Short Run and Long Run in Trade Models: A Note

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Abstract

This paper aims to capture key features of the Ricardo-Viner (RV) and Heckscher-Ohlin (HO) theories in a single dynamic general equilibrium framework. We use a simple 2-sector 2-factor model with adjustment costs associated with the movement capital across sectors. We analyze the economy's response to exogenous changes in factor endowments and output prices. Our model reproduces the predictions of the RV theory in the short run (moment immediately after a parameter change) and the predictions of the HO model in the long run (steady state implied by a new set of parameters). Numerical examples of transition paths are also provided.

Resumo

Este artigo busca capturar as principais características dos modelos de Ricardo-Viner (RV) e de Heckscher-Ohlin (HO) em um único ambiente. Utilizamos um simples modelo de dois fatores e dois setores, com custos de ajustamento associados ao movimento de capital entre indústrias. Analizamos então a resposta desta economia a mudanças exógenas nas dotações de fatores e nos preços dos produtos. Nosso ambiente reproduz os resultados do modelo de RV no curto prazo (momento imediatamente posterior à mudança nos parâmetros) e do modelo de HO no longo prazo (estado estacionário correspondente ao novo conjunto de parâmetros). Exemplos numéricos de transições são também apresentados.

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1 Introduction

A key objective of international trade theory is to explain patterns of trade and factor prices in small, competitive open economies. Particularly, the trade literature has often addressed the question of how the distribution of income (in the form of factor prices) reacts to changes in availability of inputs – such as migration flows or capital accumulation – and movements in terms of trade. In this context, two important theories offer distinct answers: the Heckscher-Ohlin (HO) model and the Ricardo-Viner (RV) model.[1]

Both these models are based on a very similar framework. They describe small open economies in which products can cross borders, but factors cannot. This means that goods prices are set exogenously by international markets, while input prices are determined domestically. A typical representation of this environment consists of a two-sector two-factor – capital and labor – static setup, with exogenous output prices and factor endowments.

The key assumption that differentiates these models regards the movement of factors across industries. On the one hand, the HO model assumes that both capital and labor can switch industries costlessly. On the other hand, according to the RV theory, labor is also fully mobile, but capital is sector specific.

Although similar, these theories deliver very distinct responses to changes in parameters. For instance, the RV model predicts that the wage rate falls (rises) and the rental rate of capital rises (falls) when total stock of labor (capital) increases. But in the HO world, factor prices are surprisingly invariant to changes in factor supplies: all impact is absorbed through changes in the output mix.

In this paper, we propose a dynamic general equilibrium model which is capable to deliver both RV and HO predictions. We follow the tradition in trade theory: there are two factors – capital and labor – and two competitive tradable sectors – a capital intensive sector and a labor intensive sector; output prices and factor endowments are exogenous. In addition to this structure, we suppose that there are adjustment costs associated with the movement of capital across sectors.

We assume that an economy initially in steady state experiences a permanent and unanticipated change in one of the exogenous variables. We show that this economy behaves according to the predictions of the RV model in the short run – defined as the moment immediately after the change – and according to the predictions of the HO model in the long run – defined as the new steady state. Intuitively, since the distribution of capital resources

[1] The RV model is also known as the specific-factors model.

across sectors is treated as a state variable, capital is immobile at the moment of the shock. This captures the idea of capital specificity of the RV model. As time passes, capital flows in response to sectoral differences in rental rates. In the long run, rental rates are again equalized and the movement of resources stops. In this situation, there are no adjustment costs, which is consistent with the HO model.

We also provide numerical examples of transitions calculated in response to changes in the stock of capital and the relative price of the labor intensive good. This allows us to gain some intuition on the relationship between short- and long-run effects in our environment.

This paper is especially motivated by the classical articles of Mayer (1974), Mussa (1974) and Neary (1978), which propose the short-run long-run distinction to conciliate the predictions of HO and RV models. Other applications of this idea include Edwards (1988), Edwards and Edwards (1990) and Milner and Wright (1998). In addition, our work is related to papers such as Mussa (1978, 1984), Kotlikoff, Leamer and Sachs (1981), Grossman (1983), Hill and Mendéz (1983), Matsuyama (1992) and Morshed and Turnovsky (2004), which introduce dynamics in trade models through costs of moving factors across sectors.

The remaining of the paper is organized as follows. Section 2 presents the setup of our model and shows how it can analytically produce both RV and HO predictions as short- and long-run outcomes. Section 3 displays transition paths calculated after changes in the exogenous parameters. Section 4 concludes.

2 The Model

Time is discrete and indexed by the subscript t, $t = 0, 1, 2, ...$ There is no uncertainty. We consider an environment which includes the basic features shared by both RV and HO models. There are two basic factors: capital and labor; and two tradable goods: good 1, which is generated by labor intensive technology (sector 1), and good 2, which is generated by a capital intensive technology (sector 2). Both technologies display constant returns to scale and are operated by competitive firms. Labor can freely move across sectors. Factor endowments and prices of tradable goods are exogenously fixed in every period.[2]

In addition to this structure, we assume that there are adjustment costs associated with the movement of capital across industries. Goods 1 and 2 are combined to produce a single nontradable final good, which can be either consumed or used to transfer capital across

[2] In other words, this is a small-open economy, in the sense that prices of tradable goods are set exogenously by international markets.

industries. There are no savings and trade is always balanced.

2.1 Households

There is a continuum of measure one of identical infinitely-lived households. They own capital and labor endowments of this economy, denoted respectively by K and L. Given an initial distribution of capital across sectors $\{K_{1,0}, K_{2,0}\}$, each household chooses a stream of consumption $\{c_t\}_{t=0}^{\infty}$ and allocations of labor and capital $\{L_{1t}, L_{2t}, K_{1t+1}, K_{2t+1}\}_{t=0}^{\infty}$ to maximize:

$$U = \sum_{t=0}^{\infty} \beta^t u(c_t)$$

where L_j and K_j respectively stand for the amounts of labor and capital allocated to industry j, $j = 1, 2$. Furthermore, $0 < \beta < 1$ is the discount factor and $u(\cdot)$ is twice differentiable, strictly increasing and strictly concave.

Households face adjustment costs if they decide to move capital from one sector to another. Specifically, households spend $i_j T(i_j/k_j)$ units of the final good to move i_j units of capital from sector j, given that the amount of capital allocated to that sector is initially k_j.[3] We assume $T(\cdot)$ such that $T'(\cdot) > 0$, $T(0) = 0$, and the adjustment-cost function $(i/k)T(\cdot)$ is non-negative and convex.[4] Therefore, the budget constraint can be written as follows:

$$P_t\{c_t + i_{1t}[1 + T(i_{1t}/K_{1t})] + i_{2t}[1 + T(i_{2t}/K_{2t})]\} \leq w_t(L_{1t} + L_{2t}) + r_{1t}K_{1t} + r_{2t}K_{2t} \tag{1}$$

$$i_{jt} \equiv K_{jt+1} - K_{jt}, \quad j = 1, 2$$

where P is the price of the final good, w is the wage rate and r_j is the rental rate of capital in sector j. In addition, allocations of capital and labor across sectors have to satisfy the following feasibility constraints:

$$K = K_{1t} + K_{2t} \tag{2}$$

$$L = L_{1t} + L_{2t} \tag{3}$$

[3] For convinience, we implicitly assume that this cost has to be paid twice, that is, both to move capital from a given sector and to install that capital in the other sector. For instance, to move i units of capital from sector 2 to sector 1, the household has to pay $iT(i/K_1)$ and $-iT(-i/K_2)$.

[4] In dynamic equilibrium models, adjustment costs are seldom introduced to reduce the volatility of investment, in order to match that observed on the data. These costs are, therefore, associated with changes in the overall capital stock. Here, we adapt this structure to make the movement of capital across sectors costly. The specific formulation used by us follows Abel and Blanchard (1983).

Optimality conditions then imply that:

$$\lambda_t P_t \left\{ T_{1t} - T_{2t} + \frac{i_{1t}}{K_{1t}} T'_{1t} - \frac{i_{2t}}{K_{2t}} T'_{2t} \right\}$$
$$= \beta \lambda_{t+1} \left\{ r_{1t+1} - r_{2t+1} + P_{t+1} \left[T_{1t+1} - T_{2t+1} + \frac{i_{1t+1} K_{1t+2}}{(K_{1t+1})^2} T'_{1t+1} - \frac{i_{2t+1} K_{2t+2}}{(K_{2t+1})^2} T'_{2t+1} \right] \right\} \quad (4)$$

where $T_{jt} \equiv T(i_{jt}/K_{jt})$, $T'_{jt} \equiv T'(i_{jt}/K_{jt})$, $j = 1, 2$. In addition, $\lambda_t = u'(c_t)/P_t$ is the shadow price of time t budget constraint.

2.2 Technology and Trade

At each point in time, a typical producer in tradable sector j generates output using a constant returns to scale technology F^j, which also satisfies Inada conditions. Firms take prices as given, and decide the amounts of capital and labor to hire from households such that profits are maximized. Therefore, first order conditions for a firm in sector j will be:

$$p_j F^j_K(K_{jt}, L_{jt}) = r_{jt} \quad (5)$$
$$p_j F^j_L(K_{jt}, L_{jt}) = w_t \quad (6)$$

where p_j is the price of tradable good j, while $F^j_K = \partial F^j / \partial K_j$ and $F^j_K = \partial F^j / \partial L_j$ are the marginal products of capital and labor in sector j. We set good 2 as the numeraire, i.e., $p_2 = 1$. Moreover, we restrict the parameters of this economy such that production in both tradable sectors is always positive.[5]

Competitive final good producers then combine goods 1 and 2 using a constant returns to scale technology described by function G, which satisfies the Inada conditions. The final good is non-tradeable and can be used either for consumption or to move capital across sectors. Therefore, in equilibrium, we have that:

$$c_t + i_{1t}[1 + T(i_{1t}/K_{1t})] + i_{2t}[1 + T(i_{2t}/K_{2t})] = G(x_{1t}, x_{2t})$$

where x_j is the quantity of tradable good j utilized in the production of the final good. Since

[5] The presence of international trade allows for the possibilty of full specialization, that is, the economy produces only one of the tradeable goods. In this paper, we focus on implications of RV and HO models under incomplete specialization. For this reason, we restrict our analysis to a parameter range such that the production of both tradeable goods is positive.

there is no international borrowing or lending, trade has to be balanced:

$$p_1 x_{1t} + x_{2t} = p_1 F^1(K_{1t}, L_{1t}) + F^2(K_{2t}, L_{2t})$$

2.3 Short Run vs Long Run

We now analyze the effects of changes in factor endowments and prices of tradable goods in this environment. We assume that the economy is initially in the steady state such that the relative price of good 1, the stock of capital and the stock of labor are fixed at $\{p_1, K, L\}$. At time $t = 0$, a once-and-for-all unanticipated increase in one of these parameters takes place. We compare the initial steady state with two situations: the moment immediately after the change – which we denote as short run – and the steady state determined by the new set of parameters – which we denote as long run. The following proposition establishes that our environment reproduces the predictions of the RV model in the short run, and the predictions of the HO model in the long run.

Proposition 1 *Suppose an economy initially in steady state with parameters $\{p_1, K, L\}$. At time $t = 0$, there is a permanent and unanticipated increase in one of these parameters. Then in the short run (moment immediately after the change) factor prices, sectoral allocations of capital and labor and sectoral outputs change according to the predictions of the RV model, while in the long run (new steady state) these variables change according to the predictions of the HO model.*

Proof. Variables with no time subscript denote their respective steady-state values. We first analyze the economy in steady state (the long run), when $i_1 = i_2 = 0$ and, from equation (4), $r_1 = r_2 = r$. Equations (1)-(6) can then be written as:

$$\begin{aligned} K &= K_1 + K_2 \\ L &= L_1 + L_2 \\ r &= p_1 F_K^1(K_1, L_1) = F_K^2(K_2, L_2) \\ w &= p_1 F_L^1(K_1, L_1) = F_L^2(K_2, L_2) \end{aligned}$$

These equations correspond to those of the HO model, in which capital and labor are fully mobile and the rental rate is equalized across sectors. They allow us to solve for K_1, K_2, L_1, L_2, w and r as functions of $\{p, K, L\}$. Therefore, the steady-state effects of changes in parameters are those described by the HO model.

We next show analyze the economy at time $t = 0$. Let $\{K_1^*, K_2^*\}$ be the steady-state distribution of capital across sectors for the initial set of parameters $\{p_1, K, L\}$. Given that the distribution of capital across sector is a state variable, equations (3), (5) and (6) at $t = 0$ are:

$$\begin{aligned} L &= L_{1,0} + L_{2,0} \\ r_{1,0} &= p_1 F_K(K_1^*, L_{1,0}) \\ r_{2,0} &= F_K(K_2^*, L_{2,0}) \\ w_0 &= p_1 F_L(K_1^*, L_{1,0}) = F_L(K_2^*, L_{2,0}) \end{aligned}$$

These equations correspond to those of the RV model, where capital is specific. They allow us to solve for $L_{1,0}$, $L_{2,0}$, w, $r_{1,0}$ and $r_{2,0}$ as functions of $\{p_1, K_1^*, K_2^*, L\}$. Therefore, the time-zero effects of changes in parameters are those described by the RV model. ■

3 Transitions

In this section, we provide numerical examples of transitions produced by the model as a consequence of unanticipated and permanent changes in factor endowments or output prices. These exercises provide intuition on the relationship between short- and long-run effects of these parameter changes. We assume that all production functions are Cobb-Douglas: $F^1(K_1, L_1) = K_1^{0.3} L_1^{0.7}$, $F^2(K_2, L_2) = K_1^{0.7} L_1^{0.3}$, $G(x_1, x_2) = x_1^{0.5} x_2^{0.5}$. Moreover, we set $u(c) = \ln c$, $\beta = .96$ and $T(i/k) = i/k$. The adjustment cost function is therefore $(i/k)T(i/k) = (i/k)^2$.

The exogenous variables are chosen to be initially $p_1 = K = L = 1$. This gives rise to a steady state in which everything is symmetric: both sectors have the same size[6] and the economy is not willing to trade with the rest of the world, i.e., $x_1 = F^1(K_1, L_1)$ and $x_2 = F^2(K_2, L_2)$. Taking this steady state as the starting point, we conduct two experiments: (i) a change in the factor supply (10% increase in the capital endowment); and (ii) a change in terms of a trade (10% increase in the relative price of good 1).[7]

[6] In this initial situation, the value of output of sector 1 coincides with that of sector 2. Sector 1 employs 70% of the labor endowment and 30% of the capital endowment.

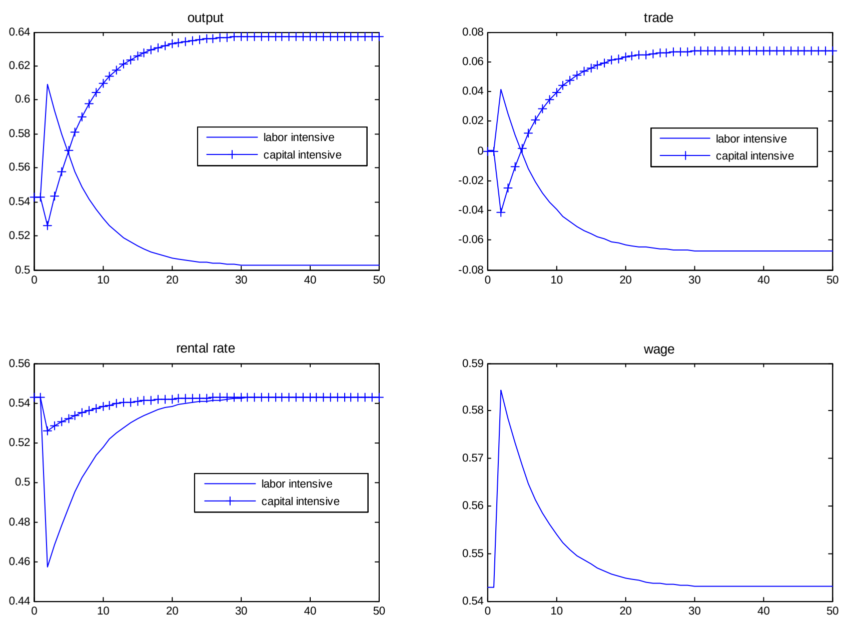
[7] Results from other experiments (such as an increase in L) are available upon request.

3.1 A 10% increase in the capital endowment

RV and HO models provide very different implications regarding changes in factor endowments. For instance, according to the RV model, an increase in the supply of capital leads to a fall in rental rates and an increase in wages. On the other hand, the HO model predicts that factor prices will be insensitive to changes in factor endowments. This example shows that these two implications can be obtained in our framework, following the short-run long-run distinction discussed above. We assume that the injection of capital takes place in the labor intensive industry, i.e., the additional capital is specific to sector 1 in the short run.

Transition paths for this exercise appear in Figure 1. We present time series for sectoral outputs, trade, rental rates and wages. Trade is defined as the difference between domestic production and use of each tradeable good $j = 1, 2$, that is, $F^j(K_j, L_j) - x_j$.

Figure 1



In the short run, the higher availability of capital resources in sector 1 creates incentives for expansion of this industry: labor flows from sector 2 to sector 1, which experiences an increase in output at the expense of the other sector. The economy becomes an exporter of the labor intensive good and importer of the capital intensive good. As a result of the expansion of industry 1, demand for labor rises, leading to higher wages. Therefore, to satisfy the zero profits condition, rental rates decline, especially in the labor intensive sector.

In the transition, capital flows towards the capital intensive industry, where the rental rate is higher. Along the simulated path, this sector expands and the labor intensive sector contracts. In this process, sector 1 releases too much labor relative to sector 2 necessities. As a result, wages fall and rental rates rise during the transition.

In the long run, rental rates are again equalized. Compared with pre-shock values, the economy displays higher output in the capital intensive industry, lower output in the labor intensive industry and same factor prices. The country now exports the capital intensive good and imports the labor intensive good.

Notice the difference between short run and long run regarding the effects on sectoral outputs. In the RV model, comparative advantage is driven by differences in sectoral endowments of the specific factor. Since the shock provides extra resources to the labor-intensive sector, the country develops a comparative advantage in producing this good, thus becoming a net exporter of the labor-intensive product. These effects can be seen at $t = 0$ in Figure 1. Nevertheless, in the HO model, comparative advantage is given by factor endowments: the extra resources make the country relatively capital-abundant and, therefore, a net exporter of the capital-intensive good, which is consistent with our results for the new steady state.

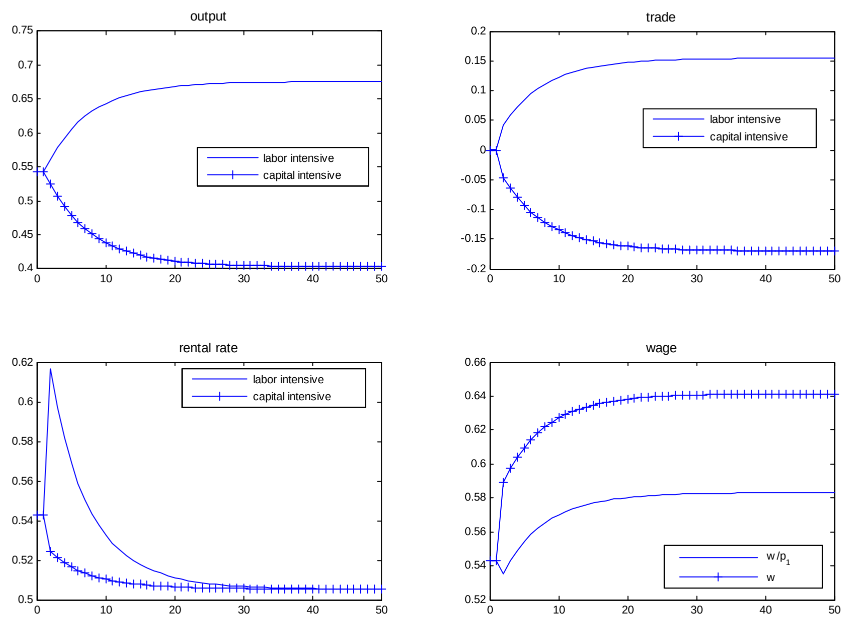
We have also analyzed the case in which the additional capital resources are sector 2 specific (available upon request). Results are very similar for $t \geq 1$. In particular, we have the same long-run equilibrium, since specificity of capital does not play any role in steady state. However, in the short run, the higher availability of capital in sector 2 leads an expansion of this industry and contraction of sector 1.

3.2 A 10% increase in the relative price of good 1

RV and HO models also have important differences regarding their predictions for changes in terms of trade. In particular, according to the RV model, an increase in the relative price of the labor intensive good will benefit the specific capital of this industry, and harm the specific factor of the other industry. The effect on real wages is indeterminate, since they rise in units of the capital intensive good, and fall in units of the labor intensive good. However, in the HO model, rental rates fall and the real wages rise unequivocally. Once more, this example shows the two effects in our model – at $t = 0$ for the RV model and at $t = \infty$ for the HO model.

Given that initially the economy does not trade with the rest of the world, we can interpret this case as a trade liberalization exercise. In other words, $p_1 = 1$ is the relative price under autarchy; an increase in p_1 then implies that, under free trade, the country has comparative advantage in production of the labor intensive good. Figure 2 displays results for this example. In addition to the time series reported in the previous case, we present paths for the wage both in terms of good 1 (w/p_1) and in terms of good 2 (w).

Figure 2

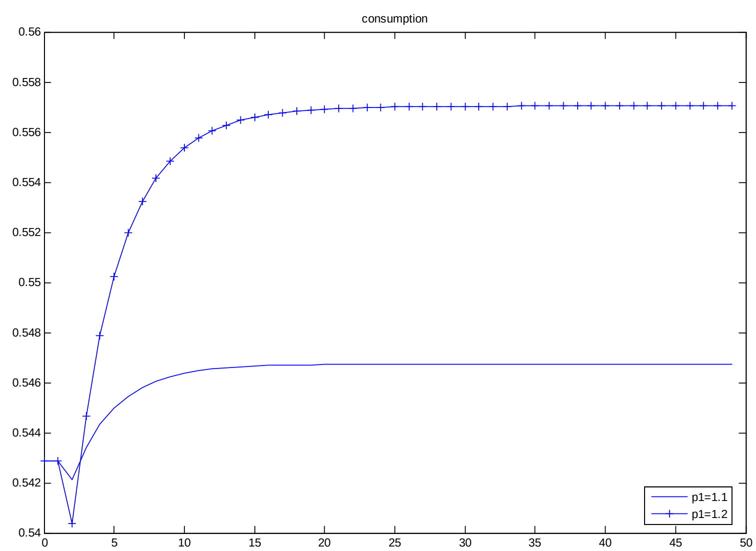


As a result of the increase of its relative price, sector 1 expands at the expense of sector 2. In the short run, this takes place through the movement of labor from sector 2 to sector 1. The increase in p_1, combined with the lower capital-labor ratio, leads to an increase in the rental rate in sector 1. On the other hand, the rental rate falls in sector 2, given the increase in its capital-labor ratio. To preserve zero profits, wages (in terms of good 2) rise, but proportionately less than the increase in p_1.

During the transition, capital flows towards sector 1 in response to the difference in rental rates, leading to a further increase (decrease) in the output of sector 1 (sector 2). In this process, sector 2 releases too much capital relative to the needs of sector 1. As a result, rental rates follow a falling path and wages follow an increasing path. In the long run, rental rates converge to a level lower than initially, and wages increase in terms of both goods.

We also analyze the effects of the trade liberalization on the path of consumption. This allows us to assess short- and long-run welfare implications of the model as a consequence of the policy change. Figure 3 displays the results. In addition to the 10% increase in the relative price ($p_1 = 1.1$), we report results for the case in which this price increases by 20% ($p_1 = 1.2$). In the long run, the model generates the usual welfare gains predicted by the HO theory. In particular, the economy with higher price increase reaches a higher long-run consumption level, given that it has stronger comparative advantage in the production of good 1.

Figure 3



Nonetheless, this outcome is intimately related to the assumption of costless mobility of factors in the long run. Specifically, our example also shows that the liberalization may entail short-run costs, which arise from the reallocation of capital across sectors. These costs are higher when p_1 increases by 20%, since this change requires a larger movement of capital towards sector 1 during the transition to the new steady state.

4 Conclusion

We proposed a dynamic general equilibrium model capable of delivering key predictions of both Ricardo-Viner and Heckscher-Ohlin theories in a single framework. In particular, our model is based on a simple 2-sector 2-factor trade model with adjustment costs associated with the movement of capital across sectors. Factor endowments and output prices are taken as exogenous parameters. Given an initial steady state, we analyzed the economy's response to changes in this parameters.

We showed that the model behaves according to the Ricardo-Viner theory in the short run – the moment of the parameter change – but according to the Heckscher-Ohlin theory in the long run – the steady state determined by new set of parameters. This follows because capital cannot move in the short run, given that the distribution of capital across sectors is taken as a state variable. This feature is consistent with the assumption of capital specificity which distinguishes the RV model. On the other hand, the absence of adjustment costs in steady state implies that capital is fully mobile in the long run, which is consistent with the HO framework. We also presented some numerical examples of transitions, which provided intuition on the relationship between short- and long-run effects of changes in parameters.

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