Intermediate Goods and Exchange Rate Disconnect

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Preliminary and Incomplete!!

Abstract

This paper introduces intermediate goods trade into a two-country real business cycle model and examines how intermediate goods trade affects the behavior of the real exchange rate. Intermediate goods trade is shown to reduce "exchange rate disconnect" by increasing the volatility of the real exchange rate relative to output and reducing the correlation between the real exchange rate and the trade balance. Intermediate goods trade also raises international output correlations.
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1 Introduction

One of the longstanding puzzles in international macroeconomics is what Obstfeld and Rogoff (2001) describe as the "remarkably weak short-term feedback links between the exchange rate and the rest of the economy." The high volatility of real exchange rates relative to GDP is one significant aspect of this "exchange rate disconnect" puzzle.

This paper investigates whether trade in intermediate goods can help explain this puzzle. The production structure of a two-country real business cycle model is extended to incorporate intermediate goods. Doing so raises the volatility of the real exchange rate relative to output and reduces the correlations between the real exchange rate and the trade balances as well as relative output. These effects are stronger when the elasticity between domestically-produced and imported intermediate goods is lower.

This paper focuses on a real aspect of economic structure in accounting for exchange rate disconnect. Other real factors that have been studied in relation to this puzzle include distribution costs (Burstein et al. (2003), Corsetti et al. (2008)) and costs of reallocating resources between traded and non-traded goods sectors (Craighead, (2008)). Although money and nominal rigidities are absent from this paper, the hypothesis may be considered complementary to alternative explanations of exchange rate disconnect which focus on price stickiness and exchange rate pass through, such as Devereux and Engel (2002).

This paper adds to a growing literature on trade in intermediate goods. The growing importance of "vertical specialization" in the world economy has been widely noted and is documented by Hummels et al. (2001) and Johnson (2014) among others.

A small but growing number of papers have integrated intermediate goods trade into international business cycle models. Ambler et al. (2002) incorporate intermediate goods into a two-country RBC model and find that their model is better able to match international output correlations, but they attribute this to the presence of multiple sectors and investment adjustment costs rather than intermediate goods trade. Several of these papers have examined whether trade in intermediate goods trade can help match the empirical observation that business cycle fluctuations are more correlated among countries with greater trade. Kose and Yi (2001) find that vertical specialization does little to improve the ability of a two-country RBC model to match output correlations. In a model with multi-stage production and firm heterogeneity, Arkolakis and Ramanarayanan (2009), find that intermediate goods trade alone does little to increase predicted comovement, but extending the model to include imperfect competition is beneficial in this regard. Johnson (2014) builds a multicountry model with intermediate goods trade and finds that its ability to match international comovements is limited. However, Burstein et al. (2008) find that production sharing trade through vertically integrated multinationals with foreign affiliates can help explain business cycle synchronization.

Intermediate goods trade has also been considered in sticky price models. In a two-country model with multistage production Huang and Liu (2007) find that intermediate goods trade leads to a larger and more persistent response of the real exchange rate to a monetary shock. They find that intermediate goods trade raises international output correlation, but only modestly increases the volatility of the real exchange rate. Lombardo and Ravenna (2014) investigate optimal monetary policy for a small open economy with intermediate goods trade.

2 Background

Exchange rate disconnect is evident in the high volatility of the real exchange rate compared to output. The table below[1] reports the standard deviations of the percentage rates of change in the real effective exchange rate, the real exchange rate vs. the US, the terms of trade, the trade balance as a share of GDP (change rather than percentage change) and real GDP for the G-7 and Euro area as a whole.

Standard Deviations

	Canada	France	Germany	Italy	Japan	UK	US	Euro Area
REER	9.77	19.03	5.28	3.90	19.84	12.04	11.03	9.98
RER vs US	12.12	18.94	17.90	16.98	19.64	19.19	-	16.88
ToT	6.92	4.27	3.31	5.15	9.65	4.58	5.32	2.48
NX/GDP	3.01	1.61	2.64	1.85	1.78	2.51	1.16	1.29
GDP	2.94	1.96	3.40	2.96	4.32	2.62	2.80	2.45

Both the REER and RER vs. the US are considerably more volatile than the trade balance or real GDP for all of the countries and the Euro area. The terms of trade is less volatile, but still has a higher standard deviation than real GDP and the trade balance in most cases.

Weak correlations between the real exchange rate and output and trade balances are another aspect of exchange rate disconnect. The table below shows the correlations between real GDP growth and changes in the REER, RER vs. US and ToT for the G-7 and Euro area.

[1] The Real Effective Exchange Rate is the BIS narrow measure; all other data are from the OECD. Annualized values of quarterly data. For Canada, France, the UK and US, the sample is 1981Q1-2014Q4; for Germany, 1991Q1-2014Q4; Japan, 1994Q1-2014Q4; Italy 1996Q1-2014Q4; Euro area, 1995Q1-2013Q3.

Correlations with GDP

	Canada	France	Germany	Italy	Japan	UK	US	Euro Area
REER	0.01	-0.10	-0.15	-0.11	-0.25	0.03	-0.15	-0.12
RER vs US	0.11	0.06	0.07	0.06	-0.13	0.09	-	0.07
ToT	0.24	-0.13	-0.37	-0.51	-0.47	-0.09	-0.11	-0.46

The absolute correlations of the REER and RER vs. US with GDP are all 0.25 or less, while the correlations of the terms of trade with GDP are somewhat higher (but still less than 0.5 in all but one case).

The table below reports the correlations between the changes in the NX/GDP ratio and changes in the REER, RER vs. US and ToT.

Correlations with $\frac{\text{NX}}{\text{GDP}}$

	Canada	France	Germany	Italy	Japan	UK	US	Euro Area
REER	0.02	0.02	0.18	0.21	-0.13	0.12	0.13	0.14
RER vs US	0.12	-0.05	0.23	0.08	-0.07	0.08	-	0.14
ToT	0.42	0.33	0.08	0.33	0.17	0.30	0.53	0.38

Correlations between changes in the real exchange rate measures and the trade balance are very small, while the terms of trade shows a somewhat stronger relationship with the trade balance.

3 Model

The model is a two-country RBC model of the type pioneered by Backus et al. (1992). The countries, labeled A and B, are symmetric. To minimize redundancy, the exposition below will focus on country A.

3.1 Technology

Each country has two sectors, an intermediate goods sector, denoted with M and a final goods sector, denoted with F. Country A's intermediate sector uses a Cobb-Douglas combination of inputs to produce an input for final goods production in both countries:

$$M_t^{A,A} + M_t^{A,B} = Z_t^{M,A} \left(K_t^{M,A}\right)^{\alpha} \left(N_t^{M,A}\right)^{1-\alpha} \tag{1}$$

where $M^{A,A}$ and $M^{A,B}$ denote intermediate goods produced in country A as inputs for final goods in countries A and B, respectively, K and N are capital and labor, and Z is a technology shifter.

Final goods are produced using intermediate goods as well as factor inputs. Intermediate goods are combined according to a constant elasticity of substitution aggregator,

$$X_t^A = \left[\omega^{\frac{1}{\psi}} \left(M_t^{A,A}\right)^{\frac{\psi-1}{\psi}} + (1-\omega)^{\frac{1}{\psi}} \left(M_t^{B,A}\right)^{\frac{\psi-1}{\psi}}\right]^{\frac{\psi}{\psi-1}} \tag{2}$$

where $M_t^{B,A}$ are intermediate goods produced in country B that are used in A, ψ is the elasticity of substitution between domestic and imported intermediates and ω is the weight on home intermediates. Capital and labor are combined according to a Cobb-Douglas function,

$$V^A = Z_t^{F,A} \left(K_t^{F,A}\right)^{\alpha} \left(N_t^{F,A}\right)^{1-\alpha} \tag{3}$$

and the final goods are produced by combining the factor and intermediate goods inputs,

$$Y_t^{F,A} = \left[\sigma^{\frac{1}{\mu}} \left(V_t^A\right)^{\frac{\mu-1}{\mu}} + (1-\sigma)^{\frac{1}{\mu}} \left(X_t^A\right)^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{\mu-1}} \tag{4}$$

where σ is the weight on factor inputs and μ is the elasticity of substitution between factors and intermediate goods inputs.

The final good is used for consumption in both countries and investment in both domestic sectors,

$$Y_t^{F,A} = C_t^{A,A} + C_t^{A,B} + I_t^A \tag{5}$$

where $C_t^{A,A}$ and $C_t^{A,B}$ are consumption of country A's final good in country A and B, respectively and I^A is total investment in country A capital.

Two different assumptions on intersectoral capital mobility are considered: (i) mobile capital and (ii) immobile capital. In the mobile capital case, the total capital stock accumulates according to

$$K_{t+1}^A = (1-\delta)K_t^A - \frac{\nu}{2}\left(K_{t+1}^A - K_t^A\right)^2 + I_t^A \tag{6}$$

and in each period it is allocated optimally between sectors subject to the constraint $K_t^{M,A} + K_t^{F,A} = K_t^A$. For the immobile capital case, capital is sector-specific and accumulates according to

$$K_{t+1}^{j,A} = (1-\delta)K_t^{j,A} - \frac{\nu}{2}\left(K_{t+1}^{j,A} - K_t^{j,A}\right)^2 + I_t^{j,A} \qquad j = F, M \tag{7}$$

where ν is an adjustment cost parameter, δ is the depreciation rate. Total investment is the sum of investment in intermediate and final goods sectors, i.e., $I_t^A = I_t^{M,A} + I_t^{F,A}$.

3.2 Preferences

The country A representative household of unit measure receives utility from consumption and disutility from labor. Its lifetime utility function is given by

$$U^A = \mathrm{E}\sum_{t=0}^{\infty}\beta^t\left[\frac{\left(C_t^A\right)^{1-\gamma}}{1-\gamma} - \chi s^A\frac{\left(\widetilde{N}_t^{F,A}\right)^{1+\theta}}{1+\theta} - \chi(1-s^A)\frac{\left(\widetilde{N}_t^{M,A}\right)^{1+\theta}}{1+\theta}\right] \tag{8}$$

where s^A is the fraction of the household working in the final goods sector and $\widetilde{N}_t^{F,A}$ and $\widetilde{N}_t^{M,A}$ represent labor per worker in each sector. Total labor in the final goods sector is $N_t^{F,A} = s^A\widetilde{N}_t^{F,A}$ and $N_t^{M,A} = (1-s^A)\widetilde{N}_t^{M,A}$ in intermediate goods production. For the case of intersectorally mobile labor, s^A is treated as a choice variable; for the immobile labor case it is a constant. The household consumption bundle is comprised of domestically produced final goods, $C^{A,A}$, and imports of final goods produced in country B, $C^{B,A}$,

$$C_t^A = \left[\phi^{\frac{1}{\eta}}\left(C_t^{A,A}\right)^{\frac{\eta-1}{\eta}} + (1-\phi)^{\frac{1}{\eta}}\left(C_t^{B,A}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{9}$$

where η is the elasticity of substitution between domestic and imported goods and ϕ is a weighting parameter which can be though of as governing the degree of "home bias" in consumption.

3.3 Solution

The model is solved as a social planner's problem, where the planner maximizes the sum of the utility functions of the two representative households. The resulting system of equations is log-linearized and solved using Dynare (Adjemian et al. 2011). Because the model is solved as a planner's problem, relative prices - including the real exchange rate - are inferred from lagrange multipliers.

Productivity in each sector is assumed to be stochastic, with deviations from the steady state following an AR(1) process:

$$\widehat{Z}_t^{j,A} = \rho \widehat{Z}_{t-1}^{j,A} + \varepsilon_t^{j,A} \qquad \varepsilon_t^{j,A} \sim N(0, \sigma_\varepsilon^2) \qquad\qquad j = F, M \tag{10}$$

where $\widehat{Z}$ denotes the percentage deviation of productivity from its steady-state value.

Parameters are set at standard values in the literature:

Parameters

Parameter	Value	Description
β	0.95	Discount factor
γ	1.5	Inverse intertemporal elasticity of substitution
α	0.36	Capital share
χ	1	Weight on labor
δ	0.05	Depreciation
ν	0.5	Capital adjustment cost
ρ	0.9	Productivity autocorrelation
σ_ε	0.01	Std. dev. of productivity shocks
ϕ	0.75	Weight on home goods in consumption
η	2	Elasticity between domestic and imported consumption
μ	0.5	Elasticity between intermediate goods and factors
ψ	0.5	Elasticity between domestic and imported intermediates

The effect of intermediate goods trade is examined by varying ω, the weight on domestic intermediate goods. Increasing ω reduces the share of domestic value added in a country's exports (i.e., the share of imported intermediates that are re-exported rises). With $\omega = 0.95$, domestic value added is 97.8% of exports, decreasing to 88.7% when ω increases to 0.5 and 85.6% at $\omega = 0.05$.

4 Results

The table below reports selected moments generated by the model for the case where both capital and labor can freely move between sectors:

Model-Generated Results (Mobile Factors)

	ω		
	0.95	0.5	0.05
Std. dev. of output	2.18	1.92	1.72
Std. dev. of RER	1.92	3.23	3.65
Corr. Y^A, Y^B	-0.11	0.16	0.43
Corr. RER, $\frac{\text{NX}}{\text{Y}}$	-0.99	-0.99	-0.85

These results indicate that intermediate goods trade can help explain one important aspect of "exchange rate disconnect" - the high volatility of the real exchange rate relative to output. With $\omega = 0.95$, the standard deviation of the RER is lower than that of output, rising to 1.69 times that of output when $\omega = 0.5$ and 2.12 times when $\omega = 0.05$. Intermediate goods trade also reduces the linkage between the real exchange rate and trade balance, as shown by the decreasing correlation between the RER and $\frac{\text{NX}}{\text{Y}}$ when $\omega = 0.05$. Furthermore, intermediate goods trade increases the cross-country correlation of output.

Figures 1 and 2 report impulse response functions for the RER for positive technology shocks for both country B sectors. In general, shocks to the intermediate goods sector have larger effects on the real exchange rate than shocks in the final goods sector. For the final goods shock, the effect is increasing as ω decreases, while for the intermediate goods shock, the effect increases when ω falls from 0.95 to 0.5, but the initial effects are similar for the $\omega = 0.5$ and $\omega = 0.05$ cases, with the $\omega = 0.5$ case showing greater persistence.

To examine how intermediate goods trade interacts with the degree of flexibility in the economy, the intersectoral mobility of labor and capital are successively restricted. The table below provides model results for the case where capital is sector-specific, but labor is mobile between sectors:

Model-Generated Results (Mobile Factors)

	ω		
	0.95	0.5	0.05
Std. dev. of output	1.71	1.84	1.24
Std. dev. of RER	1.97	3.05	3.24
Corr. Y^A, Y^B	-0.40	-0.08	0.16
Corr. RER, $\frac{\text{NX}}{\text{Y}}$	-0.99	-0.98	-0.90

For this case as well, raising the share of imported intermediates (i.e., reducing ω) raises the volatility of the real exchange rate, increases the crosss-country correlation of output and slightly weakens the link between the real exchange rate and the trade balance. impulse response functions are reported in figures 1 and 2. Capital immobility leads to hump-shaped responss of the real exchange rate to shocks in both sectors when $omega = 0.95$ (the low intermediate goods trade case), and for the final goods sector shock for the $omega = 0.5$ case. For the case where both factors are immobile, the results generated by the model are:

Model-Generated Results (Immobile K and N)

	ω		
	0.95	0.5	0.05
Std. dev. of output	1.71	1.38	1.24
Std. dev. of RER	1.97	3.08	3.24
Corr. Y^A, Y^B	-0.39	-0.06	0.15
Corr. RER, $\frac{\text{NX}}{\text{Y}}$	-0.99	-0.98	-0.91

Impulse responses for this case are given in figures 5 and 6. These results are similar to the case where only capital is immobile. With $\omega = 0.05$, the standard deviation of the RER is 1.15 times that of output, rising to 2.23 times when $\omega = 0.5$ and 2.61 times when $\omega = 0.95$ - comparison with the case of mobile factors shows that factor immobility has increased the volatility of the real exchange rate relative to output.

Another source of rigidity would be low degrees of substtutibility in production. The table below reports results with immobile K and N for a low-elasticity alternative scenario where μ, the elasticity between factor and intermediate goods inputs and ψ, the elasticity between domestic and imported intermediate goods, are reduced from 0.5 to 0.2.

Model-Generated Results (Immobile Factors and Low Elasticity)

	ω		
	0.95	0.5	0.05
Std. dev. of output	1.70	1.24	1.08
Std. dev. of RER	2.02	4.23	4.46
Corr. Y^A, Y^B	-0.39	0.16	0.64
Corr. RER, $\frac{\text{NX}}{\text{Y}}$	-0.99	-0.93	-0.82

With a less flexible production structure, the effect of intermediate goods trade on real exchange rate volatility is strengthened. With low intermediate goods trade ($\omega = 0.95$) the standard deviation of the RER is 1.27 times that of output, only slightly higher than the baseline case, but raising ω to 0.5 increases the relative volatility to 3.4 times, and to 4.29 times in the $\omega = 0.05$ case. The effect of increasing the share of imported intermediates on cross-country output correlation is also amplified by lowering the elasticities of substitution. Impulse responses for the RER following shocks to productivity in each country B sector are shown in Figures 7 and 8. Compared with the previous case, the responses are noticeably larger for the final goods shock when $\omega = 0.05$ and for the intermediate goods shock at $\omega = 0.5$ and $\omega = 0.05$. For the case with low intermediate goods trade ($\omega = 0.95$), the lower elasticities appear to make little difference.

5 Conclusion

The preliminary results in this paper suggest that intermediate goods trade may be helpful for understanding exchange rate disconnect, as well as international output comovement. With an increasing share of imported intermediate goods, the volatility of the real exchange rate relative to output increases, while the correlation between the real exchange rate and the trade balance-GDP ratio declines. Intermediate goods trade also raises international output correlations.

This research is still at a highly preliminary stage. The intuition behind the main results is straightforward - if exported goods are, in part, re-exports of goods imported from the destination country, larger adjustments of relative prices are necessary to maintain equilibrium. However, more work needs to be done to detail the mechanism. Moreover, the parameterization needs to be refined. The results with the low elasticity scenario show the importance of structural rigidity.

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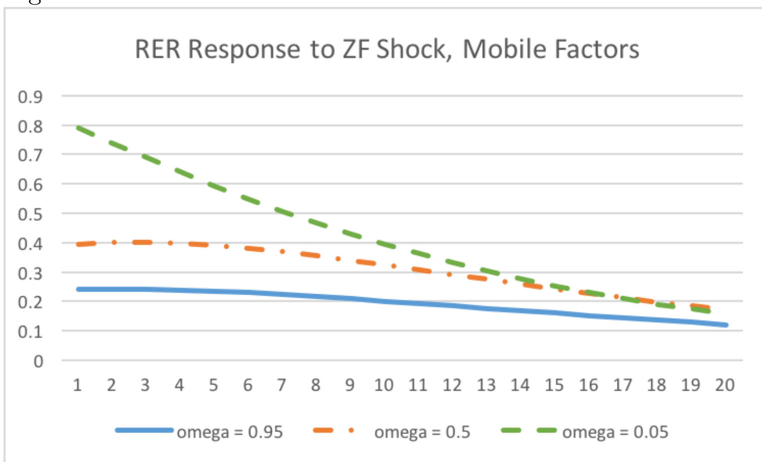
Fig 1.


RER Response to ZF Shock, Mobile Factors
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
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0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
omega = 0.95
omega = 0.5
omega = 0.05

Fig. 2.

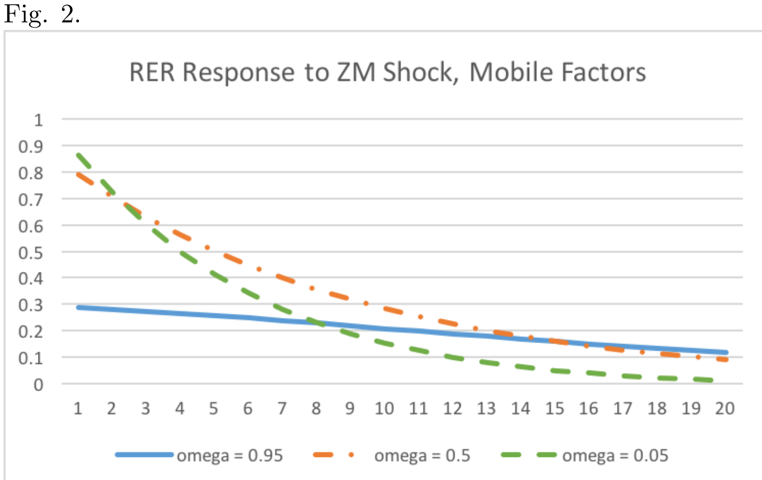
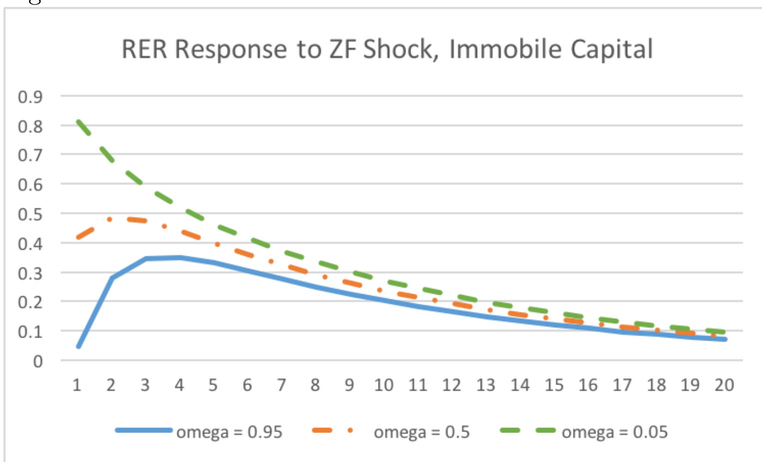

RER Response to ZM Shock, Mobile Factors
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
omega = 0.95
omega = 0.5
omega = 0.05

Fig 3.


RER Response to ZF Shock, Immobile Capital
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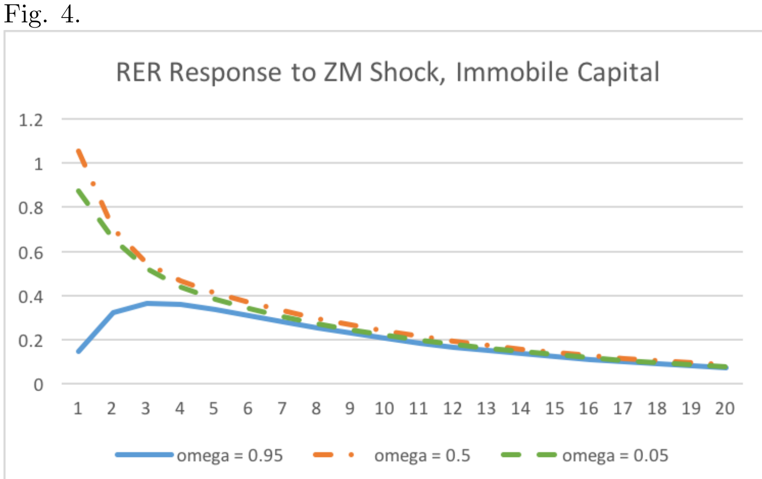
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
omega = 0.95
omega = 0.5
omega = 0.05

Fig. 4.


RER Response to ZM Shock, Immobile Capital
1.2
1
0.8
0.6
0.4
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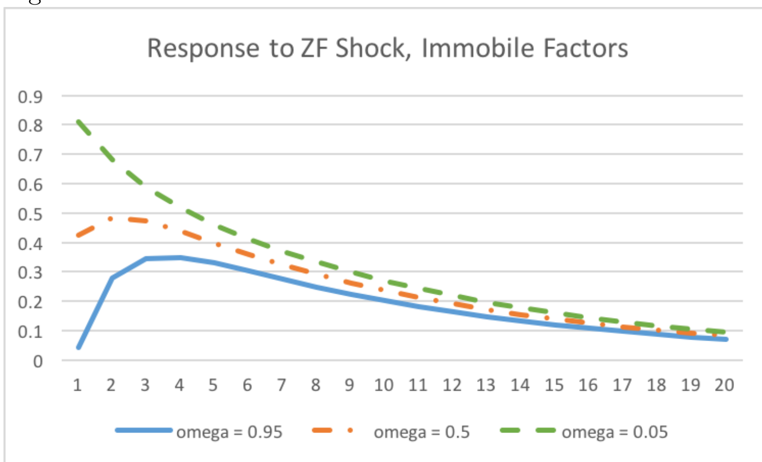
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
omega = 0.95
omega = 0.5
omega = 0.05

Fig 5.



Response to ZF Shock, Immobile Factors
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
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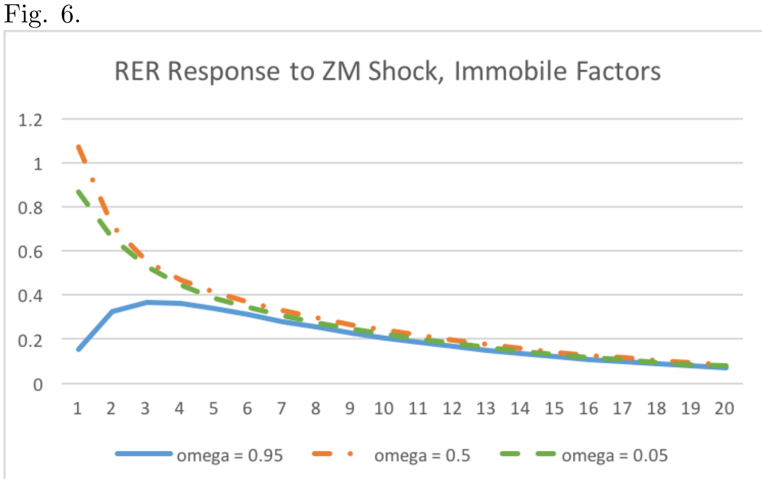
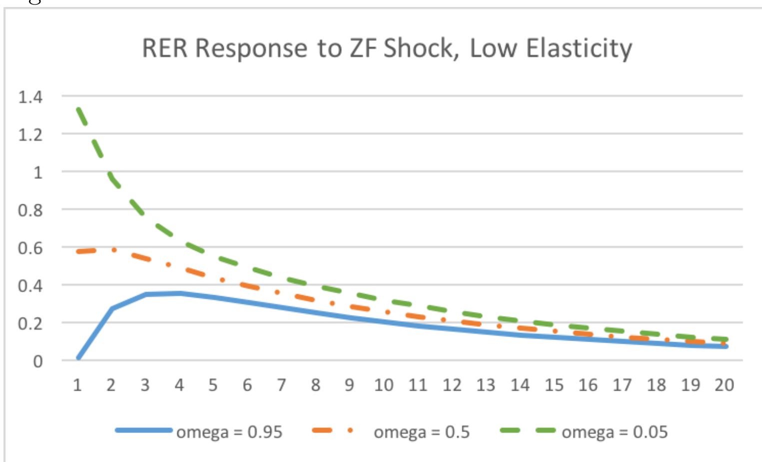
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
omega = 0.95
omega = 0.5
omega = 0.05

Fig. 6.



RER Response to ZM Shock, Immobile Factors
1.2
1
0.8
0.6
0.4
0.2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
omega = 0.95
omega = 0.5
omega = 0.05

Fig 7.


RER Response to ZF Shock, Low Elasticity
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0.6
0.4
0.2
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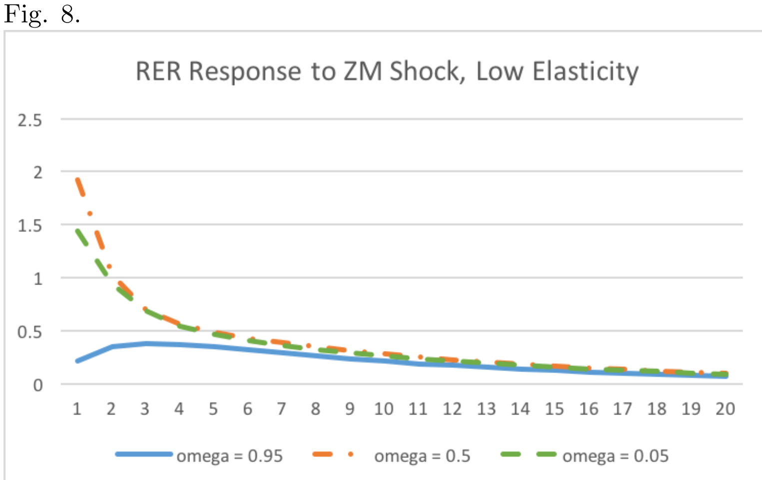
omega = 0.05

Fig. 8.


RER Response to ZM Shock, Low Elasticity
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1
0.5
0
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omega = 0.5
omega = 0.05