EVALUATING MARKET DISTORTIONS WHEN EXPECTATIONS ARE ADAPTIVE: COMPARATIVE-STATICS OR DYNAMICS?

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Abstract

We analyse the welfare outcomes of market distortions when expectations are adaptive, using a general-equilibrium model of a small, open economy that captures the trade-theoretic continuum from specific factors to Heckscher-Ohlin. We show that evaluating market distortions in a dynamic framework incorporating structural change and imperfect factor mobility will generate welfare effects that contradict those generated by a comparative-static framework. Further, the degree of factor mobility influences the size of the welfare effects. Our results suggest that the degree of factor mobility should be treated as a parameter in dynamic analysis whose value is uncertain and subjected to sensitivity analysis.

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1. Introduction

It is well established in trade theory that in standard two good, two factors of production models of small, open economies (e.g., specific factors, Heckscher-Ohlin), free trade is welfare maximising (Johnson 1960; Corden 1974; Vousden 1990; Krugman and Obstfeld 2003). A similar result holds for simple two-good exchange models; the optimal tax rate on any good is zero. These conclusions are confirmed within comparative-static partial- and general-equilibrium frameworks. But do these results hold in the presence of two phenomena that are commonly observed in most economies: (i) ongoing structural change; (ii) imperfect factor mobility?

Structural change is a well-documented empirical phenomenon; see Silva and Teixeira (2008) for the seminal survey of the economics literature on structural change. Such change can take many forms. This includes (but is not limited to): a changing composition of production techniques over time; a changing composition of primary factors in production over time; a changing composition of output and investment over time; and a changing composition of spending patterns over time. These forms of structural change have been variously attributed to: biased and Hicks-neutral technological change; changes in relative factor endowments; differential rates of technological change across sectors; and rising per-capita incomes and their interaction with differential income elasticities across commodities. The common theme in these forms of structural change is a “changing composition...over time”. Thus, structural change is an intrinsically dynamic concept.

Imperfect factor mobility is also a well-documented empirical phenomenon. For the European Union (EU), a group of nations with a greater than average degree of economic integration, imperfect factor mobility manifests itself in large and persistent regional disparities in rates of participation, unemployment, and employment creation. Further, large disparities in

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1 The following discussion of the nature and causes of structural change is largely drawn from Silva and Teixeira (2008) and relies on the survey of the literature on structural change contained therein.
incomes also persist across Union members. Possible causes of less-than-perfect factor mobility for economically integrated groups of nations, such as the EU, include: language and cultural barriers; regulatory barriers to integrated factor markets; transportation, information and other costs; and illiberal migration policies (Begg 1995; Wildasin 2000).

Less-than-perfect interregional factor mobility has also been identified within nation-states. For the United States (US), interregional factor mobility improved over the course of the 20th century consistent with improvements in transportation and communication. Interindustry factor mobility varied considerably in the US over the 19th and 20th centuries: mobility increased sharply during the 19th century due to improvements in transportation and the introduction of factory production; mobility declined during the 20th century due to the greater reliance on specialised equipment and knowledge (Hiscox 2002). With regard to other countries, interindustry factor mobility in Great Britain, France, Sweden, Canada and Australia exhibited marked cross-national differences over the 19th and 20th centuries; but it also exhibited historical trends broadly similar to those identified by Hiscox (2002) for the US, and for the same reasons (Hiscox 2001). As with the EU, imperfect interregional and interindustry factor mobility manifests itself through persistent differentials in factor returns and utilisation, i.e., over time. Thus, like structural change, imperfect factor mobility is an intrinsically dynamic concept.

Given that both structural change and imperfect factor mobility are dynamic concepts, understanding their importance on the welfare-maximising outcome for market distortions requires their evaluation within an explicitly dynamic framework. While comparative-statics can provide equilibrium solutions before and after any displacement of equilibrium, it provides no information about the time path between solutions. Further, it cannot represent, in a meaningful sense, the way that economic systems evolve over time, e.g., ongoing structural change, the gradual movement of factors across activities, etc. To properly evaluate such dynamic concepts we must apply a dynamic framework.
The main and, arguably, the most important feature of modern dynamic economic analysis is the incorporation of forward looking behaviour or rational expectations (Barro 1989, p. 1). Rational expectations now underpins large research streams in economics, such as the real business cycle framework (McCallum 1989) and modern macroeconomics (Blanchard and Fisher 1989). The dynamic concepts of structural change and imperfect factor mobility and their effect on the welfare-maximising outcome for market distortions under rational expectations has been investigated from various perspectives.

Kemp and Shimomura (2003) show how firms solve their dynamic optimisation problem taking into account the costs of adjustment, and that the leading comparative-static propositions of descriptive Heckscher-Ohlin theory hold with costly reallocation only if they are interpreted as comparative steady-state propositions. Chen and Shimomura (1998) show how to model movement of factors of production when workers have rational expectations about future wages, and choose their strategy of investment in skills. Doi et al. (2007) use an endogenous growth model that explains the joint determination of long-run trade patterns and world growth rates; and shows that the main standard trade propositions hold with some modifications. Nishimura and Shimomura (2006) show that indeterminacy and Pareto suboptimality can arise in a simple competitive two-country dynamic model of international trade, free of externalities, imperfect competition, and government intervention, due to the assumption of no international credit market. The result cannot be generated in a static trade model with equivalent assumptions.

The above-mentioned studies are important in helping to understand the results generated by the voluminous economic literature that incorporates rational expectations.² But much applied economic analysis evaluating market distortions is still conducted using comparative-statics. Further, where a dynamic framework is applied, it commonly incorporates adaptive expectations

² A recent search on Google Scholar for the term “rational expectations” resulted in 80,300 matches.
rather than intertemporal optimisation. Rather than intertemporal optimisation. Thus, a valid research question is “what is the effect of dynamic phenomena, such as structural change and imperfect factor mobility, on the welfare-maximising outcome for market distortions when expectations are adaptive?” To our knowledge, the question has not been addressed to date. To do so, we adopt the simplest form of dynamics; a recursively-dynamic discrete-time framework with no changes in stocks and where agents hold adaptive expectations. This allows for a minimum point of departure from comparative-statics, which allows for transparency in comparing the effects of comparative-statics with adaptive-expectations dynamics.

In testing the welfare-maximising outcome for market distortions, we apply a general-equilibrium model with only one type of agent, producers, who are competitive and efficient, i.e., they are price-takers and they earn no pure profits. Domestic prices are set internationally so that the economy is both small and open. With the appropriate choice of parameter values, the degree of factor mobility varies so that the model captures the extremes of specific factors and Hecksher-Ohlin, as well as degrees of mobility in between. We initially generate the standard result for market distortions imposed in a small, open economy, within a specific factors and Hecksher-Ohlin framework and also an in-between framework. We then allow for structural change and varying degrees of factor mobility within a dynamic framework, and test the importance of the two dynamic phenomena on the welfare-maximising outcome.

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3 Studies analysing market distortions for a broad range of commodities assuming adaptive expectations include: agriculture, manufacturing and services (Francois et al. 2005); agriculture (Kilkenny and Robinson 1990); industrial products (Fernandez de Cordoba et al. 2005); textiles and apparel (Trela and Whalley 1990); sugar (Elobeid and Beghin 2006); wheat (Gomez-Plana and Devadoss 2004); rice (Sumner and Lee 2000); cotton (Pan et al. 2007).

4 Recursively-dynamic models are multi-period models in which results are computed one period at a time. In contrast, fully intertemporal models compute results simultaneously for all periods.
2. A stylised general-equilibrium model

2.1 Theory, data and closure

Our model depicts the supply side of a small, open economy with two industries \((i = 1, 2)\) and two factors of production – labour \((L_i)\) and capital \((K_i)\). The return to labour is in the form of an economywide wage \((W)\), whereas rentals to capital \((Q_i)\) can be sector specific. Both industries are competitive and so take \(W\) and \(Q_i\) as given; they also take their output price \((P_i)\) as given. Output \((X_i)\) technology is characterised by a Cobb-Douglas function with homogeneity of degree one in \(L\) and \(K\). Both producers are efficient and so aim to maximise profits \((\pi)\),

\[
\pi = P_i X_i - WL_i - Q_i K_i. \tag{1}
\]

The producers’ problem is to choose output \(X_i\) subject to

\[
X_i = \frac{K_i^\alpha L_i^{-\alpha}}{A_i}, \quad (\alpha = 0.2), \tag{2}
\]

\[
X_2 = \frac{K_2^\beta L_2^{-\beta}}{A_2}, \quad (\beta = 0.8). \tag{3}
\]

\(A_i\) is the input-output coefficient for the \(i\)-th industry, i.e., solving (2) for \(A_i\) gives

\[A_i = K_i^\alpha L_i^{-\alpha} / X_1.\]

Reductions in \(A_i\) imply a productivity improvement for the \(i\)-th industry and vice versa; thus, \(A_i\) allows us to model sector-specific technical change.

As the capital technology parameters \(\alpha\) and \(\beta\) are set at <1, the model is characterised by diminishing returns in each factor separately. Nevertheless, the production functions exhibit constant returns to scale in both factors together as the capital and labour technology exponents sum to one for each producer. With \(\alpha \neq \beta\), different production technologies are employed in
each sector such that good 1 is labour intensive and good 2 is capital intensive. This also results
in a non-linear production possibilities frontier (PPF).

Substituting (2) into (1), finding the first-order condition with respect to \( L_1 \) and rearranging
gives the optimal \( L_1 \) for profit maximisation:

\[
L_1 = (1 - \alpha)^{\frac{1}{\alpha}} \left( \frac{P_1}{W_A} \right)^{\frac{1}{\alpha}} K_1. \tag{4}
\]

Together with the production function, (4) determines both \( L_1 \) and \( K_1 \). It implies

\[
\frac{K_1}{L_1} = (1 - \alpha)^{\frac{1}{\alpha}} \left( \frac{W_A}{P_1} \right)^{\frac{1}{\alpha}}. \tag{5}
\]

Linearising (5) gives

\[
k_1 - l_1 = \left( \frac{1}{\alpha} \right) \left( w + a_1 - p_1 \right),
\]

where lower-case symbols are the percentage change equivalents of upper-case symbols. Thus,
changes in \( K_1/L_1 \) are a positive function of \( (W_A/P_1) \) adjusted by the inverse of the capital-
output ratio \( (1/\alpha) \).\(^5\) Note that \( (W_A/P_1) \) is the ‘effective’ price of labour relative to the output
price, where effective means that the wage rate is adjusted for any changes in technology.

\(^5\) Normally we would use the first-order condition for \( L_1 \) to solve for \( K_1 \), then insert the resulting expression for \( K_1 \)
into the first-order condition for \( K_1 \), and then solve for the optimal \( L_1 \). But as we are assuming constant returns to
scale in both factors together \((1 - \alpha + \alpha = 1)\), such a strategy will yield no expression for the optimal \( L_1 \). This is
avoidable if we solve the producer’s problem as one of constrained maximisation. Nevertheless, solving the
producer’s problem as an unconstrained maximisation problem allows us to generate expressions explaining the
capital-labour ratio directly without further manipulation of the demand functions for capital and labour.
Via symmetry, the capital-labour ratio for industry 2 will equal

\[
\frac{K_2}{L_2} = (1 - \beta)^{\frac{1}{\beta}} \left( \frac{W_A}{P_2} \right)^{\frac{1}{\beta}}.
\]  

(6)

Although rental rates do not enter (5) and (6), the assumption of zero pure profits provides the necessary link between capital usage and the cost of capital:

\[
P_iX_i = WL_i + Q_iK_i, \ (i = 1, 2).
\]

(7)

If \(\frac{WA_i}{P_i} \ (i = 1, 2)\) rises due to a rise in \(W\), both firms will attempt to substitute capital for labour. This will in turn drive up \(Q_i \ (i = 1, 2)\) and therefore \(P_i \ (i = 1, 2)\); but the rise in \(P_i \ (i = 1, 2)\) will be less than the rise in \(Q_i \ (i = 1, 2)\)\(^6\) and the rise in \(P_2\) will be greater than the rise in \(P_1\) as \(\frac{K_2}{X_2} > \frac{K_i}{X_i}\). The increase in \(P_i \ (i = 1, 2)\) will moderate the rise in \(\frac{WA_i}{P_i} \ (i = 1, 2)\) and both firms will moderate their substitution of capital for labour, but the moderation will be greater for the capital-intensive industry \((i = 2)\).

Differences in rental rates between industries depend on investors’ appetite for risk. If investors have an insatiable appetite for risk, they will reloca te capital between industries until

\[
Q_1 = Q_2,
\]

(8)

in order to fully exploit differences in \(Q_i\) between industries without regard for risk; this implies perfect capital mobility between industries and therefore perfect mobility of both factors of production, i.e., the model approximates the Hecksher-Ohlin model. If investors have a finite appetite for risk, they will relocate capital between industries but \(Q_1 \neq Q_2\). If investors have no

\(^{6}\) Here we are assuming that \(Q_1 = Q_2\), so that capital is perfectly mobile between industries.
appetite for risk, then $K_1/K_2$ will remain constant and capital will be completely sector specific and immobile between industries; this approximates the specific-factors model.\footnote{The specific-factors model is specified with three factors (land, labour and capital) and two goods (Jones 1971, Samuelson 1971). Labour is perfectly mobile and used by both sectors (as it is here), whereas capital and land are specific to different sectors. Thus, with $K_1/K_2$ constant, capital is specific to each sector and industry 2 is the industry intensive in the use of the specific factor. So here capital plays the twin role of capital and land in the specific-factors model.}

When solving the model for risk loving investors, we apply (8). For all other investor preferences, we solve the model by imposing the condition

$$\frac{K_1}{K_2} = B \left( \frac{Q_1}{Q_2} \right)^\theta, \quad (9)$$

where $\theta$ is a parameter that represents the preference for risk by investors and $B$ is a positive parameter. When $\theta = \infty$, $Q_1 = Q_2$ in (9); this is consistent with (8). When $\theta = 0$, $K_1/K_2$ is fixed and $Q_1 \neq Q_2$; this is consistent with a zero appetite for risk by investors. For $0 < \theta < \infty$, investors’ appetite for risk is reflected by the size of $\theta$; larger values reflect a greater appetite for risk and smaller differences in $Q_i$ between industries, and vice versa. This implies imperfect capital mobility and intersectoral movements of capital are related to rentals in a way that sees capital move to the more profitable industry.

For all values of $\theta$ the PPF will be non-linear and quasi-concave. For smaller values of $\theta$ the PPF will exhibit sharper curvature reflecting a higher opportunity cost of good 1 in terms of good 2 at every allocation of factors; we discuss this further below.

Aggregate capital and labour are fixed and fully utilised. Total capital ($K$) and labour ($L$) are defined as

$$K = K_1 + K_2, \quad (10)$$

$$L = L_1 + L_2. \quad (11)$$
Domestic prices \( (P_i) \) are based on world prices \( (PI_i) \), indirect taxes \( (T_i) \) and the nominal exchange rate \( (E) \):

\[
P_i = EPI_iT_i, \quad (i = 1, 2).
\]  

Indirect taxes are *ad valorem* and \( T_i \) represents the power of the tax \( (1 + t_i) \), where \( t_i \) is the tax rate on good \( i \). All variables determining \( P_i \) are exogenous: \( E \) is the numeraire; \( PI_i \) is assumed to be independent of decisions in the domestic economy; \( T_i \) is a policy instrument. With a fixed international price ratio \( PI_i/PI_2 \), any non-unitary value for \( T_i \) will only distort domestic production decisions and will have no international terms-of-trade implications. So whilst it is assumed that both goods are tradable and that producers are price-takers, no explicit assumption is made in regard to a specific import-competing industry, or export industry; given our assumption of a fixed \( PI_i \), this is not necessary. Consequently, \( T_i > 1 \) will have the same effects as an export subsidy or an import tariff in a model with endogenous international terms-of-trade, i.e., it will raise the domestic price of good \( i \) and encourage resources to move to industry \( i \).

To avoid complicating the analysis with more structure than necessary, there is no utility function or demand side in the model. Consequently, in contemplating welfare issues we apply revealed preference and examine consumption possibilities. Consumption possibilities are maximised when firms maximise the value of output measured in world prices relative to the initial equilibrium. Thus welfare \( (U) \) is defined as follows,

\[
U = \frac{(PI_1X_1 + PI_2X_2)}{(PI_1\bar{X}_1 + PI_2\bar{X}_2)}.
\]
where the $\mathbf{X}$'s are the initial levels of output of each commodity.\textsuperscript{8} The numerator in (13) measures income (or output) at world prices and the denominator measures initial income at world prices. (13) captures a change in $X_1/X_2$ with no corresponding change in $PI_1/PI_2$, say, due to an import tariff, as a decrement in welfare.

The model contains $(8i + 5)$ variables in $(4i + 4)$ equations; the equations are (2)–(3), (5)–(13). To close the model, we need $(4i + 1)$ variables set as exogenous; these are $E$, $PI$, $T$, $K$, $L$, and $A$. Following the normalisation convention established by Harberger (1962), we set the initial values of all prices to one. The powers of both taxes are also set to one indicating zero tax rates in the initial equilibrium. To avoid spurious welfare effects in model solutions, the initial solution is chosen so as to ensure the model begins in equilibrium. With equal or zero tax rates and equal world prices (and hence equal domestic prices), the economy begins in equilibrium and operates at the point where the value of total output $\left(P_1X_1 + P_2X_2\right)$ is maximised. Given the other parameters in the model, the optimal initial values of $X$ are 0.6063. All simulations start from this initial equilibrium.

\textsuperscript{8} Note that (13) does not include revenue raised (paid) by a positive (negative) tax. With no demand side, any such revenue is returned in the form of a lump-sum payment. This is easily shown by reference to (7), which forces the value of output in domestic prices $\left(\sum_i P_iX_i\right)$ to equal total factor payments in the economy $\left(\sum_i WL_i + \sum_i Q_iK_i\right)$. This can be reinterpreted as equality between total income of producers and total expenditure by factor owners. Thus, there is no gap between income and expenditure that normally represents taxation revenue.
2.2 Comparative-static and recursively-dynamic solutions

The model represented by equations (2)–(3), (5)–(13) specifies behavioural and definitional relationships. There are \( m (= 4i + 4) \) such relationships involving a total of \( p (= 8i + 5) \) variables. Of the \( p \) variables, \( e (= 4i + 1) \) are exogenous. The \( e \) variables can be used to shock the model to simulate changes in the \( m (= p – e) \) endogenous variables. The system can be compactly written in matrix form as

\[
F(N, X) = 0, \tag{14}
\]

where \( F \) represents a \( m \times p \) matrix of differentiable functions, \( N \) is a vector of endogenous variables, \( X \) is a vector of exogenous variables, and \( 0 \) is the \( p \times 1 \) null vector. Assume that the system represented by (14) has a solution in the neighbourhood of the values described in Section 2.1. We call this the initial solution and represent it by the vectors \((N^I, X^I)\). If we perturb the model by choosing new values for some of the exogenous variables, represented by \( X^F \), we have a new solution represented by

\[
F(N^F, X^F) = 0. \tag{15}
\]

The system represented by (15) is the comparative-static solution to our model. In moving from the initial solution (14) to the final (or new) solution (15), we calculate

\[
\Delta N = F(N^F, X^F) – F(N^I, X^I), \tag{16}
\]

which tells us the effects on the endogenous variables.

Imagine we now wish to calculate a series of recursively-dynamic solutions. Working with (16), we rewrite it as

\[
\Delta N_t = F(N^F_t, X^F_t) – F(N^I_t, X^I_t), \quad t = 0. \tag{17}
\]

Equations (17) represent the same solution as (16), except they are for the first period of a \( T \) period solution calculation. For \( t = 1 \) (the second period of a \( T \) period solution), we set \( N^I_{t=1} = N^F_{t=0} \) and \( X^I_{t=1} = X^F_{t=0} \). That is, we use the final solution for \( t = 0 \) as the initial solution for \( t = 1 \).
We then calculate $\Delta N_t$ for $t = 1$ as in (17), which will be based on $N_{t-1}^F$ and $X_{t-1}^F$. For $t = 2$, we set $N_{t-2}^I = N_{t-1}^F$ and $X_{t-2}^I = X_{t-1}^F$, and repeat the same procedure as for $t = 1$. This process is then repeated ($T-3$) times whereupon we have $T$ period recursively-dynamic solutions.

In calculating comparative-static solutions, we treat the model as an initial value problem and integrate the equation system. To treat the model as an initial value problem we need only to have at least one known solution of the equation system (Malakellis 2000, p. 124). That solution is the one generated using the initial values for all variables described in Section 2.1. In calculating recursively-dynamic solutions we are linking a series of multi-period solutions; here we are integrating the equation system through time. The solution technique gives us a recursive-dynamic framework.9

2.3 Factor mobility and production possibilities

The appetite for risk by investors affects the degree of capital mobility, which, in turn, affects production possibilities. If capital is perfectly mobile ($\theta = \infty$) and $\alpha \neq \beta$, the PPF will be non-linear and quasi-concave as shown by the solid line PPF in Figure 1. Thus, moving resources from industry 1 to industry 2 will result in $|\Delta X_1| > |\Delta X_2|$ reflecting diminishing returns in both labour and capital as they move from $X_1$ to $X_2$, i.e., a diminishing marginal rate of transformation (MRT). A diminishing MRT indicates that expanding the production of the capital-intensive good 2 requires transferring more and more labour and capital away from the labour-intensive good 1, so that the ratio of the inverse of the (absolute value of the) marginal products, $MP_2/MP_1$, falls as we “transform” good 1 into good 2.

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9 The model is implemented using the GEMPACK economic modelling software (Harrison and Pearson 1996).
If we now assume capital is perfectly immobile \( (\theta = 0) \), the PPF will also be non-linear and quasi-concave but will exhibit greater curvature than before, as shown by the dashed line PPF in Figure 1; we can see this as follows. Imagine that the initial output mix is at point A in Figure 1, which is on the PPF for both economies, reflecting an equilibrium given an initial \( P_1/P_2 = \frac{P_1}{P_2} \). The initial \( P_1/P_2 \) is represented by the price line that is tangential to both PPFs at point A. Now increase the output of good 2. For a given increase in \( L_2 \), the (absolute value of the) slope of the transformation frontier will be decreasing, but will be decreasing faster the lower the degree of capital mobility; moving labour out of good 1 and into good 2 will increase \( MP_1 \) and decrease \( MP_2 \). But for the same movement of labour into production of good 2, less capital will be drawn out of sector 1 and into sector 2 the smaller is \( \theta \), so the decrease in \( MP_2 \) will be smaller the less mobile is capital. That is, for a given movement of labour out of sector 1 and into sector 2, the transformation frontier will be flatter the smaller the degree of capital mobility. For imperfectly mobile capital, \( 0 < \theta < \infty \), the PPF will lie between the dashed line and solid line PPFs in Figure 1; that is, it will exhibit less curvature than the perfectly immobile economy but more curvature than the perfectly mobile capital economy.
2.3.1 A change in relative prices

If we postulate a fall in $P_1/P_2$ (say, due to a tariff on good 2), with no change in $PI_1/PI_2$, as represented by the flatter price line in Figure 2, the perfectly mobile capital economy will move from point A in Figure 1 to point B in Figure 2; point A in both is identical. Point B represents a lower $X_1/X_2$, which is consistent with a lower $P_1/P_2$. Welfare at point B is lower than at point A given our definition in equation (13); for a given PPF, a change in $X_1/X_2$ with no change in $PI_1/PI_2$ will reduce welfare. Facing the same lower $P_1/P_2$, the best that the perfectly immobile capital economy can do is move slightly to the left of point A. This will also reduce welfare but by much less than the move from A to C. Thus, when these two economies are faced with the same distortionary shift in relative prices, the perfectly mobile capital economy reaches a lower level of welfare than the perfectly immobile capital economy, although welfare falls for both economies. Clearly, an imperfectly mobile capital economy will reach a welfare level between that represented by point A and point B in Figure 2.
2.3.2 A change in technology

If we postulate a productivity improvement in industry 1 \((\Delta A_i < 0)\), the PPF will bow outwards on the \(X_1\) axis; this is shown for the perfectly mobile and fixed capital economies in Figure 3. With no change in \(P_i/P_z\), both economies will move from point A to point C.\(^{10}\) Point C represents a higher \(X_1/X_2\), which is consistent with a higher \(A_i/A_z\). Welfare at point C is higher than at point A given our definition in equation (13); even though \(X_1/X_2\) has changed with no change in \(P_i/P_z\), the economy’s ‘effective’ supply of resources has increased thus increasing its consumption possibilities at given world prices.

\(^{10}\) This is not strictly true. The perfectly mobile capital economy will actually move to a slightly higher level of welfare than the other economies as the productivity improvement is industry specific. So the degree of factor mobility will matter for the new equilibrium as the optimal point is for a less than equal production pattern. In contrast, all economies will move to the same equilibrium for an industry-generic productivity improvement.
3. Evaluating market distortions

3.1 Comparative-statics

Applying the model outlined above, we initially impose a 10% import tariff (export subsidy) on good 2; Table 1 reports the results of comparative-static solutions with varying degrees of appetite for risk by investors and thus capital mobility; that is, \( \theta = \infty, \theta = 0, \theta = 1 \). The three \( \theta \) values represent perfectly mobile capital, fixed capital and imperfectly mobile capital. The choice of \( \theta = 1 \) for imperfect capital mobility results in \( K_1/K_2 \) moving proportionately with any change in \( Q_1/Q_2 \). We have no empirical justification for this parameter choice; it is purely a reference point between the two extremes of perfectly mobile and fixed capital.

| Table 1 Comparative-static solutions of a 10% import tariff/export subsidy on good 2 with varying degrees of capital mobility (percentage change) |
|---|---|---|---|---|---|---|
| Output | Labour | Capital | Wage | Rental | Welfare |
| good 1 | good 2 | indust 1 | indust 2 | indust 1 | indust 2 |-rate | indust 1 | indust 2 | |
| Perfect capital mobility (PCM: \( \theta = \infty \)) | | | | | | | | | |
| -8.70 | 8.33 | -5.72 | 22.87 | -19.81 | 4.95 | -3.15 | 13.53 | 13.53 | -0.18 |
| Imperfect capital mobility (ICM: \( \theta = 1 \)) | | | | | | | | | |
| -4.59 | 4.46 | -3.92 | 15.66 | -7.27 | 1.82 | -0.70 | 2.86 | 12.83 | -0.07 |
| Zero capital mobility (ZCM: \( \theta = 0 \)) | | | | | | | | | |
| -2.37 | 2.27 | -2.95 | 11.81 | 0.00 | 0.00 | 0.60 | -2.37 | 12.47 | -0.05 |

Source: model simulations.

With perfect capital mobility (PCM), we observe that the tariff on good 2 attracts resources into industry 2, whose output expands, and out of industry 1, whose output contracts. As industry 2 is capital intensive, the wage-rental rate falls for both industries; at the same time, the domestic price ratio \( (P_1/P_2) \) falls (not reported). Welfare is now lower as there is a divergence between the undistorted price ratio \( (P_1^*/P_2^*) \) and the MRT.

Where capital is imperfectly mobile (ICM) there is a smaller movement of resources due to \( T_2 = 1.1 \) Thus, the changes in industry output are also smaller. The wage-rental rate falls by less,
but now diverges between industries as the rental rate is specific for each industry; there is a
greater fall in industry 2’s wage-rental rate as it is capital intensive. The welfare loss is also
much smaller than for PCM, as predicted by the diagrammatic analysis in Section 2.3.

For zero capital mobility (ZCM), most effects, with one exception, are qualitatively similar
to those already observed but quantitatively smaller. The exception is the wage-rental rate for
industry 1, which now rises. For PCM and ICM, both labour and capital move out of industry 1
but more capital moves out of industry 1 than labour, so \( \Delta MP_1^k > 0 \) and \( \Delta MP_2^l < 0 \), which is
reflected in a lower \( W/Q_1 \). But for ZCM only labour moves out of industry 1 and so \( \Delta MP_1^k < 0 \)
and \( \Delta MP_1^l > 0 \), which is reflected in a higher \( W/Q_1 \).

Although the movement in resources in response to the import tariff is proportional to the
degree of capital mobility, the opportunity cost of those reallocated resources is asymmetrical
across the three economies. The opportunity cost can be measured by comparing \( MP_2/MP_1 \) for
each economy across the range of the PPF between the two equilibriums; the values are 0.9578
(PCM), 0.9707 (ICM), 0.9576 (ZCM). Thus, in giving up a unit of \( X_1 \), the PCM economy gains
only 0.9578 units of \( X_2 \) whereas the ZCM gains even less; this is consistent with the ZCM PPF
being flatter than the PCM PPF over the relevant range (see Figure 1). In contrast, the
opportunity cost for the ICM economy is lower than the other two economies. This indicates that
imperfect factor mobility limits the movement along the PPF to a range that has a lower
opportunity cost. That is, less movement along the PPF means that diminishing returns are not
confronted as quickly as in the PCM and ZCM economies.

The above ceteris paribus result also holds for a subsidy on the use of factors by industry 2.
Imposing a subsidy on the use of both factors by industry 2 is equivalent to imposing an output
tax on industry 2. With fixed \( PI_1/PI_2 \), subsidising \( L_2 \) and \( K_2 \) reduces the price of employing
factors facing industry 2 causing it to expand output. This leads to effects similar to those
already observed but the welfare loss will be smaller as $P_2$ will remain unchanged. Thus $X_1/X_2$ will not fall by as much.\footnote{A tariff on a good is equivalent to a domestic production subsidy plus a consumption tax on that good, and so causes a greater loss in welfare than just a production subsidy.} Thus, our qualitative results also hold for market distortions in general. Our results are also consistent with the discussion in Section 2.3. If a PCM economy faces a distorted relative price it will move from point A in Figure 1 to point B in Figure 2. A ZCM economy will only move slightly to the left of point A. When measuring the welfare loss in terms of the undistorted relative price (the price line in Figure 1), the PCM economy will have lower consumption possibilities than the ZCM economy. The result is intuitive: the more responsive is behaviour to a change in relative prices, the greater the resulting distortion in behaviour, and therefore welfare, from any given distortionary change in relative prices.

3.2 Comparative-dynamics: structural change in favour of good 2

We now compare dynamic solutions with different assumptions regarding structural change and factor mobility to assess the importance of these two dynamic phenomena on welfare in the presence of market distortions. Here we compare across dynamic solutions, i.e., we need to generate comparative-dynamic results and compare the outcomes. Comparative-dynamic results are the typical way that market distortions are evaluated in a dynamic framework; for some examples, see Ballard et al. (1985); Dixon and Rimmer (2002); Ishii et al. (1985); Kouparitsas (2001); and Walmsley et al. (2006). Comparative-dynamic results are where a baseline simulation is first run, which incorporates information on the future time path of the economy excluding any policy change, such as a market distortion. Then, a policy simulation is run that
incorporates the baseline time path plus the distortion to be evaluated. These two dynamic solutions are then compared to yield comparative-dynamic results.\textsuperscript{12}

To compare across dynamic solutions, we take as our baseline ongoing structural change as represented by industry-specific technical change of the order of 1% per annum. In this section we assume structural change that favours good 2. We then apply a market distortion on good 2 as our policy simulation. Finally we compare the two time paths of the economy. We do this for each of the three economies; Table 2 reports the results.

Table 2 Baseline results of annual 1% technical change for industry 2 (percentage change)

<table>
<thead>
<tr>
<th>Period</th>
<th>Output</th>
<th>Labour</th>
<th>Capital</th>
<th>Wage</th>
<th>Rental rate</th>
<th>Welfare</th>
</tr>
</thead>
<tbody>
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<td>ind 1</td>
<td>ind 2</td>
<td>ind 1</td>
<td>ind 2</td>
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<tr>
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<td>-0.33</td>
<td>1.35</td>
</tr>
<tr>
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<td>-2.91</td>
<td>11.63</td>
<td>2.68</td>
<td>6.92</td>
</tr>
<tr>
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<td>31.28</td>
<td>-9.51</td>
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<td>-4.90</td>
<td>22.23</td>
</tr>
<tr>
<td>25</td>
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<td>-17.31</td>
<td>69.22</td>
<td>-8.03</td>
<td>39.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perfect capital mobility (PCM: $\theta = \infty$)</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>4.66</td>
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</tr>
<tr>
<td>Imperfect capital mobility (ICM: $\theta = 1$)</td>
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<td>Zero capital mobility (ZCM: $\theta = 0$)</td>
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<td>-8.47</td>
<td>33.86</td>
<td>0.00</td>
<td>-6.83</td>
</tr>
</tbody>
</table>

Source: model simulations.

\textsuperscript{12} Note that comparative-dynamic results can be generated by recursively-dynamic models (such as that applied here) or by comparative-dynamic (or intertemporal) models (see footnote 4). Some of the dynamic analysis referenced above applies recursively-dynamic models (e.g., Dixon and Rimmer 2002) and others apply comparative-dynamic (or intertemporal) models (e.g., Ballard et al. 1985).
The baseline path for $X_1/X_2$ for each of the three economies reflects a shift in relative output in favour of good 2; however, as expected the shift is less marked the less mobile capital is between industries. Underlying these effects on relative outputs are changes in relative factor usage and prices that mirror the pattern of effects observed in the comparative-static solutions discussed in Section 3.1.

Figure 4 compares the baseline paths of welfare for the three economies. In period 1, the welfare gain is identical for all economies as predicted by Figure 3. Nevertheless, over time, we see slightly larger welfare improvements in the more mobile economies. For the least mobile economy (ZCM), slower resource reallocation leads to slightly lower growth rates in welfare. After 25 periods, PCM welfare has grown by 15.9%, ICM welfare by 15.4%, and LCM welfare by 14.7%. Figure 5 shows that the movements in welfare exactly mirror the movements in total output.

We now apply a tariff of 10% on good 2 and calculate the deviations from baseline over the 25 periods: Table 3 presents results at various points in time; Figures 6 and 7 present the time path of welfare and total output. Period 1 effects for each economy almost exactly match the comparative-static results discussed in Section 3.1 (Table 1). We see the import tariff on good 2 in period 1 distorts production in favour of good 2 and gives rise to welfare losses that are proportional to the assumed degree of capital mobility. Beyond period 1, the deviations in $X_1/X_2$ are relatively unchanged but do exhibit a slow continuous decline relative to baseline, and the rate of decline is proportional to the degree of capital mobility.
Table 3  Deviations from baseline of a 10% import tariff/export subsidy on good 2 with structural change favouring industry 2 (percentage change)

<table>
<thead>
<tr>
<th>Period</th>
<th>Output</th>
<th>Labour</th>
<th>Capital</th>
<th>Wage</th>
<th>Rental rate</th>
<th>Welfare</th>
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</thead>
<tbody>
<tr>
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<td>good 2</td>
<td>ind 1</td>
<td>ind 2</td>
<td>ind 1</td>
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<td>-4.18</td>
<td>11.44</td>
<td>0.00</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Note: PCM = perfect capital mobility; ICM = imperfect capital mobility; ZCM = zero capital mobility.

Source: model simulations.
In contrast, the welfare effects exhibit an asymmetrical response. The models embodying extreme assumptions regarding capital mobility (i.e., PCM and ZCM) exhibit welfare losses that, like relative output, are relatively unchanged over time. The model reflecting imperfect capital mobility exhibits annual welfare gains that by period 11 shows a zero welfare effect, and by period 25 shows a welfare gain of 0.1%. Thus, the standard trade models of Hecksher-Ohlin (PCM here) and specific factors (ZCM here) give a standard result when comparing dynamic equilibria; a non-standard trade model that assumes sluggishness in the movement of factors between industries (ICM) gives an unexpected result. We now observe the sluggish factor mobility case exhibiting the largest relative welfare gain, giving a new ranking from that observed with comparative-static solutions.
The asymmetrical results are a function of two effects. First, as observed in the comparative-static analysis earlier, when the distortion is imposed in period 1 the opportunity cost \( \frac{MP_2}{MP_1} \) of the reallocated resources is lower in the ICM economy than in the other two economies; this is shown in Figure 8, which plots the deviation in \( \frac{MP_2}{MP_1} \) for each economy.\(^{13}\) As before, this indicates that imperfect factor mobility limits the movement along the PPF to a range that has a lower opportunity cost relative to the movement observed in the PCM and ZCM economies.

![Figure 8 Deviation in MP\(_2/\)MP\(_1\)](image)

Note: PCM = perfect capital mobility; ICM = imperfect capital mobility; ZCM = zero capital mobility.

\(^{13}\) Note that the values of \( \frac{MP_2}{MP_1} \) calculated here represent the movement between two equilibriums on two different PPFs, whereas in the comparative-static results the values represented the movement between two equilibriums on the same PPF. Regardless, the values do inform us of the opportunity cost faced by each economy.
Second, once a welfare-enhancing change occurs in the absence of a market distortion from period 2 onwards, the increased production possibilities favour good 2. After the imposition of the import tariff on good 2 in period 1, \( \frac{X_2}{X_1} > 1 \) in all three economies. Thus, increased production possibilities favouring good 2 are more exploitable by an economy that is skewed towards the production of good 2 and faces a lower opportunity cost of increasing production of good 2. The ICM economy not only has a lower relative opportunity cost of increasing production of good 2, but it also has an opportunity cost of less than one, i.e., \( \frac{MP_2}{MP_1} > 1 \), as shown in Figure 8. Thus, from period 2 onwards, total output rises with technical change in industry 2 whereas it falls (very slowly) in the other economies.

3.3 Comparative-dynamics: structural change in favour of good 1

Here we compare dynamic equilibria where we apply a market distortion on good 2 in the presence of structural change that favours good 1. We know from the earlier analysis that structural change that favours a particular good will, over time, cause relative output to move in favour that good. We also know from the earlier analysis that the shift in relative output will be less marked the less mobile capital is between industries. We take these baseline effects as understood.

We again apply a tariff of 10% on good 2 and calculate the deviations from baseline over 25 periods; Figures 9 and 10 present the time path of the deviations in welfare and total output from baseline. The deviations in welfare for the PCM and ZCM economies are very close to those observed when structural change favours good 2 (the taxed good), whereas those for the ICM economy are the opposite of those observed when structural change favours the taxed good. As before, we see that the movement in welfare is a total function of the change in total output.
We now observe another form of asymmetry in the welfare effects of factor mobility and its interaction with structural change. Where capital is either perfectly mobile or fixed, the long-run loss is well approximated by the loss in period 1 in comparative-dynamic results or comparative-statics regardless of the direction of structural change. But where factor mobility is sluggish, the long-run welfare effect of a market distortion will depend on the underlying movements in the economy. If the market distortion favours a good that is experiencing favourable structural change then the market distortion will improve welfare in the long run. Whereas if the market distortion favours a good that is being disadvantaged by structural change, then the market distortion will increase the initial welfare loss over time.

The explanation for the asymmetrical results is the reverse of that given when structural change favoured the taxed good but it is still a function of two effects. First, as observed in the
comparative-static analysis earlier, when the distortion is imposed in period 1 the opportunity cost \( (MP_2/MP_1) \) of the reallocated resources is lower in the ICM economy than in the other two economies; this is shown in Figure 11, which plots the deviation in \( MP_2/MP_1 \) for each economy. This indicates that imperfect factor mobility limits the movement along the PPF to a range that has a lower opportunity cost of increasing production of good 2 relative to the movement observed in the PCM and ZCM economies.

![Figure 11 Deviation in MP_2/MP_1](image)

*Note:* PCM = perfect capital mobility; ICM = imperfect capital mobility; ZCM = zero capital mobility.

Second, once a welfare-enhancing change occurs from period 2 onwards, the increased production possibilities favour good 1. After the imposition of the import tariff on good 2 in period 1, \( X_2/X_1 > 1 \) in all three economies. Here, the increased production possibilities favouring good 1 are a disadvantage for an economy that is skewed towards the production of good 2 and faces a higher opportunity cost of increasing production of good 1, i.e., \( 1/(MP_2/MP_1) \). The ICM economy not only has a higher relative opportunity cost of increasing production of good 1, but it also has an opportunity cost of greater than one, i.e., \( MP_2/MP_1 > 1 \), as shown in Figure 11. Thus, from period 2 onwards, total output falls with technical change in industry 1 whereas it rises (albeit very slowly) in the other economies.
3.4 Comparative-dynamics: the relationship between factor mobility and welfare

Our results so far suggest that where capital is imperfectly mobile, there is a monotonic relationship between the degree of capital mobility and welfare for a given pattern of structural change. Here we test this proposition by deriving the relationship between $\theta$ and welfare for a given pattern of structural change, by performing a grid search for $\theta$ in the range $1 \leq \theta \leq 5$ using a uniform grid where the distance between grid points is one.

Figures 12 and 13 plot these results and also include the results for $\theta = 0$ and $\theta = \infty$ for reference. We see that for a given pattern of structural change, higher degrees of capital mobility will decrease welfare gains from the tariff on good 2, whereas higher degrees of capital mobility will increase welfare losses from the tariff on good 2 up to a point ($\theta = 2$) and then decrease them. Furthermore, the time path of positive welfare deviations will “flatten” as capital is assumed to be more mobile until it approaches the time path of perfect capital mobility. In contrast, the time path of negative welfare deviations “steepen” as capital is assumed to be more mobile up to a point ($\theta = 2$) after which they again “flatten”.

These results suggest that for a given pattern of structural change there is a monotonic relationship between the degree of capital mobility and positive welfare deviations where $0 < \theta < \infty$, but the relationship is non-monotonic for negative welfare deviations. For $0 \leq \theta \leq \infty$, the relationship between the degree of factor mobility and welfare is highly non-linear relationship in the presence of structural change, regardless of the nature of the structural change. The sensitivity analysis reinforces the earlier findings suggesting that the degree of factor mobility be treated as a parameter and subject to sensitivity analysis when evaluating the welfare effects of market distortions. As such, comparative-dynamic analyses that assume perfect interindustry factor mobility, which applies to most of the references cited at the beginning of Section 3.2, are likely to be overestimating the welfare effects of market distortions when
structural change favours the taxed good, and underestimating the welfare effects of market distortions when structural change disadvantages the taxed good.

4. Conclusion

We evaluate the adaptive-expectations welfare-maximising outcome of market distortions in the presence of two commonly observed empirical phenomena: (i) ongoing structural change; and (ii) imperfect factor mobility. Our analytical framework applies a simple, general-equilibrium model with two goods and two factors of production, representing a small, open economy. To our knowledge, these issues have not been evaluated in an adaptive expectations framework.

Traditional welfare analysis of market distortions ignores the possible importance of structural change and imperfect factor mobility on welfare outcomes. Here we test the importance by comparing the welfare effects of comparative-static solutions, which cannot explicitly account for structural change and imperfect factor mobility, with recursively-dynamic solutions, which do explicitly account for structural change and imperfect factor mobility. The comparison demonstrates that the degree of factor mobility strongly affects the sign of the welfare effect when assessing market distortions. Comparative-static solutions predict that market distortions always yield lower welfare and that the welfare loss is greater the greater the degree of factor mobility.

Our analysis of welfare outcomes using comparative-dynamic analysis (which compares baseline and policy simulations to evaluate perturbations to the economy) under different assumptions regarding structural change and factor mobility finds a non-monotonic relationship between the degree of capital mobility and welfare for a given pattern of structural change. For a given degree of imperfect factor mobility, structural change that favours the taxed good can, over time, generate welfare gains, whereas structural change that disadvantages the taxed good can,
over time, generate welfare losses. As the degree of factor mobility is decreased, the welfare gains generated by structural change favouring the taxed good will increase and the welfare losses generated by structural change disadvantaging the taxed good will also increase up to a point and then begin to decrease.

Our findings suggest that market distortions evaluated using comparative-statics should treat the degree of factor mobility as a parameter that is subject to uncertainty and be subjected to sensitivity analysis. Nevertheless, structural change cannot properly be captured in a comparative-static framework. Thus, if information on structural change is available, it should be incorporated into the analysis of market distortions by applying a dynamic framework. Here, also, the degree of factor mobility should be the subject of sensitivity analysis given the non-monotonic relationship between the degree of factor mobility and welfare in the presence of structural change. Where imperfect factor mobility and structural change are not explicitly captured in the analytical framework evaluating market distortions, it is likely that spurious welfare effects will be generated.
References


