ONLINE APPENDIX: INTEREST-RATE LIBERALIZATION AND CAPITAL MISALLOCATIONS

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ABSTRACT. This appendix provides details about the data and the calibration, and also some additional empirical results in Liu et al. (2019).

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Appendix A. Data and calibration approach

A.1. **The data.** We use the Annual Survey of Industrial Firms conducted by China's National Bureau of Statistics for calibrating the model parameters and examining the model's empirical implications. The survey data cover all the state-owned firms and non-state firms with sales above 5 million RMB. We clean up the sample by discarding some observations with extreme or implausible values. Table B.1 reports some summary statistics of our sample. The data moments reported here are broadly consistent with those in the literature (Brandt et al., 2012).

A.2. **Calibrating the SOE subsidy parameter.** We calibrate the SOE subsidy parameter $\tilde{\tau}^s$ in the model based on the measured firm-level output wedges observed in China's Annual Survey of Industrial Firms data.

We normalize the POE wedge to $\tilde{\tau}^p = 1$. We then calibrate the relative SOE wedge $\tilde{\tau}^s$ based on firms' optimizing decisions. Denote by y^j_{mit} and n^j_{mit} the output and the labor input of firm i in industry m and year t, with the ownership type $j \in \{s, p\}$. The firm's optimizing labor input decision implies that

$$\tilde{\tau}^j = \frac{W_t n^j_{mit}}{(1-\alpha)\eta y^j_{mit}}, \tag{A.1}$$

where W_t denotes the real wage rate. Given our calibration of the production function parameters of $\alpha = 0.5$ and $\eta = 0.85$, we can construct an output wedge for each firm using the firm-level observations of wage payments and value added.

After obtaining the firm-level output wedges, we compute the industry-level output wedges for each sector $j \in \{s, p\}$. In particular, the industry-level output wedge for industry m and sector j (denoted by $\bar{\tau}^j_{mt}$) is given by

$$\bar{\tau}^j_{mt} = \frac{1}{N^j_{mt}} \sum_i \mathbf{1}^j_i \times \tilde{\tau}_{mit}, \quad j \in \{s, p\},$$

where N^j_{mt} denotes the number of firms in industry m, sector j, and year t; and $\mathbf{1}^j_i$ is an indictor that equals one if and only if firm i belongs to sector j.

The economy-wide relative SOE output wedge is then given by

$$\tilde{\tau}^s_t \equiv \frac{1}{M_t} \sum_m \frac{\bar{\tau}^s_{mt}}{\bar{\tau}^p_{mt}},$$

where M_t is the number of industries in year t.

The first column in Table B.2 reports $\tilde{\tau}^s_t$ for the year from 1998 to 2007. In our calibration, we use the average value of $\tilde{\tau}^s_t$ over time to calibrate $\tilde{\tau}^s$ in our quantitative model, leading to the calibrated value of $\tilde{\tau}^s = 1.44$.

A.3. **Borrowing Capacity.** The borrowing capacity in our model is captured by the parameters θ^j, $j \in \{s, p\}$, corresponding to the loan-to-value (LTV) ratio. We measure the firm-level LTV by the ratio of long-term liabilities (LTL) to the value of the firm's fixed assets (FA). In particular, the LTV for firm i in industry m and year t is given by $LTV_{mit} = \frac{\mathrm{LTL}_{mit}}{\mathrm{FA}_{mit}}$.[1]

We then calculate the industry-level leverages by averaging the LTVs across firms within each industry for each ownership type (SOE or POE). In particular, for industry m in year t, the leverage for sector $j \in \{s, p\}$ is given by

$$LTV_{mt}^j = \frac{1}{N_{mt}^j} \sum_i LTV_{mit}^j, \quad j \in \{s, p\}. \tag{A.2}$$

At the aggregate level, the leverage of sector j is given by

$$LTV_t^j = \frac{1}{M_t} \sum_m LTV_{mt}^j, \quad j \in \{s, p\}, \tag{A.3}$$

where M_t denotes the number of industries in year t. Table B.2 (Column 3 and 4) report the leverage for POE and SOE sectors for each year from 1998 to 2007. Taking the average across time, we obtain $\theta^p = 0.28$ and $\theta^s = 0.50$.

A.4. **Productivity Measurement.** We follow Midrigan and Xu (2014) to calibrate firm-level TFP based on the production function, using data on capital and labor inputs and value-added output. In particular, the production function for firm i in industry m takes Cobb-Douglas form,

$$y_{mit} = \left[\left(z_{mit} k_{mit} \right)^{\alpha} l_{mit}^{1-\alpha} \right]^{\eta}$$

where y_{mit} denotes output, k_{mit} and l_{mit} denote the inputs of capital and labor, respectively, and z_{mit} denotes the firm-level TFP. The parameter $\alpha \in (0, 1)$ denotes the capital share and η measures the returns to scale. We assume that all the firms face the same production function parameters, which are calibrated at $\alpha = 0.5$ and $\eta = 0.85$. The production function implies that the firm-level TFP is given by

$$z_{mit}^j = \left[\frac{y_{mit}^j}{\left(k_{mit}^j \right)^{\alpha\eta} \left(l_{mit}^j \right)^{(1-\alpha)\eta}} \right]^{\frac{1}{\alpha\eta}}, \tag{A.4}$$

where we measure the firm's output by value added, capital input by the value of fixed assets, and labor input by its employment size.

[1]There are two reasons to use the long-term liability to construct the leverage ratio. First, the loan in our model is inter-temporal and one period corresponds to one year. Second, in China's Annual Survey of Industrial Firms, most of the short-term liabilities are trade credits (accountable payables), which is not captured in our model.

After obtaining the firm-level TFP, we can compute the industry-level TFP for each sector $j \in \{s, p\}$ using the relation

$$\bar{z}_{mt}^{j} = \frac{1}{N_{mt}^{j}} \sum_{i} \mathbf{1}_{mit}^{j} \times z_{mit}$$

where $\bar{z}_{mt}^{j}$ denotes the industry-level TFP for industry m in sector j, N_{mt}^{j} denotes the number of firms in industry m, sector j, and year t, and the indicator function $\mathbf{1}_{mit}^{j}$ equals one if and only if firm i in industry m belongs to sector $j \in \{s, p\}$. A firm's idiosyncratic component of productivity can then be measured by $\frac{z_{mit}^{j}}{\bar{z}_{mt}^{j}}$.

Denote by $\bar{z}_{mt} = \frac{1}{N_{mt}} \sum_{i} z_{mit}$ the average TFP across all firms in industry m, regardless of their ownership type (i.e., SOE or POE). We compute the economy-wide average TFP for j-type firms $\bar{z}_{t}^{j}$ as the average of the scaled industry-level TFP. In particular, TFP for j-type firms is given by

$$\bar{z}_{t}^{j} = \frac{1}{M_t} \sum_{m} \frac{\bar{z}_{mt}^{j}}{\bar{z}_{mt}}, \quad j \in \{s, p\}.$$

Column 1 in Table B.3 shows the relative TFP of the POE sector (i.e. the ratio $\frac{\bar{z}_{t}^{p}}{\bar{z}_{t}^{s}}$ for each year. Averaging across time, we obtain the calibrated value of the relative TFP for the POE sector $\frac{z^{p}}{z^{s}} = 1.914$.

To calibrate the value of $\frac{\sigma^{p}}{\sigma^{s}}$ in the model, we first compute the standard deviation of $\frac{z_{mi}^{j}}{\bar{z}_{m}^{j}}$ for each industry m (i.e., σ_{m}^{j}). Then we compute the mean of the ratio $\frac{\sigma_{m}^{p}}{\sigma_{m}^{s}}$ over all of the industries in each year, i.e., $\frac{1}{M} \sum_{m} \frac{\sigma_{m}^{p}}{\sigma_{m}^{s}}$. Column 2 in Table B.3 reports the results. Finally, we compute the mean of $\frac{1}{M} \sum_{m} \frac{\sigma_{m}^{p}}{\sigma_{m}^{s}}$ over time to obtain the calibrated value of $\frac{\sigma^{p}}{\sigma^{s}} = 1.23$.

We then calibrate the level of σ^{s} so that the model matches the average share of borrowers in the SOE sector (of 39%). This implies the calibrated value of $\sigma^{s} = 0.375$. It follows that $\sigma^{p} = 1.23\sigma^{s} = 0.461$.

Appendix B. Additional quantitative and empirical results

B.1. **A one-sector counterfactual.** In the paper, we have compared our model's implications for the transition dynamics and welfare to two counterfactuals: one with SOE subsidies removed, and the other with equal credit access for SOEs and POEs. We now consider an alternative counterfactual that corresponds to the one-sector model in the literature (Moll, 2014). In this one-sector model, there is no SOE subsidy and the two sectors face an identical credit limit and identical distributions of idiosyncratic shocks. We calibrate the parameters in the financial frictions and shock distributions by taking the average values of the sector-specific parameters $\{\theta^{j}, \sigma^{j}, z^{j}\}$ in our baseline calibration.

Figure B.1 shows the transition dynamics in the one-sector model following an interest-rate liberalization. When the interest-rate wedge is removed, both TFP and aggregate output increase monotonically, unlike the baseline model where there is a small initial decline in both variables. Figure B.2 shows that, unlike the baseline model which predicts that interest-rate liberalization may reduce welfare, the one-sector model predicts that the liberalization reform improves welfare unambiguously. These results are in line with the literature (Moll, 2014).

B.2. **Additional empirical results.**

B.2.1. *Time fixed effect.* In the baseline empirical specification, the regressors include changes in the interest-rate wedge ($\Delta\phi_t$) and its interaction with the distortion dummy (i.e., $D_{mt} \times \Delta\phi_t$). We now consider an alternative empirical specification, which includes time fixed effects. Under this specification, we cannot separately identify the effects of $\Delta\phi_t$, but we can still identify the effects of the interaction term.

Table B.4 reports the results for the estimation with time fixed effect. The estimated coefficient on the interaction term (1.278) is large and significant, implying that a one percentage point reduction in the interest-rate wedge would lower productivity growth in an industry with distorted allocations by about 1.28 percentage points. In comparison, our baseline specification suggests a modestly smaller effect (0.92 vs. 1.28).

B.2.2. *Alternative TFP thresholds for measuring distortions.* In the baseline regression, we construct the distortion dummy D_{mt} by comparing the 1% tails of TFP for borrowing firms and autarkic firms. The 1% threshold might be noisy because of potential outliers. We now consider a larger percentile for TFPs (2.5%, 5%, or 10%) in constructing the distortion dummy. Table B.5 below reports the estimation results, which are similar to what we have obtained in the baseline regression.

B.2.3. *Measuring distortion using MPK dispersions.* A common measure of misallocation in the literature is the cross-sectional dispersion of the marginal product of capital (Hsieh and Klenow, 2009). We now re-estimate our empirical model by measuring the industry-level distortion (D_{mt}) using the dispersion in MPK across firms within the industry.

Table B.6 reports the estimation results. A larger dispersion of MPK indicates a more severe distortion. The table shows that, all else being equal, an industry with a greater dispersion in MPK also has lower productivity growth. Although reducing the interest-rate wedge boosts productivity on average, it reduces productivity in an industry with high MPK dispersion. The qualitative results are the same as those reported in the paper.

B.2.4. *Alternative definition of borrowers.* It is possible that firms might increase their leverage because they need to borrow after suffering losses. To take into account this possibility, we focus on firms that increase borrowing but also make profits. Table B.7 reports the estimation results. The results are similar to what we have obtain in the baseline regression reported in the paper.

Table B.1. Summary statistics of the firm-level data in China's Annual Survey of Industrial Firms

Year	Num of Firms	SOEs (%)	Value Added	Employment	Fixed Assets	Wages	Liabilities
1998	143,463	30.97	1.56	49.05	3.49	0.36	1.25
1999	142,705	28.48	1.69	46.58	3.68	0.37	1.28
2000	145,781	23.75	2.00	45.94	3.86	0.41	1.29
2001	155,566	18.05	2.26	45.54	4.08	0.47	1.22
2002	164,505	13.98	2.68	46.14	4.29	0.50	1.19
2003	179,871	9.77	3.44	48.63	4.76	0.59	1.20
2004	253,626	6.92	4.63	55.93	5.69	0.78	1.32
2005	249,270	4.71	5.78	58.88	6.58	0.93	1.43
2006	277,700	3.56	7.33	63.10	7.70	1.15	1.66
2007	311,796	2.28	9.49	68.29	9.10	1.51	1.89

Notes: The units of value added, fixed assets, wages, and liabilities are expressed in trillions of RMB. The unit of employment is in millions of workers. SOEs are defined based on the firms' registration types. Specifically, SOE firms are those of type "110","141", "143" and "151". The column "SOEs" shows the share of SOE firms as a fraction of all firms. The firms' liabilities are measured by their long-term debt (with maturities of one year or longer).

Table B.2. Output wedges and borrowing capacity

	Output Wedge	Borrowing Capacity	
Year	SOE/POE	POE	SOE
1998	1.51	0.41	0.49
1999	1.49	0.30	0.53
2000	1.48	0.34	0.49
2001	1.46	0.30	0.61
2002	1.46	0.41	0.66
2003	1.45	0.41	0.52
2004	1.42	0.23	0.52
2005	1.41	0.24	0.42
2006	1.43	0.19	0.42
2007	1.29	0.19	0.38
Average	1.44	0.28	0.50

Table B.3. The relative average productivity of POEs and the relative productivity dispersion

Year	Mean ($\frac{z^p}{z^s}$)	Dispersion ($\frac{\sigma^p}{\sigma^s}$)
1998	2.279	1.107
1999	2.312	1.107
2000	2.246	1.076
2001	2.087	1.216
2002	1.977	1.195
2003	1.932	1.249
2004	1.744	1.326
2005	1.617	1.278
2006	1.578	1.257
2007	1.367	1.297
Average	1.914	1.234

Table B.4. The impact of changes in the interest-rate wedge on labor productivity in the empirical model with time fixed effects

ΔY_{mt}	(1)
$D_{mt} \times \Delta\phi_t$	1.278^{**}
	(0.499)
D_{mt}	-0.108^{**}
	(0.048)
ΔK_{mt}	0.027
	(0.114)
ΔL_{mt}	-0.034
	(0.143)
LTV_{mt}	0.021
	(0.026)
ΔY_{mt-1}	-0.090
	(0.079)
Number of Observations	$2,806$
Number of Industrial Firms	476
Hansen test (p value)	0.531
AB test AR(1) (p value)	0.000
AB test AR(2) (p value)	0.352

Notes: This table reports the estimated impact of changes in the interest-rate wedge (denoted by $\Delta\phi_t$) on industry-level labor productivity using data from the Chinese Industrial Surveys. The empirical specification differs from the baseline specification (in Eq. (64) in the text) by including time fixed effects (and accordingly, dropping the term $\Delta\phi_t$). We estimate the dynamic panel model using the Arellano and Bond (1991) approach, with the instrumental variables including the control variables and lags of the dependent variable. The control variables include the industry's average leverage (LTV_{mt}) and the year-over-year growth rates of average fixed assets (ΔK_{mt}) and employment (ΔL_{mt}). The variable D_{mt} is a distortion dummy, which equals one if the average TFP of the bottom one percentile borrowing firms is lower than that of the bottom one percentile of autarkic firms. An autarkic firm has a year-over-year change in its loan-to-value ratio of less than 1% (in absolute value). A borrowing firm has its loan-to-value ratio increased by at least 1% from the previous year. The numbers in the parentheses are robust standard errors. The statistical significance levels are denoted by * (p<0.1), ** (p<0.05), and *** (p<0.01).

Table B.5. The impact of changes in the interest-rate wedge on labor productivity (alternative TFP thresholds for constructing the distortion dummy D_{mt})

ΔY_{mt}	(1)	(2)	(3)
$\Delta\phi_t$	-0.750^{***}	-0.643^{**}	-0.803^{**}
	(0.237)	(0.266)	(0.357)
$D_{mt} \times \Delta\phi_t$	0.882^{**}	0.730^{*}	0.954^{*}
	(0.364)	(0.378)	(0.505)
D_{mt}	0.064	0.077	0.097
	(0.051)	(0.049)	(0.074)
ΔK_{mt}	0.165^{*}	0.120	0.074
	(0.098)	(0.110)	(0.152)
ΔL_{mt}	−0.059	0.027	0.039
	(0.129)	(0.129)	(0.141)
LTV_{mt}	−0.037	−0.034	−0.042
	(0.029)	(0.027)	(0.036)
ΔY_{mt-1}	0.043	0.022	0.010
	(0.069)	(0.070)	(0.072)
Number of Observations	3,104	3,175	3,191
Number of Industrial Firms	485	488	488
Hansen test (p value)	0.203	0.125	0.549
AB test AR(1) (p value)	0.000	0.000	0.000
AB test AR(2) (p value)	0.214	0.187	0.237

Notes: This table reports the estimated impact of changes in the interest-rate wedge (denoted by $\Delta\phi_t$) on industry-level labor productivity using data from the Chinese Industrial Surveys. The empirical model is specified in Eq. (64) in the text. We estimate the dynamic panel model using the Arellano and Bond (1991) approach, with the instrumental variables including the control variables and lags of the dependent variable. The control variables include the industry's average leverage (LTV_{mt}) and the year-over-year growth rates of average fixed assets (ΔK_{mt}) and employment (ΔL_{mt}). The variable D_{mt} is a distortion dummy, which equals one if the average TFP of the bottom x percentile borrowing firms is lower than that of the bottom x percentile of autarkic firms, where $x \in \{2.5, 5, 10\}$, corresponding to Columns (1), (2), and (3). An autarkic firm has a year-over-year change in its loan-to-value ratio of less than 1% (in absolute value). A borrowing firm has its loan-to-value ratio increased by at least 1% from the previous year. The numbers in the parentheses are robust standard errors. The statistical significance levels are denoted by * (p<0.1), ** (p<0.05), and *** (p<0.01).

TABLE B.6. The impact of changes in the interest-rate wedge on labor productivity (using MPK dispersion to measure distortion)

ΔY_{mt}	(1)	(2)
$\Delta\phi_t$	-0.532^{***}	-0.550^{***}
	(0.201)	(0.187)
$D_{mt} \times \Delta\phi_t$	0.096^{**}	0.100^{**}
	(0.045)	(0.041)
D_{mt}	-0.064^{**}	-0.097^{*}
	(0.029)	(0.050)
ΔK_{mt}	0.184	0.226^{*}
	(0.115)	(0.123)
ΔL_{mt}	-0.070	-0.117
	(0.129)	(0.130)
LTV_{mt}	-0.006	-0.008
	(0.021)	(0.023)
MPK_{mt}	0.119^{***}	0.096^{***}
	(0.036)	(0.033)
ΔY_{mt-1}	-0.007	-0.007
	(0.068)	(0.074)
Number of Observations	$3,189$	$3,189$
Number of Industrial Firms	487	487
Hansen test (p value)	0.188	0.144
AB test AR(1) (p value)	0.000	0.000
AB test AR(2) (p value)	0.344	0.402

Notes: This table reports the estimated impact of changes in the interest-rate wedge (denoted by $\Delta\phi_t$) on industry-level labor productivity using data from the Chinese Industrial Surveys. The empirical model is specified in Eq. (64) in the text. We estimate the dynamic panel model using the Arellano and Bond (1991) approach, with the instrumental variables including the control variables and lags of the dependent variable. The control variables include the industry's average leverage (LTV_{mt}), the year-over-year growth rates of average fixed assets (ΔK_{mt}), employment (ΔL_{mt}), industry average of firm level marginal product of capital (MPK_{mt}). The variable D_{mt} is an indicator for distorted allocations. In Column (1), D_{mt} is measured by the standard deviation of firm-level marginal product of capital within each industry. In Column (2), D_{mt} is a dummy variable which equals one if the standard deviation of firm-level marginal product of capital within each industry is above the median value of all industries. The numbers in the parentheses are robust standard errors. The statistical significance levels are denoted by * ($p<0.1$), ** ($p<0.05$), and *** ($p<0.01$).

Table B.7. The impact of changes in the interest-rate wedge on labor productivity (alternative definition of borrower)

ΔY_{mt}	(1)	(2)	(3)	(4)
$\Delta\phi_t$	-0.293^{**}	-0.346^{***}	-0.287^{***}	-0.514^{***}
	(0.120)	(0.090)	(0.105)	(0.156)
$D_{mt} \times \Delta\phi_t$	0.802^{*}	0.944^{***}	0.678^{**}	1.106^{***}
	(0.463)	(0.360)	(0.329)	(0.358)
D_{mt}	0.022	0.042	0.092	0.124
	(0.071)	(0.053)	(0.057)	(0.088)
ΔK_{mt}	0.196	0.224	0.124	0.061
	(0.141)	(0.138)	(0.159)	(0.203)
ΔL_{mt}	0.005	-0.032	0.029	0.039
	(0.156)	(0.151)	(0.166)	(0.199)
LTV_{mt}	-0.051	-0.031	-0.026	-0.023
	(0.045)	(0.029)	(0.027)	(0.079)
ΔY_{mt-1}	0.022	0.071	0.029	0.052
	(0.063)	(0.077)	(0.072)	(0.102)
Number of Observations	3,130	3,179	3,185	3,187
Number of Industrial Firms	487	487	487	487
Hansen test (p value)	0.332	0.586	0.388	0.457
AB test AR(1) (p value)	0.000	0.000	0.000	0.001
AB test AR(2) (p value)	0.214	0.154	0.188	0.177

Notes: This table reports the estimated impact of changes in the interest-rate wedge (denoted by $\Delta\phi_t$) on industry-level labor productivity using data from the Chinese Industrial Surveys. The empirical model is specified in Eq. (64) in the text. We estimate the dynamic panel model using the Arellano and Bond (1991) approach, with the instrumental variables including the control variables and lags of the dependent variable. The control variables include the industry's average leverage (LTV_{mt}) and the year-over-year growth rates of average fixed assets (ΔK_{mt}) and employment (ΔL_{mt}). The variable D_{mt} is a distortion dummy, which equals one if the average TFP of the bottom x percentile borrowing firms is lower than that of the bottom x percentile of autarkic firms. Columns (1)-(4) report the results for $x \in \{1, 2.5, 5, 10\}$, respectively. An autarkic firm has a year-over-year change in its loan-to-value ratio of less than 1% (in absolute value). A borrowing firm has its loan-to-value ratio increased by at least 1% from the previous year and has a positive profit. The numbers in the parentheses are robust standard errors. The statistical significance levels are denoted by * (p<0.1), ** (p<0.05), and *** (p<0.01).

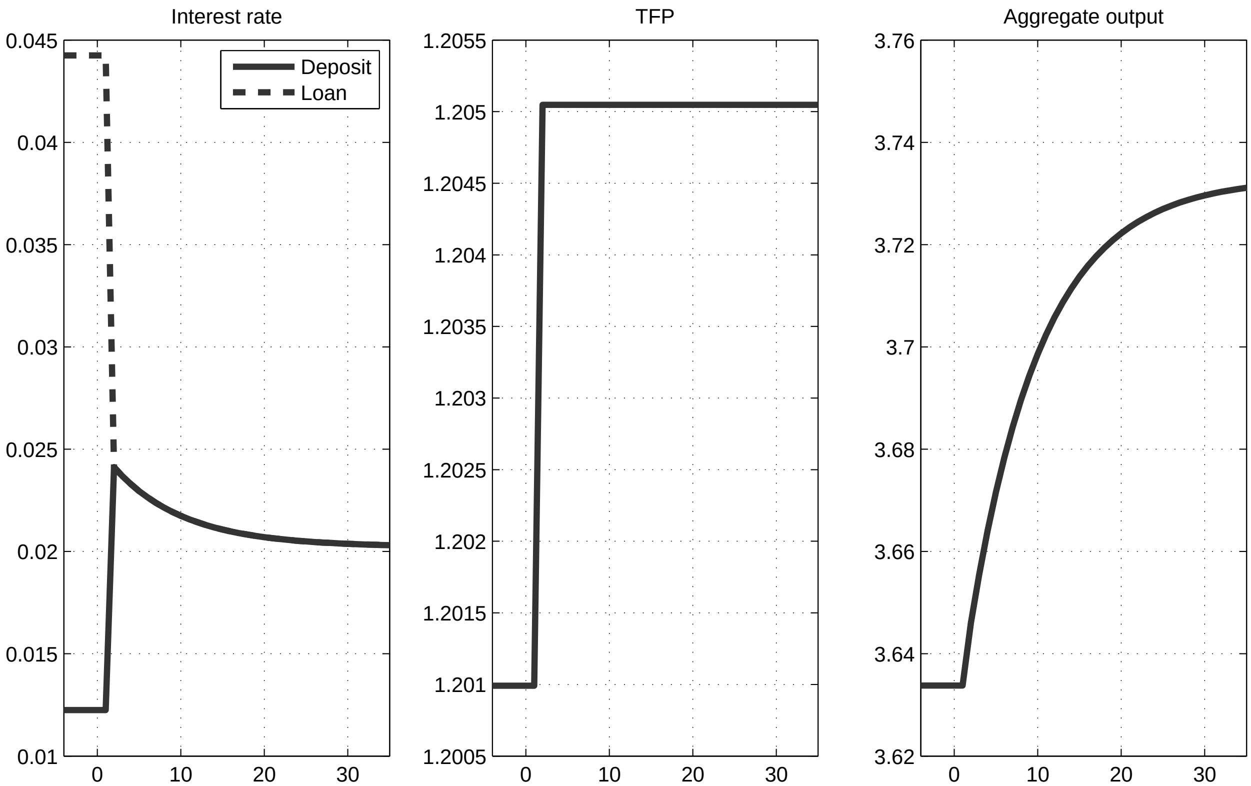

Figure B.1. Transition dynamics following interest-rate liberalization in the standard one-sector model

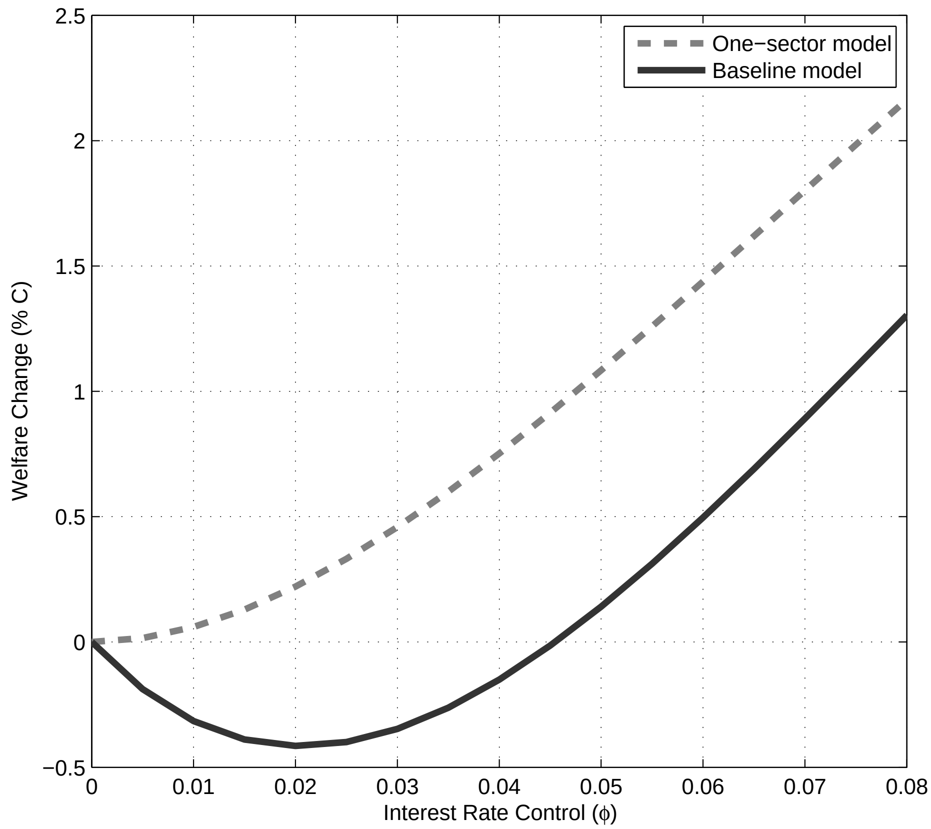

FIGURE B.2. Welfare effects of interest-rate liberalization during the transition process in the one-sector model (dashed line) vs. the baseline model (solid line). Welfare is measured by consumption equivalence. A point on the line represents the welfare gain (or loss) when the initial interest-rate wedge (ϕ) is removed.

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