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POLICY RESPONSES TO EXCHANGE-RATE MOVEMENTS

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ABSTRACT

This paper examines policy responses to exchange-rate movements in a simple model of an open economy. The optimal response of monetary policy to an exchange-rate change depends on the source of the change: on whether the underlying shock is a shift in capital flows, manufactured exports, or commodity prices. The paper compares the model's prescriptions to the policies of an actual central bank, the Bank of Canada. Finally, the paper considers the role of fiscal policy in an open economy. Coordinated fiscal and monetary responses to exchange-rate movements stabilize output at the sectoral as well as aggregate level.

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I. INTRODUCTION

A variety of economic shocks influence exchange rates, ranging from shifts in investor sentiment to changes in commodity prices to foreign business cycles. These shocks also threaten to destabilize aggregate output and inflation. In an open economy, a central question for monetary policy is how to respond to shocks that affect exchange rates.

This paper uses a simple macroeconomic model to address this issue. I derive the optimal policy responses to different types of exchange-rate shocks. I also compare these results to the practices of an actual central bank, the Bank of Canada. I focus on the BOC because it is unusually explicit about its responses to exchange-rate movements.

The main conclusions include:

• The optimal response to a change in the exchange rate depends on the cause of the change. If an appreciation results from a shift in capital flows, the optimal policy is for the central bank to reduce interest rates. If an appreciation results from a shift in net exports, the optimal response may be an increase in rates. These results support the reasoning of the Bank of Canada.

• The optimal response to a net-export shock depends on what part of net exports changes. If the demand for manufactured exports rises, then the optimal policy is a tightening. In contrast, if the prices of commodity exports rise, the optimal response is ambiguous: a decrease in interest rates may be optimal. This result conflicts with BOC policies, which include tightening whenever net exports rise.

• The economy is more stable if fiscal as well as monetary policy responds to shifts in exchange rates. When only monetary policy responds, it can stabilize aggregate output, but inefficient fluctuations occur at the sectoral level: net exports rise while domestic spending falls, or vice versa. In contrast, the right mix of fiscal and monetary policy stabilizes sectoral output.

I derive these results in a model based on undergraduate textbooks, specifically Mankiw (2007) and Ball (2009). Before introducing the model, I discuss a methodological question: why use a textbook-style model for policy analysis?

II. WHAT TYPE OF MODEL?

A large literature analyzes monetary policy in open economies. This work includes research at central banks, such as Ragan’s (2005) study of Canada, and academic papers such as Corsetti and Pesenti (2005) and Gali and Monaceli (2005). The present paper complements this literature, as it analyzes a different type of model. There are two related differences from most recent research.

First, my analysis is simpler. The main model consists of two identities and three behavioral equations. Ragan, by contrast, uses the Bank of Canada's forecasting model, TOTEM, which includes at least 78 equations with 51 calibrated parameters (Murchison and Rennison, 2006).

Large-scale models have the potential advantage of quantitative accuracy. The disadvantage is that large models yield little economic intuition. Computers have become powerful enough to solve models like TOTEM, but the human brain has not evolved enough to understand them. Policy prescriptions from such models come out of a black box. Simpler models sharpen our understanding of the economic forces behind results.

The second difference between this paper and most recent work is that my model does <u>not</u> have microeconomic foundations. I write down equations for macro variables without deriving them from optimizing behavior of individuals and firms.

Again, my approach has pros and cons. Microfoundations potentially make a model structural, allowing it to account for changes in agents' behavior when policy changes. On the other hand, an insistence on microfoundations is one reason for the complexity of many models.

In addition, models with microfoundations have elements of questionable realism. For example, many open-economy versions of the models assume purchasing power parity. In real economies, exchange-rate fluctuations are largely deviations from PPP. Many models also include interest-rate parity, a condition rejected repeatedly in empirical studies.

The microfoundations of macroeconomics are at an early stage of development. We can hope that micro-based models will eventually become realistic enough to use in applied policy analysis. In the meantime, traditional textbook-style models have a role. They capture many economists' views about the key macro relationships facing policymakers.

III. THE BASIC MODEL

The basic model is similar to ones in Ball (1999) and in the Mankiw and Ball textbooks. We start with two identities:

(1) $Y = D + X$

(2) $X = F$,

where Y is real output, D is total domestic spending (consumption, investment, and government purchases), X is net exports, and F is net capital outflows. Equation (1) is the GDP accounting identity and equation (2) is the identity relating net exports and capital flows.

The variables D, X, and F are determined as follows:

(3) $D = D(\underset{+}{Y}, \underset{-}{r})$

(4) $X = X(\underset{-}{Y}, \underset{-}{e})$

$$F = F(\underset{-}{r}, \underset{+}{e}) \quad (5)$$

where r is the real interest rate and e is the real exchange rate, with a higher e meaning an appreciation. I interpret all variables as deviations from long-run equilibrium levels.

Equations (3) and (4) are standard. Domestic spending depends negatively on the real interest rate, and net exports depend negatively on the real exchange rate. The partial derivative D_Y ($\partial D/\partial Y$) is the marginal propensity to spend out of income; I assume $0<D_Y<1$. The partial derivative X_Y is minus the marginal propensity to import; I assume $X_Y<0$ and $|X_Y|<D_Y$.

Equation (5) is a bit more novel, but captures conventional thinking about capital flows. A rise in the real interest rate makes domestic assets more attractive, reducing net capital outflows. As for the exchange rate effect, recall that e is the deviation of the exchange rate from its long run level. If this variable is positive, the exchange rate is expected to fall in the future. This makes domestic assets less attractive relative to foreign assets, raising net capital outflows.

Substituting (3)-(5) into (1)-(2) gives us

$$Y = D(Y,r) + X(Y,e) \quad (6)$$

$$X(Y,e) = F(r,e) \quad (7)$$

These are two equations in three endogenous variables, r, Y, and e. I use two different conditions to close the model. One is that the central bank holds the real interest rate constant. To capture this case, I simply omit the interest rate from the model's equations. The result is

THE ECONOMY WITH A FIXED REAL INTEREST RATE

(8) $Y = D(Y) + X(Y,e)$

(9) $X(Y,e) = F(e)$

These are two equations in Y and e. We can use them to derive the "direct" effects of shocks: how Y and e change if policy does not respond.

Alternatively, I assume the central bank adjusts the real interest rate to keep output at its long-run level. I omit Y from the D(•), X(•), and F(•) functions, and set Y=0 on the left side of (6) (since Y is the deviation from long-run output). Then (6) and (7) become

THE ECONOMY WITH STABILIZING POLICY

(10) $0 = D(r) + X(e)$

(11) $X(e) = F(e,r)$

These are two equations in e and r. They determine the policy response to a shock when the central bank stabilizes output. They also determine the total effect of the shock and policy response on the exchange rate.[1]

It can be useful to express the model graphically, especially the version with stabilizing policy. Figure 1 shows conditions (10) and (11). Given our assumptions about the D(•) and X(•) functions, condition (10) is downward sloping. We will call it the YS curve for “output stabilization.” It shows the combinations of r and e that keep output at its long run level. If the exchange rate appreciates, the central bank offsets the contractionary effect with a lower interest rate.

Equation (11), which is upward sloping, reflects equilibrium in the foreign exchange market; we will call it the FE curve. Along this curve, a higher interest rate makes domestic assets more attractive, pushing up the exchange rate. The intersection of the FE and YS curves determines the equilibrium exchange rate and interest rate.

IV. SHOCKS

The shocks in the model are shifts in the D(•), X(•), and F(•) functions, which I will call domestic-demand shocks, net-export shocks, and capital-flow shocks. Domestic-demand shocks

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[1] I do not explicitly model the behavior of inflation. One can add inflation to the model through a Phillips curve that relates changes in inflation to fluctuations in output. With this extension of the model, policies that stabilize output stabilize inflation as well. Therefore, these policies are appropriate for an inflation-targeting central bank, such as the Bank of Canada.

are like IS shocks in a closed-economy model; they include changes in consumer confidence or in government spending, for example. Net-export shocks could arise from changes in the prices of commodity exports or from business cycles in trading partners. Capital-flow shocks reflect changes in investor confidence in foreign and domestic assets.

I interpret all shocks as temporary. They cause the exchange rate and other variables to deviate from fixed long-run levels. Future research might consider shocks that shift the exchange rate permanently.

If a central bank seeks to stabilize output, the appropriate response to an exchange-rate movement depends on the underlying shock. One central bank that recognizes this point is the Bank of Canada. To my knowledge, the BOC is the only central bank that has explicitly defined different types of exchange-rate shocks and described its responses. Throughout this paper, I will compare my results to the BOC's practices.

The BOC distinguishes between "Type One" and "Type Two" exchange-rate movements. In 2005, Governor Dodge defined Type I movements as those reflecting shifts in "global demand for Canada's goods and services." Type II shocks "reflect the rebalancing of portfolios in financial markets, which may have nothing to do with current demand for Canadian goods and services." Ragan (2005) provides details about what events count as Type I or Type II shocks.

Type II shocks appear equivalent to capital-flow shocks in my model. Ragan's examples of Type II shocks include "an adjustment in financial portfolios toward Canadian assets" and "a flow of financial capital into Canada to finance the purchase of existing physical capital." Like Type II shocks, my capital-flow shocks do not directly affect the demand for goods and services, because F(•) does not appear in (6), the basic equation for GDP.

Type I shocks are similar to net-export shocks in my model. Ragan's examples of Type I shocks include "an increase in world relative demand for Canadian-produced goods and services" and "an increase in the world prices of raw materials which leads to an increase in income to Canadian commodity exporters." Notice that neither the Type I nor Type II category covers the domestic-demand shocks in my model. Most BOC discussions of exchange rates ignore shifts in domestic demand.

The correspondence between Type I shocks and net-export shocks is not perfect. Ragan's list of Type I shocks includes "greenfield investment," meaning "a flow of foreign financial capital into Canada to finance *new* investment in Canadian physical capital." In my model, I would interpret such an event as a combination of a domestic-demand shock (the new investment) and a capital-flow shock.

V. EFFECTS OF SHOCKS

Let's see how the model's three shocks affect the economy: their direct effects when the central bank holds the interest rate constant, and their total effects when the central bank stabilizes output. For either case, one can derive a shock's effects by totally differentiating the two equations defining equilibrium. However, the results are usually obvious and/or explicable with Figure 1, so I skip formal derivations.

The effects of the shocks, summarized in Table I, are the following:

- *A rise in domestic demand*: The direct effect is to raise output and reduce the exchange rate. The exchange rate falls because higher income raises imports and hence the demand for foreign currency. When the central bank stabilizes output, it raises the real interest rate and the total exchange-rate effect is positive. Figure 2A illustrates the stabilizing-policy case. The domestic-demand shock shifts the YS curve to the right (a higher r is needed for a given e), raising the equilibrium r and e.

- *A rise in net capital outflows*: Here, domestic assets become less attractive relative to foreign assets. The direct effects are a lower exchange rate and higher output. Output rises because the lower exchange rate raises net exports. In the stabilizing-policy case, the FE curve shifts down and the economy moves along the YS curve (Figure 2B). The interest rate rises. The exchange rate falls but by less than the direct effect, because of the higher interest rate.

• *A rise in net exports:* The direct effects are higher output and a higher exchange rate. In the stabilizing-policy case, both the YS and FE curves shift up, raising the exchange rate (Figure 2C). The two shifts have opposite effects on the interest rate, but the net effect is positive; the interest rate must rise to prevent the shock from raising output. Because the interest rate rises, the total increase in the exchange rate is greater than the direct effect.[2]

So far, my results for the stabilizing-policy case are consistent with policy at the Bank of Canada. According to Ragan (2005), the BOC raises interest rates when a Type I shock causes an appreciation of the Canadian dollar, and lowers rates when a Type II shock causes an appreciation. Recall that Type I and II shocks are roughly equivalent to net-export and capital-flow shocks respectively. Thus BOC policies match the results in Table I.

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[2] To see that r must rise in the stabilizing-policy case, substitute equation (11) into equation (10), which produces 0 = D(r) + F(e,r). This defines a positive relation between r and e that is not shifted by a net export shock. Since e rises, r must also rise.

VI. SECTORAL STABILITY AND FISCAL POLICY

So far, we have derived policies that stabilize aggregate output when exchange rates change. However, economic welfare depends on output stability at the sectoral as well as aggregate level. It is inefficient to have a boom in one sector and a recession in another, even if the deviations from long-run output average to zero. This issue is particularly important in open economies, because fluctuations in exchange rates affect some sectors and not others.[3]

I will assume that D and X give output levels in two sectors of the economy and label them the "domestic" sector and the "export" sector. The latter includes import-competing industries as well as exporters. We can think of the domestic and export sectors as roughly equivalent to the non-tradeable sector, which is not influenced by the real exchange rate, and the tradeable sector, which is.[4]

For each of the model's three shocks, the appropriate monetary response, shown in Table I, keeps aggregate output

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[3] The benefits of sectoral stability could be derived formally in a standard macro-with-microfoundations model (see Romer [2006] or Woodford [2003]). In these models, welfare is reduced by dispersion in output across firms as well as by variability in aggregate output.

[4] Future work should revisit the definition of sectors. In reality, some tradeable sectors, such as autos, are interest-rate sensitive, which is ruled out here. A richer model might have several sectors defined by varying combinations of interest-rate sensitivity and exchange-rate sensitivity.

constant. In each case, however, output is unstable at the sectoral level: a rise in D is balanced by a fall in X, or vice versa. For example, a rise in capital outflows reduces D (because the interest rate rises) while raising X (because the exchange rate falls).

Sectoral output can be stabilized if policymakers have an additional instrument besides the interest rate. A natural second instrument is fiscal policy. If we add a fiscal variable to the model, the right combination of fiscal and monetary policy can stabilize both D and X.

To formalize this point, I start with the model in which monetary policy stabilizes aggregate output, equations (10)-(11). Extend this model in two ways. First, include taxes, T, in the domestic demand function: D = D(r,T). Assume $-1<D_T<0$. Second, assume policy stabilizes domestic-sector output: D=0. Since (10) and (11) already impose Y=0, adding D=0 implies X=0 as well. Output is constant in both sectors. The model becomes

THE ECONOMY WITH SECTORAL STABILITY

(12) $0 = D(r,T) + X(e)$

(13) $X(e) = F(e,r)$

(14) $0 = D(r,T)$.

This model is three equations in three variables, e, r, and T.

It determines how the interest rate and taxes respond to shocks, and the total effects on the exchange rate.

As an example of applying this model, consider a rise in capital outflows. As we've discussed, a monetary tightening alone can stabilize aggregate output, but X rises and D falls. Using (12)-(14), one can show that X and D are stabilized by an increase in the interest rate and a cut in taxes. The interest rate increase is greater than the increase when only monetary policy stabilizes output. The exchange rate stays constant at its long run level: the two policy responses fully offset the effect of the capital-flow shock.

One can also use (12)-(14) to derive policy responses to domestic-demand and net-export shocks. I will skip the details. The overall point is that combining fiscal and monetary policy always improves on monetary policy alone in stabilizing sectoral output.

Of course this theoretical result raises practical questions. Under most countries' political systems, it is difficult to coordinate fiscal and monetary policy. However, movements toward greater coordination are possible, as discussed in Ball (2008). The potential benefits are large given the costs of sectoral fluctuations, which I discuss further below.

VII. COMMODITY EXPORTS VS. MANUFACTURED EXPORTS

So far I've distinguished between an economy's domestic and export sectors. Another important distinction concerns two types of exports, commodities and manufactured goods. Changes in commodity prices can move commodity exports and manufactured exports in opposite directions. In particular, higher commodity prices can cause the "Dutch disease." Commodity exports rise, but that causes an exchange-rate appreciation that reduces manufactured exports.

This effect has been important in Canada in recent years. Canada exports oil, gas, and metals. The prices of these commodities rose over 2003-2007, raising total exports, causing an appreciation of the Canadian dollar, and making manufacturing industries less competitive.

The Bank of Canada classifies any rise in net exports as a Type I exchange-rate shock, which calls for an increase in interest rates. BOC economists are explicit that policy should tighten even when the underlying shock is a rise in commodity prices. In this case, says Ragan (2005),

> many firms and workers in the contracting sectors will begin to feel the crowding-out effect associated with the Dutch disease. Often at this point some commentators urge the Bank to prevent and even reverse the appreciation of the currency by reducing interest rates.... however, the appropriate response for the Bank in this case would be to tighten its monetary policy further... causing a further appreciation of the Canadian dollar."

In other words, the BOC acknowledges that the Dutch disease hurts manufacturing, but believes the best response is a tightening that further hurts manufacturing.

I question this view on two grounds. First, as already discussed, a combination of fiscal and monetary policy can eliminate the sectoral effects of shocks. Second, even if monetary policy is the only tool, a tightening may not be the optimal response to higher commodity prices.

Modifying the Model

To address these issues, I assume net exports, X, has two components. One is net exports of manufactured goods, M. Like X in the basic model, this variable depends on the real exchange rate and income: M=M(e,Y).

The other component of net exports is commodities. Let C be net exports of commodities valued in foreign currency. Net exports in local currency can be approximated by C - e, given that all variables are deviations from long run levels.[5]

I assume that C, the foreign-currency value of commodity exports, is exogenous. To interpret this assumption, consider Canada's oil exports. Suppose the physical quantity of these

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[5] To understand this approximation, let C* be the absolute level of commodity exports measured in foreign currency, and let e* be the level of the real exchange rate. Commodity exports in local currency are C*/e*. We can normalize C* and e* so their long run levels are both one. C and e are defined as deviations from these long run levels. A first-order approximation of C*/e* is 1+(C*-1)-(e*-1) = 1+C-e. The deviation of C*/e* from its long run level is approximately C-e.

exports is constant: the oil industry pumps a fixed number of barrels from the ground. The value of these exports in foreign currency –- specifically U.S. dollars –- is determined by the world price of oil, which is set in U.S. dollars. Fluctuations in this price are exogenous to Canada.

Total net exports in local currency are the sum of manufactured and commodity exports:

(15) $X = M(e,Y) + C - e$

With this specification of X, the basic model of the economy, equations (6)-(7), becomes

(16) $Y = D(r,Y) + M(e,Y) + C - e$

(17) $M(e,Y) + C - e = F(e,r)$.

As in my basic model (Sections III-V), I ignore fiscal policy and assume the interest rate r is the only policy instrument. In this case, however, I do <u>not</u> assume the central bank adjusts r to stabilize Y. Instead, it stabilizes Y - (c-e), or real GDP excluding commodity exports. Equivalently, the central bank sets Y = c-e: it accommodates changes in income caused by changes in commodity prices. These are real shocks that change potential GDP; for our purposes, higher oil prices are equivalent to more productive oil wells. When commodity exports rise, stabilizing Y would require a decrease in non-commodity output, which would be inefficient.[6]

When policy sets Y=c-e, equations (16) and (17) become

THE ECONOMY WITH STABILIZATION OF NON-COMMODITY GDP

(18) $0 = D(r,C-e) + M(e,C-e)$

(19) $M(e,C-e) + C - e = F(e,r)$

These two equations determine r and e (again, C is exogenous).

Responses to Shocks

We can use equations (18)-(19) to determine how monetary policy responds to shocks when it stabilizes non-commodity output. The responses to domestic-demand and capital-flow shocks are similar to those in the basic model of Sections III-V. When net exports shift, the response depends on the source of the shift:

• *A Rise in Manufactured Exports*: In this case, the M(•) function shifts up. The central bank's response is similar to its response to a net-export shock in the basic model: it raises the interest rate. The shock directly raises the exchange rate, and the policy response raises the exchange rate further.

• *A Rise in Commodity Prices*: This shock raises C, the foreign-currency value of commodity exports. We can determine

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[6] Again, this welfare argument could be formalized in a standard macro model with microfoundations.

the effects by differentiating (18)-(19) with respect to C. The key results are:

1. The effect on r is ambiguous: the central bank may raise or lower the interest rate.[7]

2. Even if the increase in C raises r, this effect is smaller than the rise in r caused by an equal-sized increase in manufactured exports.[8]

3. The increase in C raises the exchange rate, e. The total rise in e can be larger or smaller than the direct effect of the shock, depending on whether r rises or falls.

Why does policy respond differently to shifts in commodity and manufactured exports? Recall that policy stabilizes non-commodity output, Y-(c-e). An increase in manufactured exports directly raises non-commodity output, so policy must tighten to offset this effect. A rise in commodity exports does not directly affect non-commodity output. It affects it indirectly, because total income rises, raising domestic spending. However, this effect is smaller than that of higher manufactured exports. As a result, a smaller monetary tightening (if any) is needed to stabilize non-commodity output. This explains Result 2 above.

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[7] Differentiating (18)-(19) yields $dr/dc = [D_Y M_e - D_Y F_e - M_Y F_e - M_e]/[D_r(F_e - M_e + M_Y + 1) - F_r(M_e - D_Y - M_Y)]$. To see that this effect is ambiguous, note for example that it is positive if $D_Y=1$ and $M_Y=0$ and negative if $D_Y=M_Y=0$.

[8] More precisely, let $M(e,Y)=M'(e,Y)+Z$, where the function $M'(\bullet)$ is fixed. One can show that $dr/dZ > dr/dC$.

Result 1 says the policy response to a rise in commodity exports is ambiguous. The explanation is that this shock has both a positive and a negative effect on non-commodity output. The positive effect is the rise in domestic spending resulting from higher income. The negative effect is the Dutch disease –- a fall in manufactured exports resulting from a higher exchange rate. The sum of these two effects is ambiguous, so offsetting them may require either tighter or looser policy.

We can gain further insight by examining the condition that determines whether policy tightens or loosens. For simplicity, let $M_Y=0$ (the marginal propensity to import is zero). In this case, the interest rate rises in response to higher commodity prices if and only if

(20) $$D_Y > (-X_e)/(-X_e+F_e) .$$

That is, policy tightens if the marginal propensity to spend is sufficiently high. When (20) holds, the expansionary effect of higher commodity prices –- the effect of higher income on spending -- outweighs the contractionary effect.[9]

[9] As in Section VI, we can extend the model to include taxes in the domestic demand function. In this case, a combination of fiscal and monetary policy can stabilize both manufactured exports and output in the domestic sector, while accommodating shifts in commodity exports. Once again, policy responds differently to shifts in M(•) and changes in C. When M(•) shifts up, sectoral output is stabilized by a combination of tighter monetary policy and looser fiscal policy. When C rises, fiscal policy tightens, and it is more likely that monetary policy loosens than when it is the only instrument.

VIII. CONCLUSION

This paper considers the response of monetary policy to exchange-rate movements in a simple macroeconomic model. The optimal response depends on why the exchange rate changes. When an appreciation occurs, it is optimal to lower the interest rate if the underlying shock is a shift in capital flows, but raise the interest rate if the shock is higher domestic spending. If the shock is higher net exports, the optimal response depends on why exports rise. If the reason is higher demand for manufactured exports, it is optimal for policy to tighten; if the reason is higher prices for commodity exports, the optimal response is ambiguous.

These results support the policies of the Bank of Canada -- except the result about commodity prices. The Bank argues that tighter policy is necessary whenever net exports rise. In my model, however, a rise in exports resulting from higher commodity prices can reduce output relative to the efficient level. The contractionary effect of the Dutch disease can outweigh the expansionary effect of higher income. In this case, a monetary easing is optimal.

This paper also considers the role of fiscal policy in an open economy. Monetary policy alone can stabilize aggregate output, but inefficient fluctuations occur in the economy’s domestic and export sectors. Coordinated fiscal and monetary policies can stabilize sectoral output.

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Table 1

EFFECTS OF SHOCKS (BASIC MODEL)

	Direct effect on Y	Direct effect on e	Response of r	Total effect on e
↑ Domestic Demand	+	-	+	+
↑ Net Exports	+	+	+	+ (> direct effect)
↑ Net Capital Outflows	+	-	+	- (< direct effect)

Figure 1

Equilibrium With Stabilizing Policy

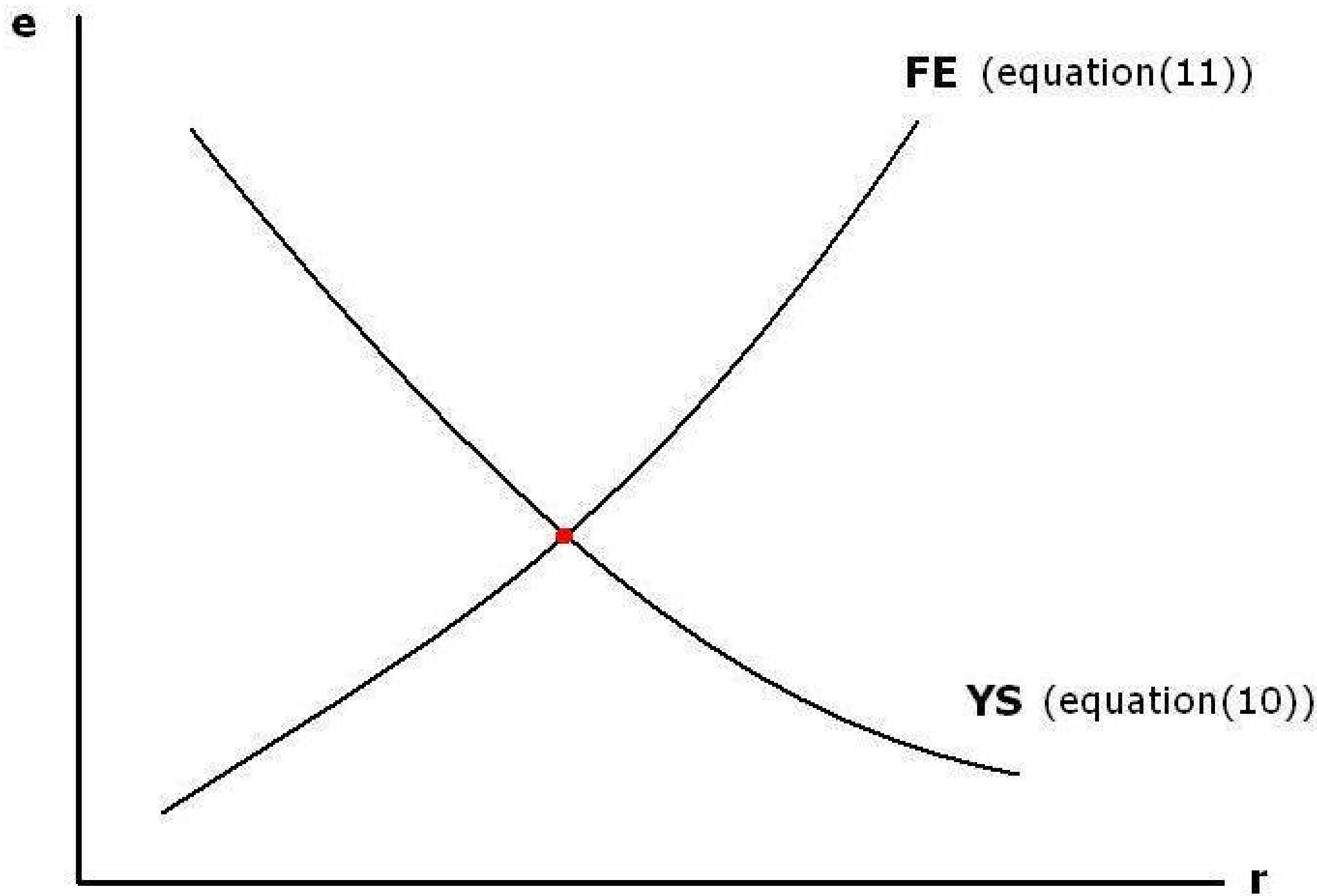
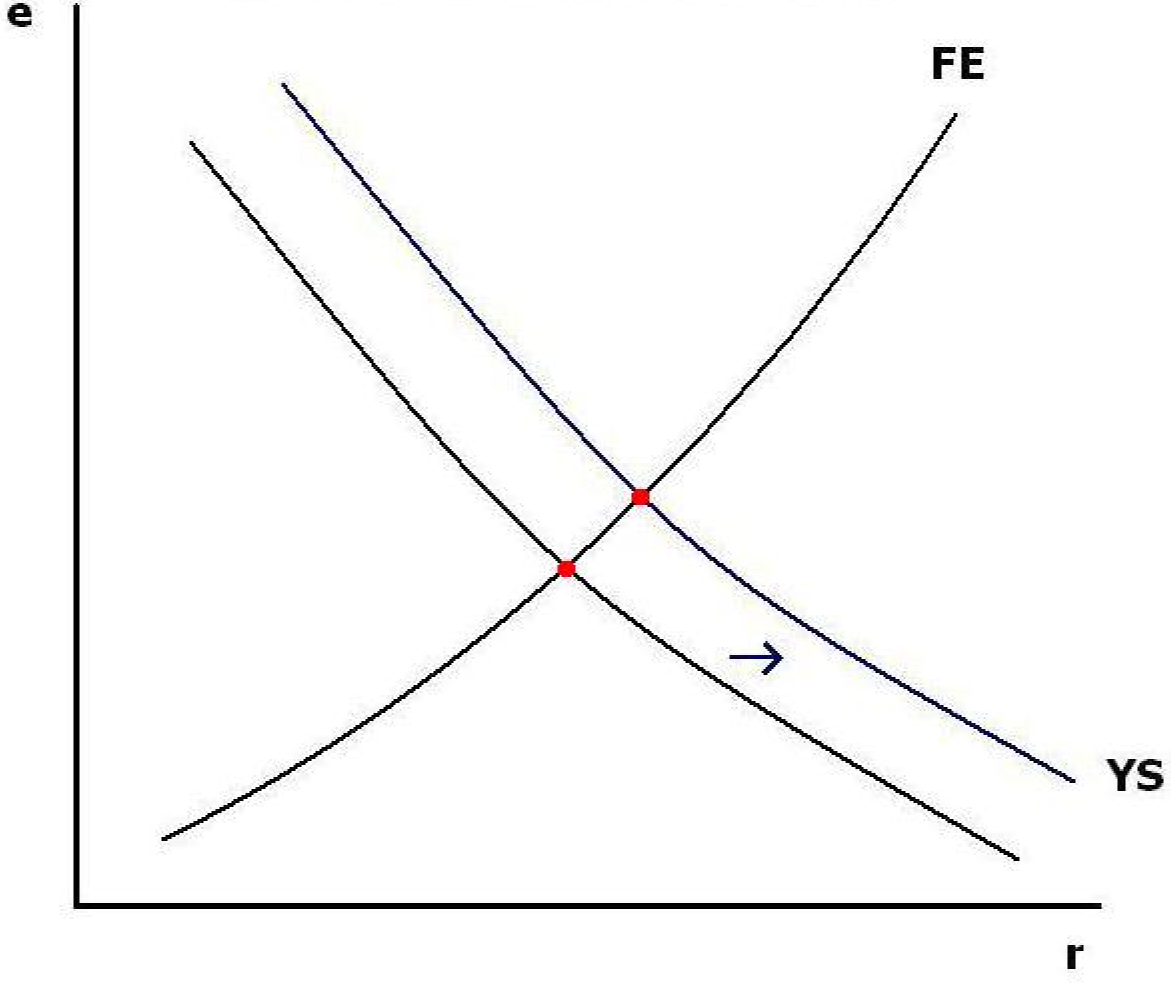
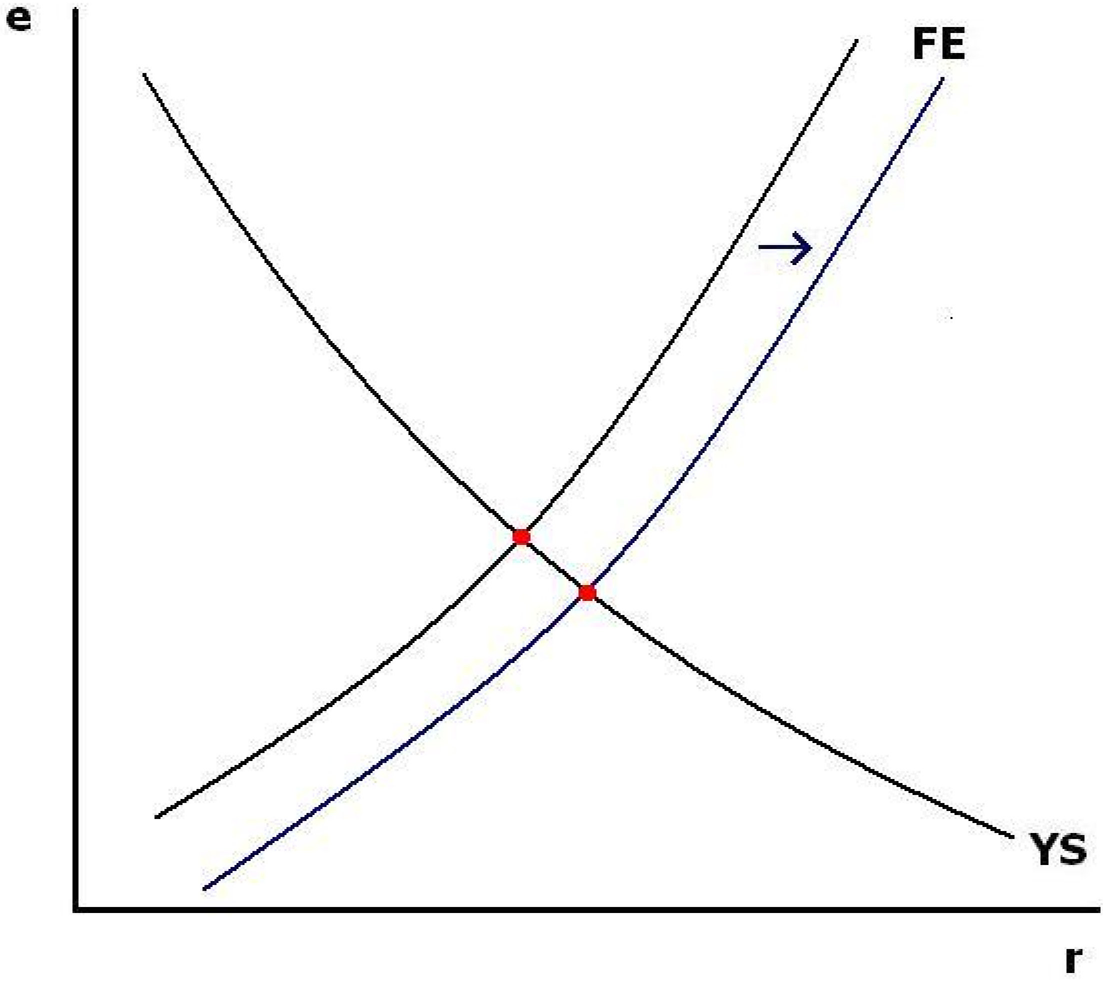


Figure 2 Effects of Shocks

A: A Rise in Domestic Demand



B: A Rise in Net Capital Outflows



C: A Rise in Net Exports