indebtedness κ at 0.001 so that the evolution of net foreign assets does not affect dynamics, while guaranteeing that the net foreign asset position is stabilized at zero in the long run.

The feedback coefficients in the monetary policy rule are calibrated as follows: the smoothing parameter ρ^R is given a value of 0.8, the coefficient on inflation ϱ_π 1.5, the coefficient on output gap ϱ_y 0.1 and the coefficient on nominal exchange rate ϱ_s is calibrated at 0.5.

The choice of the financial sector parameters is only meant to be suggestive. We calibrate the elasticity of the external finance premium to changes in net worth, ψ, the key parameter governing the strength of the financial accelerator, at a value of 0.05. This a value often used to calibrate this parameter (for example, BGG (1999)) and it is in line with some empirical work done estimating the strenght of the financial accelerator mechanism (for example, Christensen and Dib, 2008, Freystätter, 2010). The steady state external finance premium G is set to 1.0075 corresponding to an annual risk spread of three hundred basis points. We fix the steady state spread to reflect the average spread between the banks' lending rate and the base rate representing the riskless interest rate in the economy at the time. We chose a shorter sample to calculate the average, 1986–1995, as the spread seems to have fluctuated and our aim is to capture the behaviour of the economy particularly at the time of the boom and bust. The ratio of capital to net worth is calibrated to 2.1 implying a firm leverage ratio, defined as the ratio of debt to asset, of 0.52.The choice of the leverage ratio is a rough guess as obtaining accurate data is very challenging. However, it is well known that Finnish firms were highly leveraged at the time. Therefore, our steady state leverage ratio may actually underestimate the actual leverage ratio at the time. Furthermore, the share of firm debt in foreign currency $(1-\omega^d)$ is set at 27%, a level to which the share of foreign currency loans in total lending rose to by 1991 (Honkapohja and Koskela, 1999). The steady state quarterly survival probability ν is set to 0.9728.

4 Boom and bust experiments

In this section, we present some quantitative experiments designed to illustrate how and under which conditions the model is able to capture some key features of the Finnish boom-bust episode. We focus on three events that are claimed to have played a key role in the Finnish boom-bust episode and compare the model outcome with actual Finnish data. Firstly, we use our model to assess the role of financial market deregulation in the 1980s in the boom that preceded the crises. Secondly, we evaluate the negative impact of the collapse

of the Soviet-Finnish trade in the beginning of 1991. Thirdly, we investigate the effect of the collapse of the fixed exchange rate regime in September 1992.

In our experiments, we consider four types of aggregate shocks: 1) a credit supply shock, 2) a financial wealth shock 3) a capital obsolescence shock, and 4) a country borrowing premium shock. The first three shocks are 'unconventional' in the sense that they hit the net worth of the entrepreneurial sector or the cost of external finance directly. The fourth shock stems from international financial markets and, although slightly more conventional, is greatly amplified by the existence of the financial accelerator mechanism and the presence of foreign currency denominated debt.

We use the first two shocks from domestic financial markets (credit suppply and financial wealth shocks) to represent the deregulation process of the Finnish financial markets in the 1980s.The third shock, the capital obsolescence shock, captures the collapse of the Soviet-Finnish trade in the beginning of 1991 that turned Soviet-oriented export-sector capital useless. The fourth shock, a country borrowing premium shock, captures the outflow of foreign capital and the depreciation of the nominal exchange rate at the time of the collapse of the fixed exchange rate regime in September 1992.

Figure 1 shows the real side behaviour of the Finnish economy late 1980s and early 1990s that we try to match with our model. As we see, investment boomed from middle of 1988 until the end of 1989. The increase in investment was 20 per cent in 6 quarters. At the same time, GDP increased by 5 per cent. It is commonly argued that the overheating of the economy was due to the deregulation of the financial markets in the 1980s and a rapid credit expansion. In the beginning of 1991, trade with the Soviet Union practically stopped. Consequently, investment fell by 20 per cent and GDP by 6 per cent within 6 quarters from the end of 1990 level. The collapse of the fixed exchange rate regime followed in September 1992. Within a year, investment contracted by another 9 per cent and GDP by 1–2 per cent. Our experiments in this section are designed to match particularly the development of investment and output. We keep the calibration unchanged throughout the experiments and show that our model framework is suitable for explaining both the boom and the bust.

The exchange rate regime is clearly essential in assessing the response of the economy to a shock. In this study, the experiments are conducted taking the effective exchange rate regime at the time of the event as given. This implies that the first two experiments, the financial market deregulation and the collapse of Soviet trade, are studied under a fixed exch rate regime. The third experiment analyzes the response of the economy immediately after the collapse of the fixed exchange rate regime, ie under a flexible exchange rate regime. One could argue that the effects of the financial market deregulation and the collapse of Soviet-Finnish trade would indeed have been different under a flexible exchange rate regime. For example, according to Gerltler, Gilchrist and Natalucci (2003), a crises will usually be worse if the nominal interest rate (and the nominal exchange rate) is not free to respond.

4.1 Experiment 1: Financial market deregulation

In order to study financial market deregulation, we consider two financial market shocks: a credit supply shock that decreases the risk premium directly and a financial wealth shock that increases the net wealth in the hands of the entrepreneurs leading to a decline in the external finance premium. These are both shocks to the demand for capital. Figure 2 plots the response of the economy to both of these shocks under a fixed exchange rate regime.

The credit supply shock is a shock to the external finance premium paid by firms to obtain finance. This shock captures the huge expansion of bank lending following financial market deregulation and decreased costs of borrowing for firms. The second shock, a financial wealth shock, is a shock to the net worth in the hands of the entrepreneurial sector. The financial wealth shock, on the other hand, captures the rapid appreciation of asset prices that is exogenous to the model, an asset price bubble. It can be argued that in the late 1980s there were signs of false expectations of a lasting boom and that the overoptimistic perceptions of the future contributed to unsustainable increases in asset prices.As a consequence to this shock, the aggregate purchasing power of entrepreneurs as a group increases, which sustains the demand for capital and pushes up its price. It is possible that both the credit supply shock and the financial wealth shock played a role in the boom phase driving investment up. However, as we show in our experiment, even separately, both of these shocks are able to trigger an economic expansion similar to the one observed in Finland from the middle of 1988 until the end of 1989.

We fix the sizes of the shocks so that the boom in investment is broadly of similar magnitude to the one at the end of 1980s and keep the autoregressive coefficient at 0.7 in both cases. In our experiment, both the credit supply shock and the financial wealth shock are able to produce an economic expansion similar to the one observed in Finland. Both financial market shocks lower the external finance premium which leads to a long-lasting increase in investment and output, and an appreciation of asset prices.The increase in asset prices raises net worth and thus lowers the cost of creadit further. Inflation picks up and, in our open economy model, the real exchange rate appreciates resulting in a decline in net trade (dampening the increase in output). The model is thus able to mimic most of the basic features of the 1980s boom in Finland. The only exception is consumption that instead of increasing falls slightly initially. However, the initial fall in consumption is very modest and, after a delay, consumption rises too. Due to the initial fall in consumption, the increase in output is slightly smaller, around 4–5 per cent, than the observed 6 per cent increase. However, the timing of the boom is reproduced by the model reasonably accurately with investment and output peaking after 6 quarters, as in the data, and starting to decline afterwards.

The difference between the two financial market disturbances is that the boom is slighly more persistent in the case of a positive financial wealth shock. Net worth propagates the financial wealth shock longer and keeps the external finance premium below the steady state for a longer time period. Furthermore, in the case of the credit supply shock, the initial fall in the external finance premium needed to produce the boom is clearly greater than in the case of the

financial wealth shock when the shock hits the wealth of the entrepreneurial sector directly.

4.2 Experiment 2: The collapse of Soviet-Finnish trade

In this section, we illustrate the consequences of the collapse of Soviet-Finnish trade in the beginning of 1991. The initiating shock is a five per cent capital obsolescence shock. The shock follows an AR(1) process with persistence parameter 0.85. This shock captures the fact that part of the capital stock became useless as trade with the Soviet Union practically stopped in the beginning of 1991.We fix the size of the shock simply to mimic the roughly 20 per cent decline in investment observed between the beginning of 1991 and September 1992 (within 6 quarters). Figure 3 plots the responses of the model to this shock under a fixed exchange rate regime. We compare the results obtained with and without financial frictions.

In the model without financial frictions, the loss of capital produces only a modest downturn. This is due to investment picking up after an initial drop. The decline in capital below its steady state induces an increase in investment due to high returns to capital. Without financial frictions, the cost of external finance does not increase as a result of the negative disturbance, which supports the economy in the case of a sudden loss of economically valuable capital.

With financial frictions, however, the sharp fall in entrepreneurs' net worth, due to the capital obsolescence shock destroying economically valuable capital from firm balance sheets, increases the external finance premium. The increase in the cost of external finance is a drag on the real economy so long as the net worth of the entrepreneurs rises back to trend (a deleveraging process). Output decline at the through in this case is more than twice as large as in the frictionless case. The magnified effect is due to an enhanced and persistent decline in investment. With the balance sheet constrained entrepreneurs, the negative impact of the loss of economically valuable capital is greatly amplified via firm balance sheets. The amplification is, in addition to the shock itself, due to falling asset prices leading to further decreases in entrepreneurial net worth and higher cost of credit inducing a magnified drop in investment.

Comparing the model outcome with the data shows that the model is able to reproduce a persistent 6 quarter fall in investment roughly the same magnitude (about 20 per cent) as observed between the beginning of 1991 and the collapse of the fixed exchange rate regime in September 1992. Furthermore, the model is able to reproduce a decline in output: The data shows a 6 per cent drop in output that occurred within the 6 quarters, while the fall produced by the model is slightly faster and stronger. The response of consumption produced by the model is slighly slower than observed in the data but the magnitude is in line with the evidence.

In our open economy model, the recovery of output back to trend is slowed down by gradually falling net trade.This is due to an increase in inflation and an appreciation in the real exchange rate resulting from the capital obsolescence shock. However, in Finland the fall in net trade did not materialize before the next big shock hit the economy, namely the collapse of the fixed exchange rate regime in August 1992.

4.3 Experiment 3: The collapse of the fixed exchange rate regime

In this section, we illustrate the role played by financial factors after the collapse of the fixed exchange rate regime. In this paper, we focus on the effects of the collapse without discussing the underlying reasons why this happened. We model the shock as a sudden 4 percentage point increase in the country borrowing premium (with an autoregressive coefficient of 0.6). An increase in the country borrowing premium is a way to model sudden capital outflows along with a depreciation of the nominal exhange rate. In the Finnish data, the drop in investment following the collapse of the fixed exchange rate regime was 9 per cent in about 4 quarters. At the same time, GDP fell by 1–2 per cent. As previously, the size of the shock is chosen to match the magnitude of contraction in investment. We illustrate the role played by the financial accelerator and foreign currency denominated debt in reproducing the impact of the collapse of the fixed exchange rate regime. Figures 4–6 plots the responses of the model to the country borrowing premium shock under a flexible exchange rate regime.

In this experiment, the initial shock originates from international financial markets. An increase in the country borrowing premium raises the effective foreign interest rate. According to the UIP condition, the nominal exchange rate depreciates. The positive impact of a nominal and real exchange rate depreciation is an increase in net trade. Without the financial accelerator, investment and consumption fall but this is almost offset by an increase in exports. As a result, output falls but the outcome is only a mild recession.

With the financial accelerator, the fall in investment is clearly stronger and more protracted. Investment falls by 7 per cent within 4–5 quarters and recovers only slowly. This is mainly due to falling asset prices that result in a decline in net worth and an increase in the external finance premium. Based on our model, about half of the overall 10 per cent fall in investment is explained by an operative financial accelerator mechanism.

In the presence of foreign currency denominated debt, the decline in investment is even stronger. The additional negative impact depends on the extent firm debt is expressed in foreign currency. In the case of Finland, about 27 per cent of firm debt was denominated in foreign currency in 1991 (Honkapohja and Koskela, 1999). Our experiment shows that the presence of foreign currency denominated debt magnifies the contraction in investment from 7 per cent to 10 per cent. The drop in output is also clearly magnified. Based on our model, about a quarter of the overall fall in investment and

output is explained by foreign currency denominated debt. Furthermore, the recovery of investment and output is postponed further.With part of firm debt denominated in foreign currency, the depreciation of the nominal exchange rate hits the entrepreneurs' net worth directly by increasing the real indebtedness of the entrepreneurial sector. Net worth falls and the risk premium increases more than in the case of only domestic currency denominated debt. The further increase in the risk premium magnifies the drop in investment and output. Overall, our model illustrates how the positive effect of an increase in net trade is offset by a dramatically stronger and more persistent decline in investment.

Furthermore, financial factors contribute to the slow recovery of the economy back to trend. To reduce the spread between the cost of external finance and the riskless rate, net worth must increase. The recovery of entrepreneurial net worth back to trend takes time. Throughout the deleveraging process, the risk premium remains above its steady state value and drags the economy down.

We conclude that our model is able to produce a persistent fall in investment, consumption and output, and an increase in net trade roughly in line with the actual response of the Finnish economy after the collapse of the exchange rate regime. Thus, our model with the financial accelerator seems to capture the key financial factors contributing to the severity of the Finnish crises and to the slow recovery. The indebtedness of the entrepreneurial sector and the fact that a significant part of loans were foreign currency denominated are at the core of the explanation. Even if, as Gertler, Gilchrist and Natalucci (2003) show, the abandonment of the fixed exchange rate regime frees the hands of the central bank and allows the economy to recover faster than under the fixed exchange rate regime, financial factors were dragging the Finnish economy down and contributing to the slow recovery of the economy despite improved competitiveness and the pickup in net trade.

5 Conclusions

This paper studies the boom-bust episode in Finland late 1980s and early 1990s focusing on the role of financial frictions and investment behaviour. The boom-bust cycle manifested itself in the strong and persistent movement in investment first above and later below its trend. We show in this paper how financial factors combined with the shocks that hit the Finnish economy produced first a boom that was followed by a severe depression.

We construct a DSGE model with balance sheet constrained firms and an unconventional shock structure that captures the key events of the episode. In this framework, we show how financial factors, either boosting or depressing economic activity, contributed first to the boom and later to the severity of the crises and to the slow recovery of the Finnish economy from the crises. We argue that the financial accelerator mechanism is a key amplifying mechanism that helps the model to match, in particular, the large and persistent swings of investment first above and later below its trend.

This paper focuses on three shocks that hit the Finnish economy commonly claimed to have either initiated the boom or produced the severe depression. These three key events are the financial market deregulation in the 1980s, the collapse of the Soviet-Finnish trade in the beginning of 1991 and the collapse of the fixed exchange rate regime in 1992. Our model framework allows us to study whether and under which conditions these events combined with financial constraints are able to induce a boom and a bust similar to the Finnish experience.We argue that the shocks that hit Finland were powerful sources of strong economic fluctuations since they hit the balance sheets of leveraged and credit constrained firms.

In this paper, we produce a boom similar to the one experienced in Finland late 1980s by modeling the financial market deregulation in the 1980s as shocks from the financial market lowering the cost of credit. The boom is induced in our model by two alternative financial disturbances: a credit supply shock that lowers the cost of credit directly and a financial wealth shock that increases the net worth in the hands of the entrepreneurs leading to a lower cost of credit. We argue that both of these shocks combined with balance sheet constrained firms are able to produce a boom that mimics some basic features of the Finnish expansion.They both lower the cost of credit which leads to a long-lasting increase in investment and output, an appreciation of asset prices and thus a further increase in net worth, a pickup in inflation, an appreciation in the real exchange rate and a fall in net trade.

The collapse of the Soviet-Finnish trade hit the Finnish economy in the beginning of 1991 at a time the boom already showed some signs of weakening. We argue that the collapse of Soviet-Finnish trade is better understood as a capital obsolescence shock as opposed to a conventional trade shock. The severe impact of the collapse of the Soviet-Finnish trade was due to the shock destroying part of the economically valuable capital and thus leading to a sharp decline of the net worth in the hands of the entrepreneurs. Due to the presence of balance sheet constrained firms, the contraction of net worth increased the cost of finance and dragged investment down. We illustrate that the severity of the impact depends on the strength of the financial accelerator mechanism. Without balance sheet constrained firms, the result would only have been a mild recession: investment activities would have picked up soon to replace the obsolete capital. In contrast, an operative financial accelerator mechnism explains the stong and persistent fall in investment and output after the collapse of Soviet-Finnish trade. We argue that a traditional trade shock does not capture the direct damage to the capital stock and firm balance sheets that are key to capturing the magnitude and persistence of the impact observed in the data.

The collapse of the Soviet-Finnish trade was followed by the collapse of the fixed exchange rate regime in September 1992. Despite the depreciation of the real exchange rate and a pickup in net trade, investment contracted further and output remained depressed for several years. This study attributes the slow recovery of the Finnish economy to the persistent weakness in investment activities due to financial factors.With balance sheet constrained firms the fall in output and asset prices after the collapse of the fixed exchange rate regime led to increased firm indebtedness (ie. lower net worth) and thus an increase in

the cost of finance that depressed economic activities significantly more than would have been the case without an operative financial accelerator.We assess that an operative financial accelerator accounts for about half of the weakness of investment actitivies after the collapse of the fixed exchange rate regime.

Furthermore, the Finnish crises was exacerbated due to about 30 per cent of firm debt denominated in foreign currency at the time of the collapse.Therefore, the depreciation of the nominal exchange rate increased the debt burden of the firms raising the cost of external finance further. We argue that roughly one fourth of the overall fall in investment and in output resulted from the additional adverse effect due to the presence of foreign currency denominated debt. Furthermore, our model illustrates how increased firm indebtedness and the deleveraging process slowed down the recovery of the Finnish economy from the crises. After the shock the firms' net worth recovered only slowly and the cost of external finance remained elevated until firms had decreased indebtedness and their net worth had recovered. In other words, it was the deleveraging process of firms that led to the persistent weakness in investment activities.

We conclude that our model is able to tell the story of the Finnish boom-bust cycle in a DSGE framework where the balance sheet constrained firms play a key role. Our model is particularly successful in explaining the role of financial factors and in reproducing quantitatively the behaviour of investment activities and output during the boom-bust cycle. However, several questions are left for future research. For example, more work is needed to capture more accurately the behaviour of private consumption during both the boom and the bust phase. This may involve assessing the role of downward wage rigidities that are known have been a key feature of the Finnish economy at the time. Several important questions remain about the role of economic policies at the time. For example, one could ask whether the boom-bust cycle could have been mitigated by appropriate economic policies. The decline of the real economy was followed by a large-scale banking crises deepening in 1992 and contributing to the severity of the crises. The additional negative impact of the banking crises should also be assessed. In this paper, we calibrate the degree of financial frictions necessary to explain the dynamics of the boom-bust cycle in Finland. Further work could thus include estimating the model to study the strength of the financial accelerator mechanism at the time and the role of the various shocks.

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Appendix

Table 1. Calibrated parameter values for the Finnish economy

Symbol	Definition	Value
β	discount factor	0.99
θ	final goods elasticity of substitution	6
δ	capital depreciation rate	0.05
η	weight on leisure in the utility function	4.2
α	the share of capital in production function	0.45
ψ	the elasticity of external finance premium with respect to firm leverage	0.05
ν	survival rate of entrepreneurs	0.9728
G	steady state external finance premium	1.0075
k/n	steady state ratio of capital to net worth	2.1
Π	steady state gross inflation rate	1.01
b	habit persistence parameter	0.7
χ	investment adjustment cost parameter	4
ρ	intratemporal elasticity of substitution between consumption of domestic and foreign goods	1.5
ω	the share of domestic goods in the consumption composite	0.45
ω^d	the share of firm debt in domestic currency	0.73
ϕ	the sticky price parameter/probability of keeping prices fixed	0.75
ζ	the price elasticity of export demand	1
τ	the share parameter of export demand	0.25
κ	the elasticity of country borrowing premium with respect to net foreign indebtedness	0.001
ξ^u	the elasticity of marginal depreciation with respect to the utilization rate	1
ϱ_π	Taylor rule coefficient on inflation	1.5
ϱ_y	Taylor rule coefficient on ouput gap	0.1
ϱ_s	Taylor rule coefficient on nominal exchange rate	0.5
ρ^R	Monetary policy smoothing parameter	0.8

Table 2. Implied steady state relatioships

	Data (1980:1–1998:4)	model
$\frac{k}{y}$	4.6	5.5
$\frac{i}{y}$	0.28	0.28
$\frac{c}{y}$	0.79	0.72
$\frac{c^F}{y}$	0.36	0.35
$\frac{c^{H*}}{y}$	0.34	0.35
$\frac{c^H}{y}$	0.38	0.37
$\frac{wh}{y}$	0.54	0.46

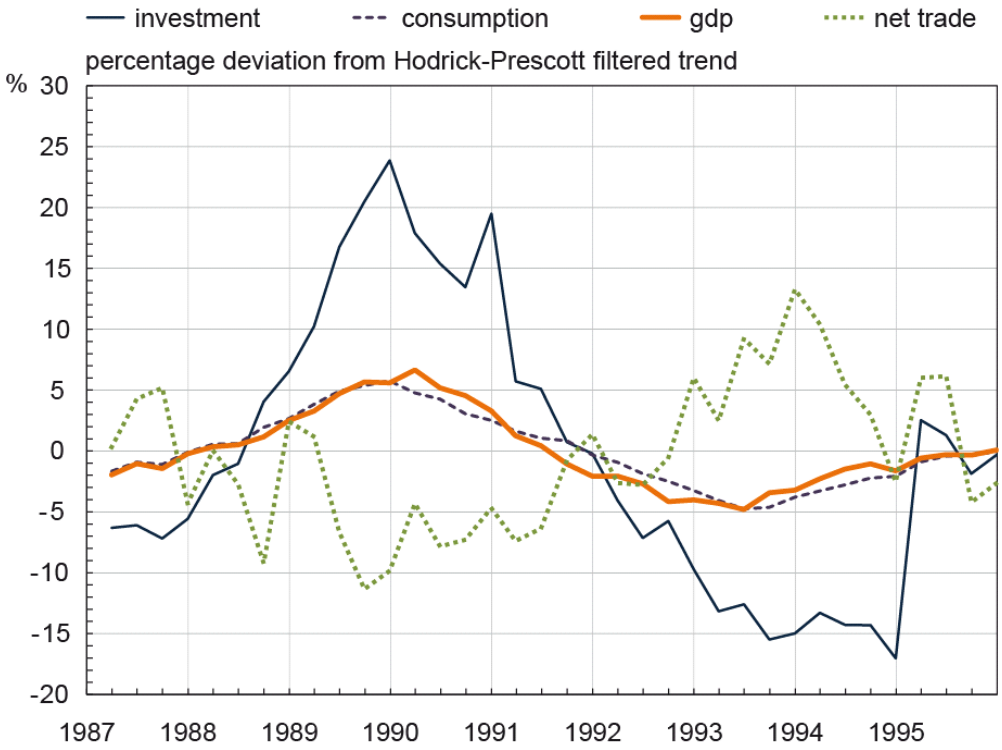

Figure 1: Data on the boom-bust episode

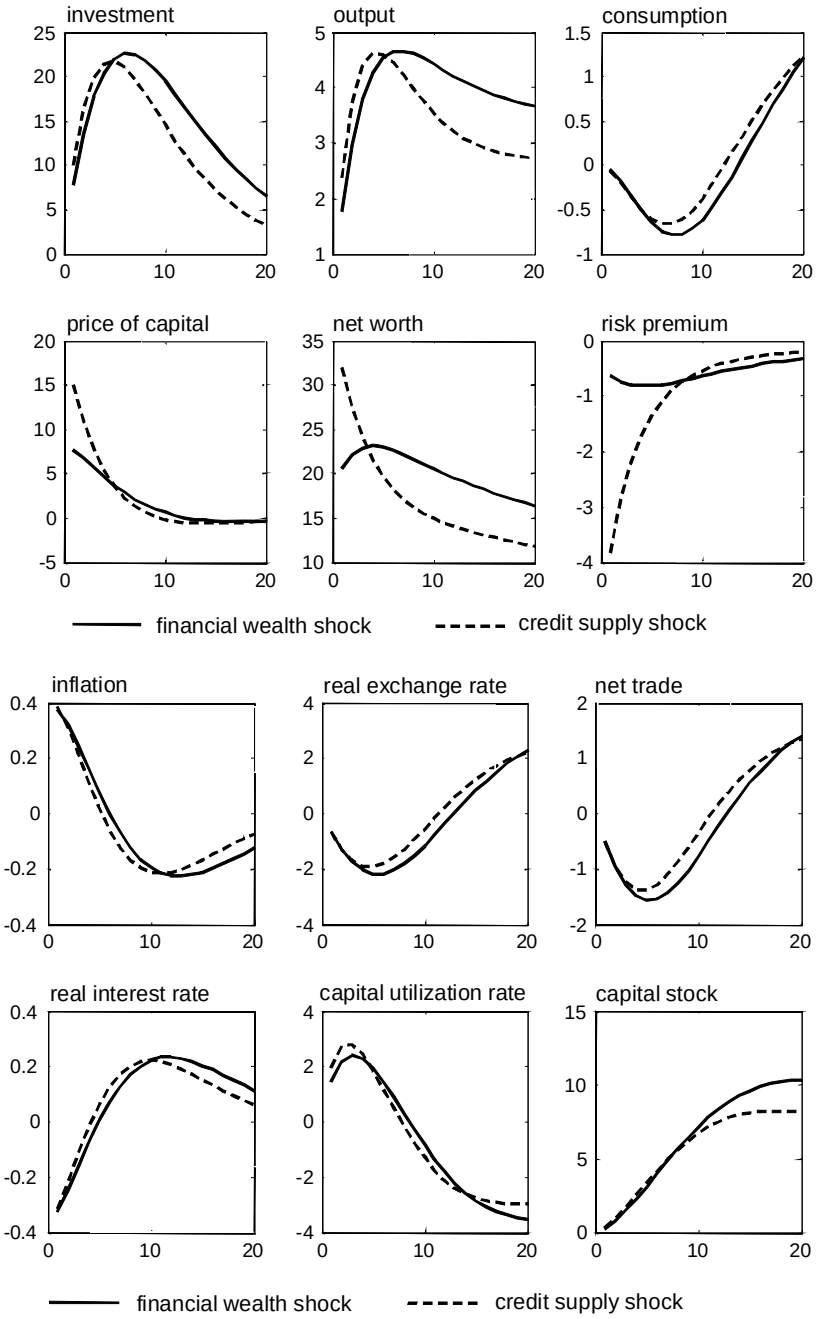

Figure 2: Boom: financial market deregulation (credit supply (dotted line) vs financial wealth (solid line) shock)

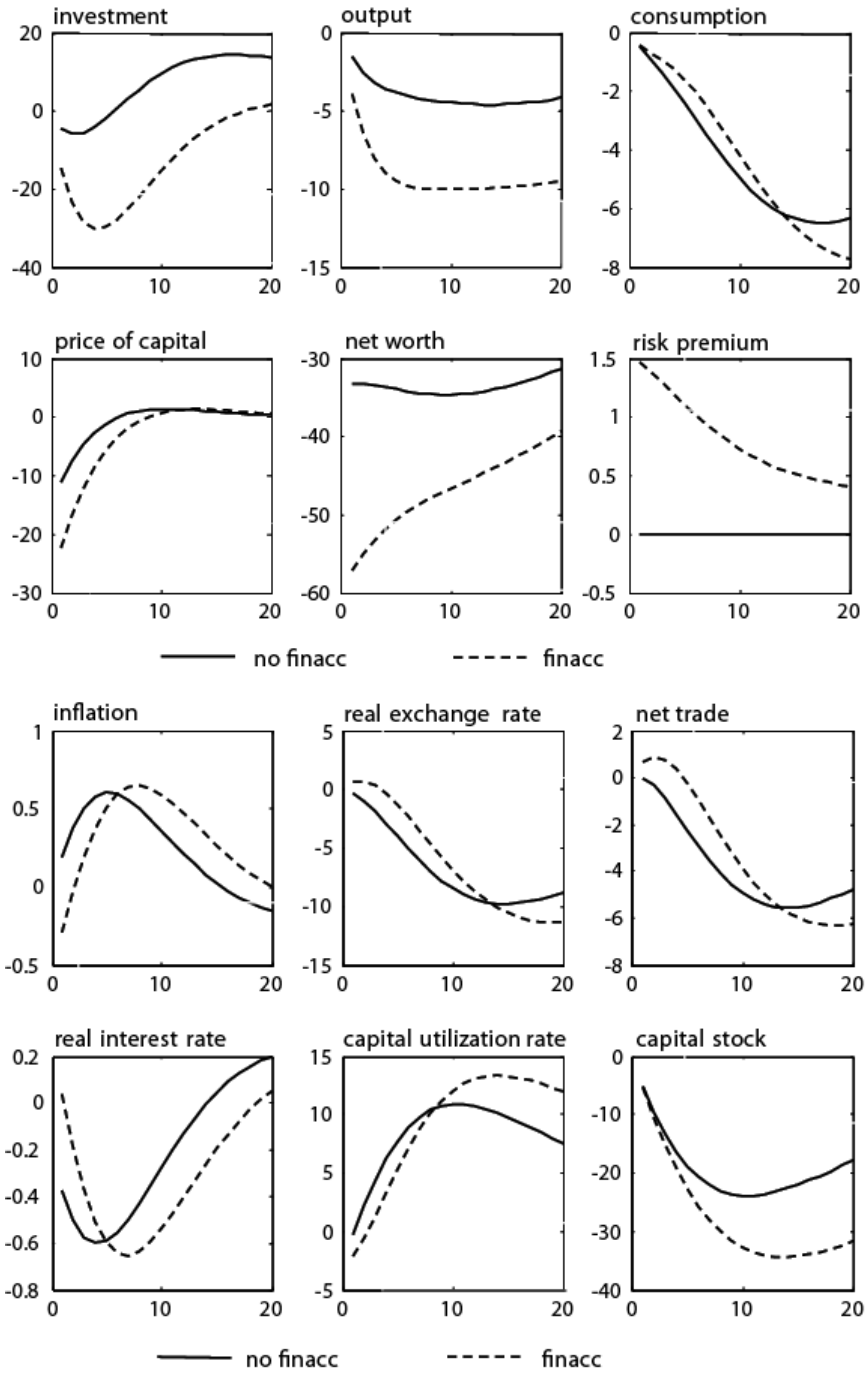

Figure 3: Bust: Collapse of Soviet trade (capital obsolescence shock with (dotted line) and without (solid line) financial accelerator)

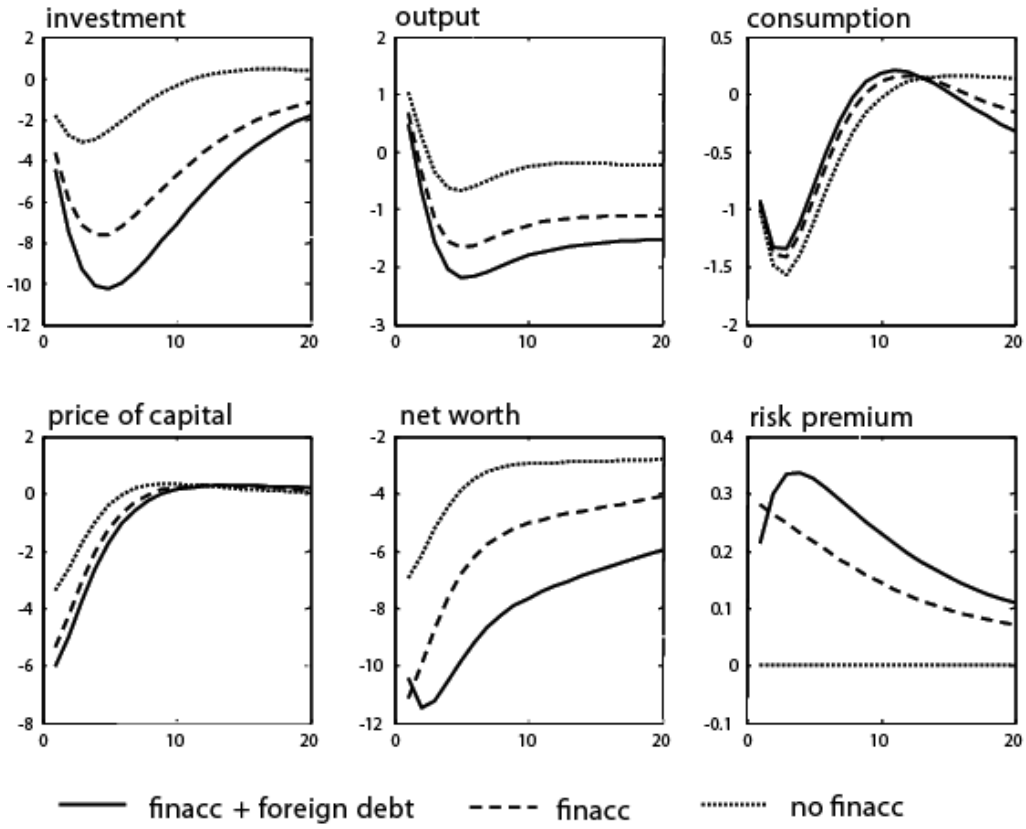

Figure 4: Bust: Collapse of fixed exchange rate regime (A country borrowing premium shock without financial accelerator (dotted line), with financial accelerator but only domestic debt (dashed line), with financial accelerator and 27% foreign debt (solid line))

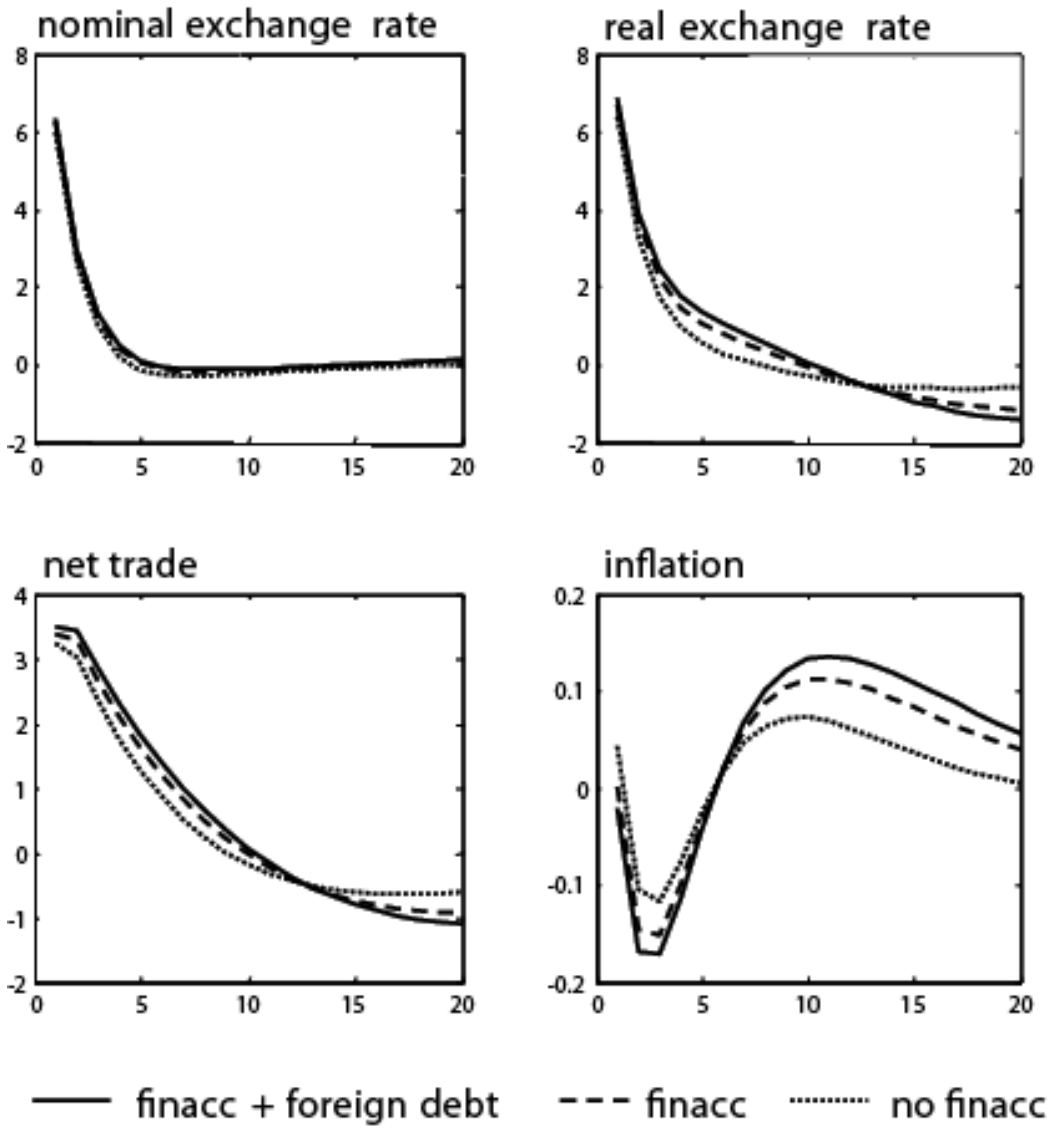

Figure 5: Bust: Collapse of fixed exchange rate regime (A country borrowing premium shock without financial accelerator (dotted line), with financial accelerator but only domestic debt (dashed line), with financial accelerator and 27% foreign debt (solid line))

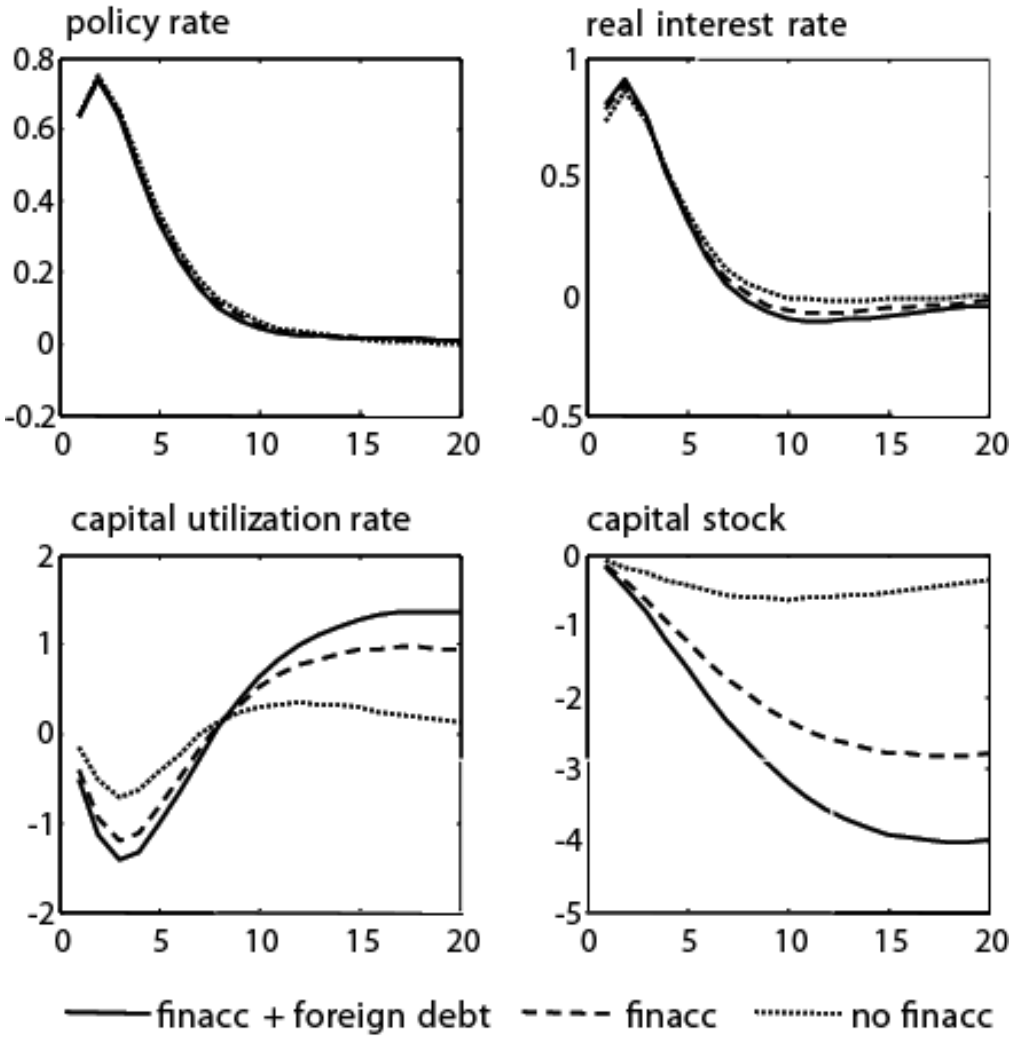

Figure 6: Bust: Collapse of fixed exchange rate regime (A country borrowing premium shock without financial accelerator (dotted line), with financial accelerator but only domestic debt (dashed line), with financial accelerator and 27% foreign debt (solid line))

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