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Regional Equality and National Development in China: Is There a Trade-Off?

ANPING CHEN AND NICOLAAS GROENEWOLD

ABSTRACT Despite high economic growth over the past 30 years, China's substantial and persistent regional disparities have been the subject of continuing concern to policy makers, as well as the target of a wide variety of policies. An important issue in the policy debate about whether and how best to attack these disparities is whether measures designed to improve regional equality come at a cost to national development, i.e., whether there is a trade-off between the level of national output and the equality of its distribution across the regions. There is little analysis of this issue in the literature. We help fill this gap by setting up a two-region model designed to capture some of the salient features of the Chinese economy. We subject this model to a number of policy shocks and assess the effects on regional disparities in per capita output, on the one hand, and on aggregate output on the other to investigate the trade-off. We also consider income and welfare as alternatives to output. We find, first, that disparities in per capita output, income, and welfare may move in different directions so that it is important to specify which disparity is being targeted. Second, since both disparities and aggregate outcomes are endogenous, how they move together depends on the nature of the shock driving the model. Thus, some policies designed to reduce disparities face a trade-off and others do not. Only a reduction in internal migration restrictions unambiguously reduces all three disparity measures and increases aggregate output, income, and welfare. All other policies considered face a trade-off in at least one dimension. Third, whether there is a trade-off depends also on the time horizon—some policies face a trade-off in the short run and not in the long run and vice versa.

Anping Chen is an associate professor in the School of Economics at Jinan University in Guangzhou, Guangdong, China. His e-mail address is: anping.chen@yahoo.com.cn. Nicolaas Groenewold is a professor of economics at the University of Western Australia, Perth, Western Australia, Australia. His e-mail address is: nic.groenewold@uwa.edu.au. *We are grateful to the Australian Department of Education, Employment and Workplace Relations and to the Business School at UWA for support for Chen to visit UWA under the Endeavour Award scheme in 2009 and to the Department of International Co-operation at Jinan University and the UWA Business School for grants which supported the visit of Groenewold to Jinan University in 2008. We have benefited from comments of the editor and three anonymous referees as well as those received from participants in the Economics Seminar at the University of Western Australia, from members of the China Economy and Business Program at the Australian National University and from members of a seminar at the China Center for Economic Studies at Fudan University.*

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That aggregate growth in China has been high for several decades is well known. Even the recent "Global Financial Crisis" has had relatively little impact, with China being a central engine for world economic growth in the face of faltering economies around the globe. What is perhaps less well known is that the regional distribution of Chinese prosperity has been very uneven and is likely to continue to be so for the foreseeable future. This dark underside of the Chinese "economic miracle" has not gone unnoticed by Chinese policy makers at the highest level and central government policy to address this issue has been a continuing feature of macroeconomic policy.[1]

Policies to reduce regional disparities are clearly desirable on the basis of equity and have also been supported on the basis of the danger of social unrest, which might be caused by widening gaps between rich and poor regions. Yet, there has been a noticeable caution in the vigour with which such policies are pursued by policy makers who are reluctant to jeopardise the continuation of a high aggregate growth rate. Thus, there is, in some quarters at least, a perception that directing policy to improve regional equality may have a cost in terms of lower national performance; that is, there is the perception of a trade-off between national output and the equality of its distribution across the regions.

If there is such a trade-off, it is clearly an important constraint on the execution of policy. Yet, there has been little analysis of this issue either at a theoretical or empirical level. This is not surprising since the resolution of the question is not likely to be simple; after all, in any reasonable macroeconomic model inter-regional per capita output disparities and aggregate output will both be endogenous so that whether they move together or not will, in general, depend on the nature of the shock driving the model. In policy terms, we would expect the existence of a trade-off to depend on the policy being used to pursue equality. If this is indeed the case, it is all the more important to investigate this issue since some policies may be constrained by a serious trade-off while others may not.

Of course, those familiar with the literature on economic development and on regional development in particular, will realise that the consideration of such a trade-off is not new. Indeed, it dates back at least to the work on the inverted U curve between economic development and regional inequality; see particularly Williamson (1965) and earlier work by Kuznets (1955), Myrdal (1957), and Hirschman (1958). The idea captured by the inverted U curve is that in the early stages of development, regional (and other) inequality rises but eventually falls as development (usually measured in terms of income or output per capita) proceeds. There is, thus, a relationship between inequality and development which has an inverted U shape. A recent discussion by Golley (2007, Chapter 2) develops the relationship between these papers and explores possible underlying mechanisms.

While the original literature focuses on the relationship between (per capita) output or income and disparities, many of the empirical applications come from growing economies. Moreover, policy applications are often to growing economies so that in more recent literature the question is often cast in terms of the relationship between growth and inequality.[2] A substantial theoretical and empirical literature has developed in this area but little consensus has been reached. Thus theoretical analysis in papers by Galor and Zeira (1993), Alesina and Rodrik (1994), Persson and Tabellini (1994), and Benhabib and Rustichini (1996) present arguments that growth and inequality are negatively related while Kaldor (1956), Benabou (1996), Edin and Topel (1997) argue the opposite effects. Empirical work is equally inconclusive with the work reported in papers by Alesina and Rodrik and Persson and Tabellini finding that inequality is harmful for growth while Forbes (2000) reports the opposite finding and various papers present ambiguous results including those by Barro (2000), Partridge (2005), Fallah and Partridge (2007), Chambers (2007), Bjornskov (2008), and Barro (2008).

The literature on inequality and development in China is relatively sparse. Li and He (2006) recently predicted that China will continue to maintain rapid economic growth during the 11th Five-Year Plan but that the income gap between regions will be further enlarged because of three factors: continuing structural adjustment, the deepening of administrative reforms, and the enhancing of market forces. Kuijs and Wang (2005) argue that China can have a more balanced growth path with a sustainable reduction of income inequality if appropriate policies, such as reducing subsidies to industry and investment, encouraging the development of the services industry, and reducing the barriers to labour mobility are implemented. Wan, Lu, and Chen (2006) explicitly tested the growth-inequality nexus in China, focusing on rural–urban income inequality and regional growth using a provincial-level panel data set. They found that an increase of inequality has negative effects on growth irrespective of time horizons. Finally, Qiao, Martinez-Vazquez, and Xu (2008) find that fiscal decentralisation has resulted in more rapid economic growth accompanied by greater regional inequality.

To sum up, there is a substantial literature, both theoretical and empirical, in the broadly defined area of inequality and development but no consensus on the direction of the relationship between them. Moreover, there is relatively little work that deals explicitly with China.

Our paper contributes to filling this gap. Our contribution to the literature is fourfold. First, we revert to the original question of the relationship between inequality and the level of (per capita) output in contrast to much of the literature that has focused on the growth of output. Second, we extend the analysis from one of output to include income and welfare. We are thus able to look at inter-regional inequality and national development in three alternative dimensions: output, income, and welfare. Third, we focus on inter-regional disparities rather than household income or urban–rural inequality. This reflects, in part at least, an important policy focus in China. Fourth, we recognise the joint endogeneity of the two variables: the inter-regional gap and the national level of output (or income or welfare). This approach is in contrast to much of the empirical literature that tends to consider causation from inequality to growth or output and ignores the possibility of reverse causation. Our analysis follows arguments by Lundberg and Squire (2003) that a two-way relationship between these variables ought to be entertained.

Our approach is theoretical and we proceed by setting up a simple theoretical economic model, which we analyse using numerical simulation based on a linearised form of the model.[3] We subject the model to a variety of shocks designed to simulate policy actions and observe the effects on both inter-regional disparities and national variables to assess the trade-off question.

While the model is designed to capture some features of the Chinese economy and is calibrated with Chinese data, we argue that with some exceptions (such as a relaxation of the internal migration restrictions), many of the policies simulated are more widely applicable than just to China.

The structure of our model is most closely related to three recent theoretical papers on China that use numerical models, one by Hu (2002), one by Hertel and Zhai (2006), and a third by Whalley and Zhang (2007). While all these papers use small numerical models of (aspects of) the Chinese economy, none of them focuses on policy measures, which might be used to reduce regional disparities, and moreover, none addresses the trade-off question.

The general nature of our findings can be briefly summarised as follows. First, different measures of the inter-regional gap (i.e., in per capita output, income or welfare) do not necessarily all move in the same direction so that policy needs to be clear as to which gap is being targeted. Second, whether a narrowing of the gap between the interior and the coast comes at the expense of the national level of the relevant variable depends on the policy shock, which drives the change and on whether short- or long-run consequences are being considered. Third, whether there is a trade-off or not depends on the variable of interest. Fourth, most policies analysed face a trade-off in at least one of the three dimensions examined in either the short run or the long run.

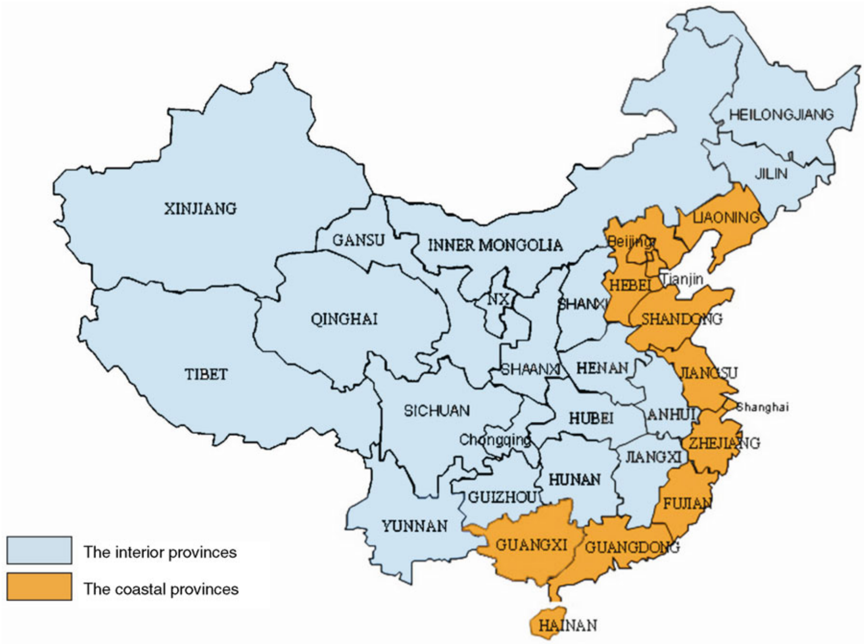

FIGURE 1. THE TWO REGIONS OF MAINLAND CHINA.

The Model

To keep the regional structure of the model as simple as possible, we assume that there are two regions, conventionally called the coastal and interior (or inland) regions (denoted C and I). This two-region scheme has been widely used in policy discussion until the mid-1980s and continues to be widely used in empirical work on China.[4] The two-region disaggregation we use is illustrated in Figure 1.

The coastal region is relatively wealthy compared to the interior, and at its broadest level, it is the disparities between the coast and the interior which have been at the centre of Chinese concerns about regional inequalities. We assume that each region has two sectors, agriculture and manufacturing (denoted A and M). We abstract, therefore, from both the service sector and from the foreign sector. This does not reflect a judgement that these sectors are unimportant in Chinese economic development or even unimportant for regional disparities, but simply that they are more than we need to say something interesting about the trade-off between regional disparities and national development.

Each region has households, firms, and regional governments. There is also a central government. There are assumed to be two types of labour in each region, skilled (*S*) and unskilled (*U*), with some households ("skilled households") supplying skilled labour and others ("unskilled households") supplying unskilled labour for which they receive wage income. All households also receive profits from firms in the region in which they live. They use income to purchase agricultural and manufacturing output from the firms; in addition, they receive a government-provided consumption good, which is private in the rival sense.

Agricultural firms produce output using three factors—unskilled labour, a fixed amount of land, and a government-provided public good (which we call infrastructure). Manufacturing firms employ four factors—unskilled and skilled labour, a fixed amount of capital, and infrastructure.[5] We assume that only labour is inter-sectorally and inter-regionally mobile and that only in the long run; in the short run, no factors are mobile.[6] In the long run, unskilled labour can migrate between manufacturing and agriculture as well as between regions and skilled labour can migrate between regions. We assume that labour migrates in response to wage differences between sectors or regions although there are also costs of migration, some of which we relate to implicit costs imposed by the *hukou* system and to the higher cost of housing in the cities.

We distinguish between central and regional governments, with the latter including all sub-national government levels although we recognise that, in practice, the latter level includes several layers (provincial, prefecture, county, and township). This distinction between two levels of government is an important part of our model since both regional and central governments can be expected to implement policies, which have regional objectives and effects.

In our model, both levels of government provide households with a consumption good. From the households' perspective, the government-provided consumption good is homogeneous. In addition to supplying the consumption good, the regional governments are assumed to provide infrastructure, which is an input into the production process for both agriculture and manufacturing.

On the taxation side, we incorporate three taxes into the model in a way, which broadly reflects the stylised facts of the Chinese taxation system: 1) a national value-added tax (VAT), the rate for which is set by the central government at the same level for both regions and the proceeds from which are shared between the central government and the regions with the same shares for each region, 2) a business tax levied by regional governments on the value of manufacturing output, and 3) an agricultural tax that we assume to be levied by regional governments on the value of agricultural output.[7]

We assume that skilled households supply skilled labour inelastically to manufacturing firms in their own region (each household supplying one unit) and that each unskilled household supplies one unit of unskilled labour to either agriculture or manufacturing firms also in its own region. Both types of household choose consumption to maximise utility and all firms choose employment to maximise profits, taking real wages as parametric. Governments are assumed to behave exogenously although they need to satisfy their budget constraints.

We consider the behaviour of households, firms, and governments in turn.[8]

Households. Households derive utility from the consumption of the two privately produced goods as well as from a good supplied by governments. There are two types of households (skilled and unskilled) in each region. We assume a representative household of each type in each region with potentially different preferences modelled by a constant-elasticity-of-substitution (CES) utility function of the form:

$$V_{ki} = \beta_{ki}(\gamma_{Aki}C_{Aki}^{-\rho_{ki}} + \gamma_{Mki}C_{Mki}^{-\rho_{ki}} + \gamma_{Gki}GH_i^{-\rho_{ki}})^{\frac{-1}{\rho_{ki}}}, i = I, C; k = U, S \tag{1}$$

where V_{ki} = utility of the representative household of type k, region i,

C_{Aki} = real private consumption of agricultural output per household of type k, region i,

C_{Mki} = real private consumption of the manufactured good per household of type k, region i,

GH_i = real government-provided consumption per household, region i,

β_{ki} = the scale parameter for household of type k, region i,

γ_{jki}, = the share parameters, good j, household type k, region i,

ρ_{ki} = the substitution elasticity parameter, household type k, region i (the elasticity of substitution is $1/(1 + \rho_{ki})$),

with

$$\beta_{ki} > 0, k = U, S; i = I, C$$

$$0 < \gamma_{jki} < 1, j = A, M, G; k = U, S, i = I, C$$

$$\gamma_{Aki} + \gamma_{Mki} + \gamma_{Gki} = 1, k = U, S; i = I, C$$

$$\rho_{ki} > -1, k = U, S; i = I, C$$

Households maximise utility subject to a budget constraint. To formulate the household budget constraint, we need to combine quantities of the two goods in a single measure since both household types consume some of each good and the unskilled households receive wage income in terms of both goods. While we could use one of the goods as a *numeraire* and write the whole model in terms of relative prices, we find it more convenient to do this using the price of a composite good which has a price index:

$$P_C = (P_A)^{\lambda}(P_M)^{1-\lambda}$$

where P_j is the price of good j ($j = A,M$) and λ is the share of agricultural output in total output. We will also use this good to value national income and output.

We assume that households "pay" the VAT, which the central government collects at a given rate T_V. Since there are no intermediate goods in the model, the VAT is equivalent to a tax on the value of final consumption and, since households spend all their income, it is also equivalent to an income tax. Using the price index for the composite good, the household budget constraint for region i can be written as

$$(1+T_V)(P_A C_{Aki} + P_M C_{Mki})/P_C = J_{ki}, \quad k = U, S; i = I, C$$

or using the definition of P_C and letting P denote the relative price, $P = P_A/P_M$, we can write:

$$(1+T_V)(P^{1-\lambda} C_{Aki} + P^{-\lambda} C_{Mki}) = J_{ki}, \quad k = U, S; i = I, C$$

where J_{ki} = household income in terms of the composite good for household type k, region i.

Utility maximisation subject to the household budget constraint gives the demand functions:

$$C_{Aki} = \frac{J_{ki} P^{\lambda-1}/(1+T_v)}{P^{-1}\left(P\frac{\gamma_{Mki}}{\gamma_{Aki}}\right)^{\frac{1}{\rho_{ki}+1}} + 1}, k = U, S; i = I, C \tag{2a}$$

$$C_{Mki} = \frac{J_{ki} P^{\lambda}/(1+T_v)}{P\left(P\frac{\gamma_{Mki}}{\gamma_{Aki}}\right)^{\frac{-1}{\rho_{ki}+1}} + 1}, k = U, S; i = I, C \tag{2b}$$

Households may migrate between sectors and between regions. In China, internal migration is subject to restrictions (based on the household registration system, or *hukou*) which we model as part of the cost of migration.[9] We assume that intra-regional migration is dominated by inter-sectoral migration from agriculture to manufacturing (roughly rural–urban migration) and inter-regional flows are dominated by those from the poor to the rich region. These assumptions avoid the discontinuities, which result from two-way costly migration; see Mansoorian and Myers (1993) for an analysis of a model with such discontinuities and Woodland and Yoshida (2006) for an approach similar to ours but applied to immigration from poor to rich countries.[10]

Only unskilled households supply labour to both sectors so intra-regional migration applies only to unskilled labour. On the other hand, both types of household may migrate between regions although, to reduce complications, we assume that if unskilled households wish to migrate from agriculture in one region to manufacturing in the other, they first migrate to agriculture in the other region before "subsequently" moving to manufacturing.

We model migration as occurring in response to wage differentials adjusted for costs of migration. Given our migration assumptions, we have four migration equilibrium conditions. For intra-regional migration, there is an equilibrium condition for each region of the form:

$$P^{-\lambda}W_{MUi} = P^{1-\lambda}W_{AUi} + MC_{Ui}, i = I, C$$

and for inter-regional migration there are two conditions, one for each type of worker:

$$P^{1-\lambda}W_{AUC} = P^{1-\lambda}W_{AUI} + MC_{AU}$$

$$P^{-\lambda}W_{MSC} = P^{-\lambda}W_{MSI} + MC_{MS},$$

where the *MC* terms are migration costs (measured in terms of the composite good) and the *W* terms are real wages, measured in terms of units of output of the sector in which they are paid. In the migration conditions, wages are converted into units of the composite good to make them commensurate with each other and with the migration costs. In the data based used for calibration (Table 1 below), there is a substantial wedge between interior and coastal wages for similar workers; on average, coastal wages are about 50 percent higher than their interior counterparts, suggesting substantial barriers to migration.

Given our assumptions about possible migration flows, intra-regional migration is likely to be more costly for Chinese workers.[11] In the first place, the *hukou* restrictions are more focussed on preventing free migration from the countryside to the cities, and secondly, the high cost of urban housing is also likely to be a significant barrier to the movement to the cities. Both of these can be considered as sources of congestion costs since both will increase with population density of the cities.[12] While both of these will impose costs on intra-regional migration, for the sake of exposition, we focus on the housing cost component.

TABLE 1. VALUE OF VARIABLES BY REGION.

Variable	Y_A (100 million yuan)	Y_M (100 million yuan)	Y (100 million yuan)	W_{AU} (yuan)	W_{MU} (yuan)	W_{MS} (yuan)	R (yuan)	L_{AU} (10,000)
Coast	7,863.65	72,082.09	79,945.74	4,891.30	16,445.59	23,229.64	11,554.30	11,247.62
Interior	9,079.01	41,030.04	50,109.05	3,042.23	10,527.94	15,735.23	7,485.70	20,968.93

Variable	L_{MU} (10,000)	L_{MS} (10,000)	L_U (10,000)	L_S (10,000)	L (10,000)	T_A (%)	T_M (%)	T_V (%)
Coast	11,416.73	4,664.00	22,664.35	4,664.00	27,328.35	4.40	6.19	9.39
Interior	10,515.57	5,727.48	31,484.50	5,727.48	37,211.98	4.40	6.19	9.39

Variable	GC (yuan)	GRH (yuan)	GH (yuan)	GRF_A (100 million yuan)	GRF_M (100 million yuan)	ΠF_A (100 million yuan)	ΠF_M (100 million yuan)	ΠH_A (yuan)
Coast	1,652.86	982.76	2,635.62	340.31	3,543.72	2,015.93	38,012.62	737.67
Interior	1,100.89	489.33	1,590.22	316.36	1,908.27	2,300.11	18,408.48	618.11

Variable	ΠH_M (yuan)	J_U (yuan)	J_S (yuan)	J (yuan)	C_{AU} (yuan)	C_{MU} (yuan)	C_{AS} (yuan)	C_{MS} (yuan)
Coast	13,909.59	19,538.60	66,160.00	27,495.21	2,679.20	15,182.20	4,858.40	55,622.40
Interior	4,946.92	8,607.30	35,043.90	12,676.26	1,180.30	6,688.20	4,805.40	27,230.40

Source: *China Statistical Year Book* (State Statistical Bureau 2001–2007).

We assume that the excess demand for urban housing depends on a relative price and a measure of the tightness of the rental market. The relative price is the rental rate, R, relative to the unskilled wage in manufacturing (which is the aspiring migrants' destination) both measured in terms of the composite commodity. The measure of the state of the rental market we use is the level of employment of unskilled labour already in manufacturing (L_{MUi})—the more unskilled already in manufacturing, the greater will be the demand for rental housing relative to supply. We assume the excess demand function has the simple linear form:

$$H^{xd} = -\Delta_{Ri}(R_i/(P^{-\lambda}W_{MUi})) + \Delta_{Li}L_{MUi}$$

where the Δs are positive parameters and R_i represents rental costs facing rural households contemplating moving to the city in region i. Setting excess demand to zero and solving for R_i gives:

$$R_i = \Delta_i L_{MUi} P^{-\lambda} W_{MUi}$$

where $\Delta_i = \Delta_{Li}/\Delta_{Ri}$. Thus, rental payments are proportional to manufacturing unskilled employment (and therefore urban population), generating standard congestions costs. We argue that this variable may also be used to capture the costs of *hukou* restrictions since the larger is the number of unskilled workers already in the cities, the greater will be the resistance to the arrival of additional workers and the higher the wage, ceteris paribus, the more vigorously will incumbent workers defend their position by urging authorities to enforce the migration restrictions. Thus *hukou* effects will reinforce the congestion effects of rising housing costs. We, therefore, set MC_{Ui} in the intra-regional migration condition above equal to R_i, so that

$$PW_{AUi} = (1 - \Delta_i L_{MUi})W_{MUi}, i = I, C \tag{3a}$$

In the case of the inter-regional migration conditions, we assume that the MC terms represent moving costs which are constant so that the conditions are

$$P^{1-\lambda}W_{AUC} = P^{1-\lambda}W_{AUI} + MC_{AU} \tag{3b}$$

$$P^{-\lambda}W_{MSC} = P^{-\lambda}W_{MSI} + MC_{MS} \tag{3c}$$

where MC_{AU} and MC_{MS} are treated as exogenous variables.[13]

Households receive income from wages and profits, both of which are received in terms of the firm's own output. Skilled households receive wages only from manufacturing while unskilled households receive wages from both agriculture and manufacturing. Firms distribute profits in equal per capita amounts to all households in the region in which they are located. In addition to these income flows, we need to account for housing rental payments by unskilled households working in manufacturing. Since we are not interested in the housing market as such but only in the effects of housing costs on the migration decision, we do not include a complete model of the housing market. Rather, we make the simple assumption that the urban housing stock is exogenous and owned by skilled worker households. Unskilled households working in manufacturing (roughly unskilled urban households) rent housing from the skilled households and pay a rental payment of R as derived above. This is therefore modelled simply as a transfer from unskilled to skilled households in manufacturing. Recalling that income is measured in terms of the composite good, we can write the budget constraint for skilled households as:[14]

$$J_{Si} = P^{1-\lambda}\Pi H_{Ai} + P^{-\lambda}\Pi H_{Mi} + P^{-\lambda}W_{MSi} + (L_{MUi}/L_{MSi})R_i,\ i = I, C \tag{4a}$$

and for unskilled as

$$\begin{aligned} J_{Ui} = {} & P^{1-\lambda}(\Pi H_{Ai} + [L_{AUi}/L_{Ui}]W_{AUi}) + P^{-\lambda}(\Pi H_{Mi} + [L_{MUi}/L_{Ui}]W_{MUi}) \\ & - (L_{MUi}/L_{Ui})R_i,\ i = I, C \end{aligned} \tag{4b}$$

where the rental payment, R_i, from unskilled to skilled households in manufacturing in region i is as derived above:

$$R_i = \Delta_i L_{Mui} P^{-\lambda} W_{MUi},\ i = I, C \tag{4c}$$

and ΠH_{ji} = profit distribution per household by sector j, in region i,

W_{jki} = real wage income per household, sector j, type k, region i measured in terms of sector j's output, and

L_{jki} = employment (= number of households), sector j, type k, region i.

Firms. There are both agricultural and manufacturing firms in each region. We assume that the number of firms in each industry and in each region is fixed, and without loss of generality, we set this number equal to 1 in each case.

In agriculture, the firm produces output using land (in fixed supply), unskilled labour hired from within the region in which it is located and the public infrastructure provided by the regional government. The manufacturing firm uses both skilled and unskilled labour as well as capital (in fixed supply) and the infrastructure provided by the government in its region.[15] Both sectors use Cobb–Douglas constant-returns-to-scale production technology:

$$\begin{aligned} & Y_{Ai} = B_{Ai}(LAND)^{(1-\alpha_{AUi}-\alpha_{AGi})}(L_{AUi})^{\alpha_{AUi}}(GRF_{Ai})^{\alpha_{AGi}}, \\ & 0 < \alpha_{AUi}, \alpha_{AGi}, (1-\alpha_{AUi}-\alpha_{AGi}) < 1 \end{aligned}$$

$$Y_{Mi} = B_{Mi}(CAPITAL)^{(1-\alpha_{MUi}-\alpha_{MSi}-\alpha_{MGi})} L_{MUi}^{\alpha_{MUi}} L_{MSi}^{\alpha_{MSi}} (GRF_{Mi})^{\alpha_{MGi}},$$
$$0 < \alpha_{MUi}, \alpha_{MSi}, \alpha_{MGi}, (1-\alpha_{MUi}-\alpha_{MSi}-\alpha_{MGi}) < 1$$

where B_{Ai} is total factor productivity (TFP), L_{AUi} is total (unskilled) employment in agriculture and GRF_{Ai} represents regional government expenditure on infrastructure, which benefits firms in agriculture, all in region i. Similarly, B_{Mi} is TFP in manufacturing, L_{MUi} and L_{MSi} are employment of unskilled and skilled workers in manufacturing, and GRF_{Mi} is infrastructure provided by region i's government to manufacturing firms in the region. Since we assume both land and capital to be immobile factors in fixed supply, we can simplify and write

$$D_{Ai} = B_{Ai}(LAND)^{(1-\alpha_{AUi}-\alpha_{AGi})}$$

and

$$D_{Mi} = B_{Mi}(CAPITAL)^{(1-\alpha_{MUi}-\alpha_{MSi}-\alpha_{MGi})}$$

so that the production functions can be written as

$$Y_{Ai} = D_{Ai} L_{AUi}^{\alpha_{AUi}} (GRF_{Ai})^{\alpha_{AGi}}, \quad 0 < \alpha_{AUi}, \alpha_{AGi}, (1-\alpha_{AUi}-\alpha_{AGi}) < 1, i = I, C \tag{5a}$$

$$Y_{Mi} = D_{Mi} L_{MSi}^{\alpha_{MSi}} L_{MUi}^{\alpha_{MUi}} (GRF_{Mi})^{\alpha_{MGi}}, \quad 0 < \alpha_{MSi}, \alpha_{MUi}, \alpha_{MGi}, \\ (1-\alpha_{MSi}-\alpha_{MUi},-\alpha_{MGi}) < 1, i = I, C \tag{5b}$$

Hence, shocks to D_{ji} can be interpreted as changes in available amounts of the fixed factor (land in agriculture or capital in manufacturing) or changes in TFP.

Consider now firms' behaviour. Profits (in terms of the firm's own output) are defined as

$$\Pi F_{Ai} = (1-T_{Ai})Y_{Ai} - W_{AUi}L_{AUi}, i = I, C \tag{6a}$$

$$\Pi F_{Mi} = (1-T_{Mi})Y_{Mi} - W_{MUi}L_{Mui} - W_{MSi}L_{Msi}, i = I, C \tag{6b}$$

where T_{Ai} is the tax on agricultural output and T_{Mi} is the tax levied on the value of manufacturing output, in each case in region i. We assume that each firm takes the wage, the tax rate, and the quantity of infrastructure as given. Hence, the only choice variable in each case is the level of employment—unskilled only in agriculture and both skilled and unskilled in manufacturing—and this choice will also determine output via the production function. We follow convention and assume that all firms choose employment to maximise profits.

The profit-maximising condition for manufacturing firms will result in the usual marginal productivity conditions:

$$\alpha_{MSi}(1-T_{Mi})Y_{Mi} = W_{MSi}L_{MSi}, i = I, C \tag{7a}$$

$$\alpha_{MUi}(1-T_{Mi})Y_{Mi} = W_{MUi}L_{MUi}, i = I, C \tag{7b}$$

and in agriculture, the corresponding condition is

$$\alpha_{AUi}(1-T_{Ai})Y_{Ai} = W_{AUi}L_{AUi}, i = I, C \tag{7c}$$

On the labour supply side, each household type in each region is assumed to provide one unit of labour inelastically to the firms in its own region so that labour force, labour supply, employment, and the number of households are all equal.

Governments. There are three sources of government revenue. The central government levies a VAT at a uniform rate across the country and shares the revenue with the regional governments. In addition, each regional government levies a tax on agriculture and one on manufacturing. Each government (central and regional in the coast and the interior) receives tax revenue in the form of output and transforms this output into a homogeneous government good. It would seem natural to include a government production function by which the government combines some of the agricultural good and some of the manufacturing good that it receives as tax revenue into the government consumption good. But since we are not interested in this in particular, but merely wish to define a government expenditure variable that we can shock to simulate the effects of fiscal policy, we opt for the simplest structure in which governments can convert either of the private goods into the government good at the constant rate of one unit of the government good for one unit of the composite good equivalent of each of the two private goods. This is equivalent to a production function that is linear in the tax revenues (expressed in terms of the composite commodity).

The central government provides this homogeneous government good to households as a consumption good in both regions, in per capita amounts, which are the same for all households within the region but may differ across regions. Each regional government provides some output to households as a consumption good (in equal per capita amounts) within its own region as well as providing some to firms as agricultural and manufacturing infrastructure.

There is no asset accumulation in the model so that neither households nor firms nor governments can lend or borrow. Governments therefore must balance their budgets. Consider the central government first. It raises VAT of $T_V(L_{SI}J_{SI} + L_{UI}J_{UI})$ in region I and $T_V(L_{SC}J_{SC} + L_{UC}J_{UC})$ in region C. Of this, a proportion $(1 - \theta)$ is transferred to the regional governments and the remainder is transformed into the government consumption good, which is provided to households in both regions. Its budget constraint is therefore

$$L_I GC_I + L_C GC_C = \theta T_V (L_{SI} J_{SI} + L_{UI} J_{UI} + L_{SC} J_{SC} + L_{UC} J_{UC}) \tag{8}$$

where GC_i ($i = I$, C) is government good per household provided to residents of region i by the central government.

The regional governments receive some revenue from the VAT, which is measured in terms of the composite good but also some from local firms, which is measured in terms of the firm's own output and is therefore re-valued in terms of the composite good before being transformed into the government good. The regional governments' budget constraints have the form

$$\begin{aligned} L_i GRH_i + GRF_{Ai} + GRF_{Mi} = T_{Ai} P^{1-\lambda} Y_{Ai} + T_{Mi} P^{-\lambda} Y_{Mi} \\ + (1-\theta) T_V (L_{Si} J_{Si} + L_{Ui} J_{Ui}), i = I, C \end{aligned} \tag{9}$$

where GRH_i is the amount per capita of the government good provided by region i's government to households in its region; GRF_{ji} is the amount of the infrastructure good (non-rival in use) provided to the firms in sector j, region i and the components on the right-hand side are agricultural tax revenue, manufacturing tax revenue, and the regional government's share of the VAT, all measured in terms of the composite good.

Closure and definitions. It remains to define a number of important aggregate variables and set out market-clearing conditions to complete the specification of the model.

First, the aggregate counterparts to the regional disparity variables are defined. We begin with output and define both regional output and national output.[16] Converting each sector's output to the composite good before adding them, we have

$$Y_i = P^{1-\lambda} Y_{Ai} + P^{-\lambda} Y_{Mi}, i = I, C \tag{10a}$$

$$Y = Y_I + Y_C \tag{10b}$$

Similarly, for income (per capita) at the regional and national levels:

$$J_i = (L_{Ui}/L_i) J_{Ui} + (L_{Si}/L_i) J_{Si}, i = I, C \tag{11a}$$

$$J = (L_I/L) J_I + (L_C/L) J_C \tag{11b}$$

The appropriate procedure for welfare is less straightforward because of the problem of interpersonal comparison of utilities. We decide to treat all individuals equally and simply measure regional and national welfare as the population-weighted average of the utilities of the different households in each case:

$$V_i = (L_{Ui}/L_i)V_{Ui} + (L_{Si}/L_i)V_{Si}, i = I, C \tag{12a}$$

$$V = (L_I/L)V_I + (L_C/L)V_C \tag{12b}$$

Next, we introduce a number of definitions. First, the relationship between GH_i, the amount of the government good per capita received by households in region i from both sources (regional and national governments), and its components is given by

$$GH_i = GRH_i + GC_i, \quad i = I, C \tag{13}$$

Market-clearing conditions are imposed on goods and labour markets. Goods markets clearing in each sector implies

$$Y_{jI} + Y_{Jc} = (1+T_v)(L_{UI}C_{jUI} + L_{SI}C_{jSI} + L_{UC}C_{jUC} + L_{SC}C_{jSC}) + T_{jI}Y_{jI} + T_{jC}Y_{jC} \tag{14}$$

$$j = A, M$$

where the left-hand side is national output of good j and the right-hand side is the sum of consumption (two types of households, two regions) and the amount of each good surrendered to governments as tax revenue. All variables are measured in terms of units of good j itself.

The market for each type of labour in each region clears so that employment is equal to the number of households of each type in each region.

$$L_{AUi} + L_{MUi} = L_{Ui}, i = I, C \tag{15a}$$

$$L_{MSi} = L_{Si}, i = I, C \tag{15b}$$

Moreover, the number of households of each type in the country as a whole is given (we do not, e.g., model education and training by which unskilled workers might become skilled).

$$L_{kI} + L_{kC} = L_k, k = U, S \tag{15c}$$

We also define regional populations and national population.

$$L_{Ui} + L_{Si} = L_i, i = I, C \tag{15d}$$

$$L_I + L_C = L \tag{15e}$$

Firms are assumed to distribute all their profits to households in their own region in equal per capita amounts:

$$\Pi F_{Ai} = L_i \Pi H_{Ai}, i = I, C \tag{16a}$$

$$\Pi F_{Mi} = L_i \Pi H_{Mi}, i = I, C \tag{16b}$$

This completes the specification of the model. To summarise, the model consists of the 65 equations (1–16) in 85 variables: V_{ki}, C_{jki}, GH_i, T_v, P, J_{ki}, ΠH_{ji}, L, L_i, L_k, L_{ki}, Y_{ji}, D_{ji}, L_{jUi}, L_{MSi}, GRF_{ji}, ΠF_{ji}, T_{ji}, W_{jUi}, W_{MSi}, GC_i, GRH_i, θ, Y, Y_i, J, J_i, V, V_i, R_i, Δ_i, MC_{AU}, and MC_{MS}. Of these 21 are exogenous: D_{ji}, GRF_{ji}, T_{ji}, GC_i, θ, Δ_i, MC_{AU}, MC_{MS}, L_k where we have assumed that T_v and the GRH_i variables adjust to satisfy the government budget constraints (although these closure assumptions will be changed for some of the simulations). Hence, there are 64 endogenous variables, one less than the number of equations. One of the equations is redundant; however, since the household and government budget constraints, definitions and one of the product market-clearing conditions imply the other; we drop one of the product market-clearing conditions in the simulations that follow.

Short-run and long-run versions of the model. In the simulations to be reported below, we distinguish between short-run and long-run versions of the model. Since the model is static rather than dynamic, the distinction is based on differences in closure assumptions. In particular, we follow Krugman (1991) and define the short run as the length of time before inter-regional migration begins to respond to the changes in the wage differential. The distinction is based on the idea that migration is slow to respond fully to changes in economic incentives. Thus, for example, Pissarides and McMaster (1990) estimate that it takes as long as 20 years for reasonably complete adjustment of migration to labour market shocks.

In terms of the model, the distinction between short and long runs simply involves suspending equation (3), the migration equilibrium equations and making labour supplies of each type, in each sector of each region exogenous; i.e., L_{jUi} and L_{MSi} become exogenous variables. However, given equation (15c), this means that L_k cannot also be exogenous and we delete these equations (or equivalently, make the L_k endogenous). The long run is used to refer to the simulation results using the model as set out above.

Linearising the model. The model as it stands is too complicated to solve analytically so that we linearise it in terms of proportional changes for which we use a process of log differentiation. This converts the model from one which is non-linear in the levels to one that is linear in the proportional rates of change of the variables. The resulting linearised versions of equations (1–16) are given in Appendix 2.

The numerical version of the linearised model. Having linearised the model in terms of proportional changes, we can solve the model for any one of the (changes in the) endogenous variables in terms of (the changes in) the exogenous variables. However, given the number of endogenous variables, this is unlikely to lead to any interpretable results and we proceed to solve the model numerically, using data for China's regions (reported in Table 1) to calibrate the key parameters of the model, detailed discussion of which we relegate to Appendix 3.

The Simulations

There are various policies by which governments might attempt to influence the regional distribution of output, income, or welfare. We simulate four policies that either the interior government or the central government might undertake to reduce regional disparities. For each policy, we assess the effects on the disparities themselves and examine whether there is a trade-off between the reduction of disparities and national development. We examine three alternative disparity measures (output, income, and welfare) and their corresponding aggregate levels to assess the nature of the trade-off.

The policies are

1. A regional government fiscal policy aimed at increasing economic activity (and hence welfare) in the poor region. The model structure provides various possible balanced-budget fiscal policy combinations. We choose an increase in interior government-provided consumption aimed at increasing output via the usual multiplier effects in the region. We assume that the interior government's budget is balanced by changing the provision of infrastructure to agriculture although we could have assumed that that the provision of infrastructure to manufacturing or the two tax instruments, which the regional government has available, are adjusted instead. Results for alternative closures are reported in Appendix 5.
2. Measures that either the regional or the central government might undertake to increase productive capacity in the agriculture sector in the interior, such as releasing more land for agriculture or improving agricultural technology. It might be argued that there is little additional land available for release to agriculture in China. However, the shock here may also be thought of as the implementation of policy, which halts or slows down the alienation of farm land for non-agricultural purposes. If the shock is interpreted as a productivity improvement in agriculture, it should be pointed out that, in general, governments need to spend resources on activities such as research and development (R&D) to generate productivity increases. Since we ignore these costs, the comparison to balanced-budget policy shocks such as policy 1 is not strictly

"fair" and will exaggerate the effectiveness of the productivity policy relative to standard fiscal policy. However, since we focus on signs of the multipliers rather than their magnitude, this is a small price to pay for the considerable simplification effected by not having to explicitly model the process that converts tax revenue into R&D and then into productivity improvements.[17]

3. A reduction in inter-regional migration costs. Either the regional or central government might undertake this policy, depending on the precise nature of the migration costs.
4. A reduction in the costs of intra-regional migration. Recall that intra-regional migration is inter-sectoral migration within the region; i.e., migration from (rural) agriculture to (urban) manufacturing within a particular region and that we have modelled the costs of such migration as being driven either by urban housing costs faced by rural migrants or by the costs of obtaining urban *hukou* or both. Housing costs might be reduced by either central or regional governments.[18] As to a reduction in *hukou* costs, we think of this as being driven by a reduction in the seriousness with which the *hukou* restrictions are enforced for those aspiring to migrate from agriculture to manufacturing. We note that originally the *hukou* system was instituted and administered by the central government but that since reforms began in the late 1970s, it has increasingly been the wealthier coastal provinces (particularly the large cities), which have maintained the force of the *hukou* restrictions, presumably to keep out low-wage workers from agriculture. Coastal provinces are, therefore, hardly likely to undertake reform or allow relaxation of the migration restrictions in order to reduce disparities and it must be assumed that only the central government is likely to apply pressure to reduce restrictions.

Results

Base case results. A summary of the results of the four simulations defined above are reported in Table 2. Detailed results for these four simulations for all variables in the model are provided in Appendix 4.[19] We discuss the four policies in turn.

Policy 1: An interior government fiscal policy. Recall that the policy we focus on here is an increase in the government consumption good provided by the interior government and that the variable, which adjusts to maintain a balanced budget, is infrastructure expenditure for agriculture.

Consider the short-run effects first. Table 2 shows that policy 1 has the desired effect of reducing the welfare gap but, in contrast, the inter-regional gap in terms of income and output per capita widen. Moreover, the improvement in the welfare

TABLE 2. SUMMARY OF BASE CASE SIMULATION RESULTS.

Variables	Policy 1: $grh_I = 100$		Policy 2: $d_{AI} = 100$		Policy 3: $mc_{AU} = mc_{MS} = -100$		Policy 4: $del_I = del_C = -100$	
	SR	LR	SR	LR	SR	LR	SR	LR
v_{UI}	2.982	9.133	11.155	–20.854	0.000	15.237	26.207	47.104
v_{SI}	–2.472	0.982	18.130	2.043	0.000	19.492	–39.288	–11.296
v_{UC}	0.057	–13.434	–0.259	66.947	0.000	–32.065	26.029	–12.158
v_{SC}	–1.966	–4.767	8.902	23.754	0.000	–17.068	–42.010	–19.331
v_I	0.840	9.990	13.894	–32.085	0.000	19.990	0.485	32.521
v_C	–0.727	–15.186	3.294	75.679	0.000	–30.981	–0.362	–25.564
v	–0.112	0.777	7.455	3.076	0.000	4.185	–0.030	10.976
j_{UI}	–1.968	5.346	8.910	–26.642	0.000	16.822	31.764	54.029
j_{SI}	–3.456	0.090	15.648	–0.447	0.000	20.146	–40.948	–11.556
j_{UC}	0.863	–14.200	–3.910	70.765	0.000	–35.349	30.276	–10.568
j_{SC}	–3.243	–5.078	14.684	25.304	0.000	–16.276	–44.579	–23.729
j_I	–2.601	7.725	11.777	–38.495	0.000	21.741	0.825	35.621
j_C	–0.823	–16.104	3.726	80.254	0.000	–32.746	–0.464	–27.710
j	–1.508	–0.607	6.831	3.025	0.000	3.992	0.033	10.966
y_{AI}	–22.083	–38.501	100.000	191.866	0.000	–40.113	0.000	–57.875
y_{MI}	0.000	0.176	0.000	–169.720	0.000	–6.052	0.000	12.830
y_{AC}	0.000	34.057	0.000	–0.877	0.000	64.987	0.000	34.529
y_{MC}	0.000	–0.091	0.000	0.455	0.000	8.649	0.000	15.818
y_I	–2.615	–6.192	11.843	30.856	0.000	–12.997	0.782	3.988

TABLE 2. (CONTINUED)

Variables	Policy 1: $grh_I = 100$		Policy 2: $d_{AI} = 100$		Policy 3: $mc_{AU} = mc_{MS} = -100$		Policy 4: $del_I = del_C = -100$	
	SR	LR	SR	LR	SR	LR	SR	LR
y_C	−0.869	2.866	3.934	−14.285	0.000	14.675	−0.490	15.171
y	−1.542	−0.624	6.981	3.107	0.000	4.013	0.000	10.862
y_I-l_I	-2.615	7.798	11.843	−38.861	0.000	21.879	0.782	35.600
y_C-l_C	−0.869	−16.183	3.934	80.646	0.000	−32.815	−0.490	−27.873
p	27.221	12.570	−123.268	−62.642	0.000	−15.190	15.356	77.958
l_{AUI}	0.000	−25.081	0.000	124.990	0.000	−54.577	0.000	−78.742
l_{MUI}	0.000	0.296	0.000	−1.477	0.000	−1.539	0.000	46.253
l_{MSI}	0.000	0.388	0.000	−1.932	0.000	−23.958	0.000	−2.021
l_{AUC}	0.000	46.537	0.000	−231.911	0.000	88.801	0.000	47.182
l_{MUC}	0.000	−0.054	0.000	0.269	0.000	14.173	0.000	55.539
l_{MSC}	0.000	−0.476	0.000	2.373	0.000	29.421	0.000	2.482
l_I	0.000	−13.990	0.000	69.717	0.000	−34.876	0.000	−31.612
l_C	0.000	19.049	0.000	−94.931	0.000	47.490	0.000	43.044

Notes: Lower-case letters refer to the proportional changes in the upper-case counterparts defined in the text and collected in Appendix 1; since y_j and l_j are log differences of output and population, respectively, y_j-l_j is the log difference of output per capita. The policies are policy 1: an increase in regional government expenditure in the interior; policy 2: a productivity improvement in interior agriculture; policy 3: a reduction in inter-regional migration costs; policy 4: a reduction in intra-regional migration costs. All shocks are set equal to 100 so that the results can be interpreted as percentage changes.

gap comes at the expense of the national level of welfare that falls. National income and per capita output also fall as a result of policy 1. Thus, in the short run, the policy seems largely counter-productive: while welfare in the interior improves and the welfare gap relative to the coast narrows, income and output per capita in the interior both fall and the corresponding gaps widen. The national levels of all three variables fall.

In the long run, all gaps are reduced by the policy and national income and per capita output both rise relative to the short run but not by enough to offset the adverse short-run movements so that they are both lower relative to the initial equilibrium.

The implications for the trade-off question depend on the dimension in which it is being assessed and on whether a short- or a long-run view is taken: in the short run, there is a trade-off in the welfare dimension but not for income and output per capita while in the long run, these results are reversed, there being a trade-off in the income and output dimensions but none when welfare is used as the relevant measure.

The mechanism underlying the short-run results is that the increase in government-provided consumption expenditure in the interior region makes all interior households better-off, ceteris paribus. This is typically the effects that proponents of such a policy focus on. But "there is no such thing as a free lunch" and the government's budget constraint requires that revenue is increased or that other expenditure is reduced. Here, we assume that the variable, which the government adjusts to maintain budget balance, is expenditure on government-provided infrastructure for agriculture, which must be reduced and it is this which largely drives the counter-intuitive results. The decrease in agricultural infrastructure in the interior reduces both output and per capita output in interior agriculture through a direct production-function effect. The interior agricultural wage is also reduced (since labour becomes less productive as a result of the reduction in the provision of infrastructure) and the (national) relative price moves in favour of agriculture because of the reduction in supply. The reduction in the interior unskilled wage reduces unskilled households' income in the interior and the relative price change reduces skilled households' income in both regions since they are paid in terms of manufacturing output. Overall, income falls in both regions and, as a result, falls nationally.

On the output front, there is a fall in output in both regions; in the interior because of the direct effect of the reduction in infrastructure expenditure and in the coastal region because of a valuation effect driven by the relative price change. The result is a fall in national output. Welfare is improved in the interior, given the beneficial effects of the increase in the government consumption good, but falls in the coast in response to the relative price effect, which hits this manufacturing-intensive region and welfare falls nationally because of the higher weight of the coast in the national social welfare function.

In the long run, the reduction in the agricultural wage in the interior causes both inter- and intra-regional migration. In particular, there is a substantial migration of unskilled workers from the interior to the coast and a smaller movement of unskilled workers from agriculture to manufacturing in the interior. Overall, there is a net shift of population from the interior to the coast, which further reduces output in the interior and increases it in the coast although, given the decreasing marginal product of labour in both sectors, output per capita moves in the opposite direction in each case. This results in a reduction in the disparity between coastal and interior per capita output, but ironically, this occurs not because the regional government has improved the productive environment in the interior but because the resulting reduction in agricultural wages has driven its citizens to migrate to the coast, raising the interior average product.

The income gap is also narrowed in the long run, as interior agricultural wages recover partially and coastal wages in agriculture are depressed by the influx of migrants. The welfare gap narrows further in the long run and national welfare improves as a result of the migration. All trade-offs reverse in the long run—now there is a trade-off in the output and income dimensions but none for welfare.

As mentioned in the previous section, alternative forms of regional government fiscal policy are possible. Thus, for example, the budgetary implications of the increase in government consumption expenditure can be offset by other means—a fall in spending on manufacturing infrastructure or an increase in either of the regional government's tax instruments (on agriculture and manufacturing) or some combination of the above. The results of these alternative assumptions are reported in Appendix 5 and are briefly discussed in the next subsection.

Policy 2: An increase in agricultural productive capacity. A summary of the effects of this policy are also reported in Table 2 with full results given in Appendix 4. In the short run, the increase in agricultural productivity in the interior improves agricultural output and so the total regional output, for given levels of other factors (which are fixed in the short run). The increase in agricultural output results in a change in the relative price in favour of manufacturing, which results in an increase in output in the coast; this is a pure valuation effect, though, since regional output is measured in terms of the composite good. The increase in output in the interior is larger than that in the coast so that the output gap decreases and national output increases so that there is no trade-off in terms of output per capita.

The improvement in agricultural productivity directly affects the labour market since it increases the marginal product of labour[20] and so increases the firms' demand for (unskilled) labour that drives up the wage of unskilled labour in the interior, which contributes to an increase of income in the interior. Skilled workers are also made better off but this happens not because the demand for skilled labour increases (since there is no skilled labour employed in agriculture) but because of the relative price change in favour of manufacturing output in terms of which skilled wages are paid. This, in turn, helps improve the income in the coast, which is relatively manufacturing-intensive. Thus, income increases in both the interior and in the coast; however, the increase in income in the interior is larger than that in the coast so that the income gap narrows and national income increases so there is also no trade-off in the income dimension.

The income effect results in a similar change in welfare in which both regions' welfare increases but that in the interior is larger so that the regional welfare gap falls while the national level of welfare rises.

In the short run, therefore, this policy seems to be uniformly successful—all three gaps are narrowed while, nationally, output per capita, welfare, and income all rise.

In the long run, though, some of these effects are reversed and trade-offs arise. The increase in agricultural wages in the interior induces migration mainly by agricultural workers from the coast to the interior, which leads to an increase in the interior's agricultural output and a fall in that in the coast but with per capita outputs moving in the opposite direction, under the influence of decreasing marginal product of labour. The per capita output gap therefore widens in the long run even though national output rises as a result of this labour re-allocation.

The movement of labour from the coast to the interior reduces wages in interior agriculture and increases them for coastal agricultural workers. This flows through to incomes and welfare so that in the long run, the welfare and income gaps widen and there is a fall in the national levels of these variables although this fall is not enough to offset the short-run gains.

In summary, in the short run, an improvement in agricultural productivity in the interior increases output per capita, income, and welfare in both regions as well as narrowing the gaps for all three variables. In the long run, as labour migrates to the interior, many of these gains are reversed so that interior output per capita, income, and welfare all fall (relative to both the short-run solution and the initial equilibrium) while they all increase for the coast so that all three gaps widen. Paradoxically, therefore, in the long run, the coast seems to be the main beneficiary of this policy designed to help the interior. National levels of all three measures still rise in the long run but not by as much as in the short run.

Policy 3: A reduction in inter-regional migration costs. Table 2 shows that policy 3 has no effects in the short run, which is not surprising since the inter-regional migration channel through which it operates is closed in the short run. Thus, trivially, there are no trade-offs in the short run.

However, in the long run, the migration relaxation induces substantial migration from the interior to the coastal region for both unskilled (in agriculture and manufacturing) and skilled workers, with the largest effects being for unskilled agricultural workers although there are also substantial movements of skilled workers in manufacturing. The first effect is to increase output in the coast in both manufacturing and agriculture but reduce it in the interior. With decreasing marginal productivity, output per capita rises in the interior and falls in the coast so that the per capita output gap narrows; the rise in output in the coast more than offsets the fall in the interior so that national output increases. There is, therefore, no long-run trade-off in the per capita output dimension.

The shift of workers from the interior to the coast generally pushes interior wages up and coastal wages down. Incomes follow suit so that the income gap between the two regions narrows. At the same time, national income goes up marginally so that here, too, there is no trade-off between a reduction in the gap and the national level of the variable.

Finally, the changes in welfare follow those in wages and income: the migration of workers from the interior to the coastal region means that the welfare of both types of household improves in the interior and deteriorates in the coast so that the welfare disparity improves. Moreover, this is not at the expense of national welfare, which also increases so that the reduction in the welfare gap is not achieved at the cost of national welfare.

Thus, in summary, the policy of reducing the costs of inter-regional migration has no effects in the short run (by assumption) but is completely successful in the long run: the inter-regional gaps in income, welfare, and per capita output are all reduced, none of them at the expense of the national level of the corresponding variable. Nevertheless, as expected, the policy does have a cost (in all three dimensions) to the coastal provinces, the governments of which can, therefore, be expected to continue to resist such action.

Policy 4: A reduction in intra-regional migration costs. The final set of results in Table 2 shows the effects of a fall in intra-regional migration costs. Recall that intra-regional migration is that by unskilled workers from agriculture to manufacturing within the same region; in equilibrium, the allocation of workers between these two sectors is determined by the relative wages adjusted for congestion costs, which are largely composed of housing and *hukou* costs. In the modelling, we focus on the housing costs. Recall also that urban housing is assumed to be owned by skilled workers so that a fall in housing costs represents a fall in the transfer of purchasing power from unskilled to skilled workers. Therefore, in contrast to the inter-regional case just discussed, there are short-run effects in the present case since there is a fall in the rent paid by migrants to the owners of urban housing, which translates into a fall in the incomes of the skilled and a rise in the incomes of the unskilled in both regions. This in turn flows through into consumption and into welfare effects and results in disparities in both income and welfare being slightly reduced. There is also a reduction in the inter-regional disparity in per capita output but this is just a relative price effect driven by changes in consumption. The effects on output are also small so that, on the whole, the short-run effects on the disparities are favourable but small.

The long-run effects are more substantial, as expected, since now, migration is possible. There is a large reduction in the number of unskilled workers in agriculture in the interior, some of them moving to manufacturing in the same region but a substantial number going to both agriculture and manufacturing in the coast so that, overall, coastal population rises but interior population falls. Both intra-regional and inter-regional effects are therefore large and clearly factors, which increase the cost of migration, whether via housing costs or implicit costs of *hukou* restrictions, can be important barriers to internal migration, and can have an important effect on inter-regional disparities.

In the interior, the output effects are interesting. The fall in agricultural output occasioned by the out-migration of agricultural workers is more than offset by the expansion of manufacturing output where some of the workers go. There is, therefore, a small increase in interior output despite the overall loss of employment although it should be noted that part of this effect is a valuation one driven by the change in relative prices. While there is a small increase in overall interior output, the increase in per capita output is larger given the force of decreasing marginal product of labour. In the coast, there is an increase in output because of the increase in the workforce but per capita output falls. For the economy as a whole, the re-allocation of employment raises output. Hence, in the long run, all disparities fall, none at the expense of the corresponding aggregate value so that there are no long-run trade-offs.

Sensitivity analysis. In the previous subsection, we have discussed in some detail the results of the simulation of four policies that might be undertaken to reduce inter-regional disparities. Not surprisingly, different policies have different effects and different implications for the trade-off question. We can however, draw the following broad conclusions. First, a trade-off between reducing disparities and maintaining the aggregate level of a policy target variable is often present.

Second, whether the trade-off exists depends on the particular policy shock. Third, whether a trade-off exists depends on the variable being targeted. Fourth, whether a trade-off exists depends on whether a short- or long-run view is taken.

In addition to the simulations discussed in the previous subsection, we have also run a large number of additional simulations to assess the sensitivity of our results to model closure chosen as well as to the values of the substitution parameter in the utility function. In particular, we have experimented with four alternative ways to finance the regional government's budget when it increases consumption expenditure (model closures) and we have assessed the sensitivity of the results to two alternative values of the substitution parameter elasticity (which is 0.44 in the base case). Detailed results for these additional simulations are reported in Appendix 5. In the case of the alternative regional government budget closures, the extra simulations show that while the details differ (sometimes in important ways), our broad conclusions listed above are generally unaffected. Similarly, for the experiments with alternative values of the substitution parameter, the overall conclusions are not affected.

Conclusions

The focus of this paper is the tension between reducing inter-regional disparities and maintaining the level of aggregate activity—is there a cost in the form of national development foregone when policies to reduce inter-regional gaps are implemented? We argued that this is an important policy issue for China where inter-regional gaps are large and persistent and where there is a strong focus by policy makers on aggregate economic performance.

Our starting point in the analysis of this question was that both regional- and national-level variables are likely to be endogenous in any satisfactory regionally disaggregated macro model so that whether an inter-regional gap and the corresponding national variable move together or in opposite directions will, in general, depend on the shock imposed on the model.

To explore this issue, we built a small two-region model capturing some of the characteristics of the Chinese economy and subjected it to a number of shocks of which we described four in detail. The effects of these shocks on inter-regional gaps in per capita output, income, and welfare as well as on the corresponding national levels of these variables were analysed using simulations of a numerical version of the model.

Given that the signs of the effects of policy shocks are of most relevance for the question at hand, we summarise these signs in Table 3. We consider three gaps: in per capita output, income, and welfare as well as the aggregate counterparts to

TABLE 3. SUMMARY OF RESULTS.

Variables	Policy 1		Policy 2		Policy 3		Policy 4	
	SR	LR	SR	LR	SR	LR	SR	LR
Welfare gap	–	–	–	+	0	–	–	–
Income gap	+	–	–	+	0	–	–	–
Per capita output gap	+	–	–	+	0	–	–	–
Aggregate welfare	–	+	+	+	0	+	–	+
Aggregate income	–	–	+	+	0	+	+	+
Aggregate output	–	–	+	+	0	+	0	+

these variables. Four broad conclusions may be drawn from the information in the table.

First, different gaps may move in different directions so that policy makers need to be clear as to which gap is being targeted. Of the four policies we focussed on, this was true of the regional government fiscal policy (policy 1) for which the income and output gaps moved together but the welfare gap moved in the opposite direction in the short run. On the other hand, all three gaps move in the same direction in response to other policies.

Second, whether a narrowing of the gap between the interior and the coast comes at the expense of the national level of the relevant variable depends also on the shock. Thus in the long run, there are trade-offs in all dimensions for policy 2, but in no dimension for policies 3 and 4 while for policy 1 there is a trade-off in some but not other dimensions.

Third, the trade-off may change when we move from the short to the long run. This is particularly noticeable for policies 1 and 2 where the trade-off conclusions are reversed in all dimensions between the short and the long runs.

Finally, only the reduction of migration costs (policy 3 and 4) narrows all three gaps with no cost in terms of lower national levels in the long run. This is true for both inter- and intra-regional migration cost reductions. In both cases in the long run, however, the coastal region loses in terms of welfare, income, and output per capita and can, on the basis of these results, be expected to continue to oppose a relaxation of the restrictions on internal migration in China.

NOTES

1. See Groenewold, Chen, and Lee (2008), Chapters 2 and 3 for detailed information on Chinese regional disparities and regional policy since the founding of the People's Republic of China.

2. But see Chang and Ram (2000) and Easterly (2007) for recent examples of analyses of the relationship between per capita income and inequality.
3. This makes our model a (very) small computable general equilibrium (CGE) model. For an example of a large CGE model of the Chinese economy, also with regional disaggregation, see the discussion/applications of the SinoTERM model built at the Centre of Policy Studies at Monash University; e.g., Horridge and Wittwer (2008, 2009, 2010). Applications of other large CGE models to China's economy include Peng and Mai (2008) and Mai et al. (2009).
4. Recent papers using this classification are Fleisher and Chen (1997), Demurger (2001), Fujita and Hu (2001), Bao et al. (2002), Brun, Combes, and Renard (2002), Hu (2002), Lin, Wang, and Zhao (2004), Whalley and Zhang (2007), and He, Wei, and Xie (2008).
5. We abstract from agglomeration effects, which have been central in much discussion of regional development; see for example Hu (2002) where both agglomeration and trade play a central role in the analysis of regional disparities and migration in a model that is "inspired" by China.
6. In principle, it would be straightforward to include inter-regional capital mobility but this would unnecessarily complicate the analysis and distract from our focus on labour migration, which has been at the heart of discussion of disparities in China. Besides, there is recent evidence (Li 2010) that capital mobility between China's provinces is much lower than is consistent with free capital mobility.
7. While our structure drastically simplifies the structure of Chinese taxes, we would argue that it captures the salient features; see Lin and Liu (2000), Zhang and Martinez-Vazquez (2003), Jin, Qian, and Weingast (2005), Shen, Jin, and Zou (2006), Jin and Zou (2005), Tochkov (2007), Zhang and Zou (1998), Zhang and Zou (2001), and Zhang (2006) for recent information on aspects of the Chinese public finances. It should also be noted that the tax on agriculture was abolished in 2006. We nevertheless include it in our model since for much of the post-war period, it has been an important source of revenue for provincial governments.
8. A list of variables is given in Appendix 1.
9. See Cheng and Selden (1994) for a general description and history of the *hukou* system. There have been various analyses of the effects of the *hukou* system. Apart from the analysis by Whalley and Zhang (2007), which we mentioned in the introductory section, they include Hertel and Zhai (2006), who analyse the *hukou* restrictions in the context of urban–rural inequality, Liu (2005), who uses individual record data to investigate the effects at the individual level, and Poncet (2006), who uses data on inter-regional migration to consider the effects of a change in *hukou* over time on such flows.
10. Other authors (such as Boadway and Flatters 1982; Groenewold and Hagger 2005, 2007; Groenewold, Hagger, and Madden 2000, 2003; Myers 1990; Petchey 1993, 1995; and Petchey and Shapiro 2000) have avoided the discontinuity by assuming migration to be costless but this will not do in our case since we wish to model the effects of changes in migration costs.
11. In practice, the migration of unskilled workers from agriculture in one region to manufacturing in the other is likely to be the most costly but recall our assumption above that this occurs in two stages—inter-regional and then intra-regional—and here we merely assume that the second of these stages incurs the higher cost.
12. For a recent paper in which housing costs drive congestion costs in a regional setting see Südekum (2009).

13. An alternative to our approach to the modelling housing costs would be to model the housing market explicitly, with demands, supplies, and assumptions about the ownership of the housing stock and so on. Then, housing services would be included in the composite commodity and we could define a real wage, which would fall as the price of housing increased and the migration condition could be specified in terms of relative real wages. Given that we have no interest in the housing market per se, it seems that our structure achieves the same qualitative effect with the advantage of considerable simplicity. Besides, it is not clear how to fit *hukou* costs into such a framework.
14. Note that we ignore the possibility of the transfer of remittances from those members of rural households who have migrated to the urban areas. While these are undoubtedly significant in practice, to keep track of them in the current model would be to excessively complicate the model.
15. The assumption that each sector has a fixed region-specific factor has a respectable history in regional modelling; see, e.g., the original "New Economic Geography" paper by Krugman (1991). Note, though, that since we abstract from land use in manufacturing, we exclude the possibility that rising land rentals will reinforce the congestion effects of rising housing and *hukou* costs discussed above.
16. Note that in much of the development literature, national development is measured using per capita output or income. In our model, national population will be assumed to be constant so that per capita output will always change equi-proportionately with aggregate output and similarly for income and welfare so that aggregate and per capita variables may be used interchangeably to measure national development.
17. We are grateful to a referee for pointing out the "unfairness" of the comparison between a tax-financed fiscal expansion and a "free" productivity increase.
18. Note that, if the reduction in housing costs consumes government resources, as it would, for example, if the government increases the supply of public housing, this policy also suffers from the "unfairness" problem of policy 2 discussed in the previous footnote.
19. Appendices 4 and 5 are available as part of a longer working paper version of the paper available from the web site: http://www.business.uwa.edu.au/school/disciplines/economics/2009
20. Note that in contrast to the stylised facts of agricultural development, technical progress here is not labour saving but Hicks-neutral so that all marginal products increase.

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Appendix 1 Definition of Variables

V_{ki} = utility of the representative household of type k, region i

C_{Aki} = real private consumption of agricultural output per household of type k, region i

C_{Mki} = real private consumption of manufactured good per household of type k, region i

GH_i = real government-provided consumption per household, region i

T_v = value-added tax rate

P = price of agricultural good in terms of manufactured good

J_{ki} = household income in terms of the composite good per household of type k, region i

ΠH_{ji} = profit distribution per household by sector j, region i

L = national employment

L_i = employment, region i

L_k = employment, type k

L_{ki} = employment, type k, region i

L_{jki} = employment, sector j, type k, region i

Y_{ji} = real output, sector j, region i

Y = national real output

D_{ji} = productivity parameter, sector j, region i

GRF_{ji} = real regional government-provided public infrastructure, sector j, region i

T_{ji} = output tax rate, sector j, region i

W_{jki} = real wage, sector j, skill type k, region i

GC_i = real central government-provided consumption good per household, region i

GRH_i = real regional government-provided consumption good per household, region i

θ = central government's share of valued-added tax

J_i = real income per household, region i

J = national income per household

V_i = utility of the representative household, region i

V = national welfare

R_i = housing rental payment, region i

Δ_i = rental payment parameters, region i

MC_{AU} = interregional migration cost, unskilled labour
MC_{MS} = interregional migration cost, skilled labour

Appendix 2 Linearised Version of the Model

The model is linearised in terms of proportional differences by taking logarithms and differentials of each equation. The linearised form of equations (1–16) of the model are as follows, with the linearised form having the same number as the original equation but being distinguished by a prime.

The linearised utility function is

$$v_{ki} = \sigma_{cakiv} c_{Aki} + \sigma_{cmkiv} c_{Mki} + \sigma_{ghkiv} gh_i, \; i = I, C; \; k = U, S \qquad (1')$$

where lower-case letters represent the proportional changes (log differential) of their upper-case counterparts and

$$\sigma_{cakiv} = \frac{\gamma_{Aki} C_{Aki}^{-\rho_{ki}}}{\gamma_{Aki} C_{Aki}^{-\rho_{ki}} + \gamma_{Mki} C_{Mki}^{-\rho_{ki}} + \gamma_{Gki} GH_i^{-\rho_{ki}}}$$

$$\sigma_{cmkiv} = \frac{\gamma_{Mki} C_{Mki}^{-\rho_{ki}}}{\gamma_{Aki} C_{Aki}^{-\rho_{ki}} + \gamma_{Mki} C_{Mki}^{-\rho_{ki}} + \gamma_{Gki} GH_i^{-\rho_{ki}}} \text{ and}$$

$$\sigma_{ghkiv} = \frac{\gamma_{Gki} GH_i^{-\rho_{ki}}}{\gamma_{Aki} C_{Aki}^{-\rho_{ki}} + \gamma_{Mki} C_{Mki}^{-\rho_{ki}} + \gamma_{Gki} GH_i^{-\rho_{ki}}}.$$

The linearised consumption demand functions are

$$c_{Aki} = j_{ki} + \lambda p - \sigma_{cakij} p - \sigma_{elaski} p - \sigma_{tv} t_v, \; i = I, C; \; k = U, S \qquad (2a')$$

where $\sigma_{cakij} = \dfrac{\dfrac{\rho_{ki}}{\rho_{ki}+1}}{1 + P^{\frac{-\rho_{ki}}{\rho_{ki}+1}} \left(\dfrac{\gamma_{Mki}}{\gamma_{Aki}}\right)^{\frac{1}{\rho_{ki}+1}}}$, $\sigma_{elaski} = \dfrac{1}{\rho_{ki}+1}$, and $\sigma_{tv} = \dfrac{T_v}{1+T_v}$.

$$c_{Mki} = j_{ki} + \lambda p - \sigma_{cakij} p - \sigma_{tv} t_v, \; i = I, C; \; k = U, S \qquad (2b')$$

The linearised migration equilibrium conditions corresponding to equation (3) are

$$p + w_{AUi} = w_{MUi} - \sigma_{mcui}(l_{MUi} + \delta_i), \; i = I, C \qquad (3a')$$

where $\sigma_{mcui} = \dfrac{W_{MUi} - PW_{AUi}}{PW_{AUi}}$.

$$p - \lambda p + \sigma_{wAUC} w_{AUC} - \sigma_{wAUI} w_{AUI} = mc_{AU} \qquad (3b')$$

where $\sigma_{wAUC} = \dfrac{W_{AUC}}{W_{AUC} - W_{AUI}}$ and $\sigma_{wAUI} = \dfrac{W_{AUI}}{W_{AUC} - W_{AUI}}$

$$-\lambda p + \sigma_{wMSC} w_{MSC} - \sigma_{wMSI} w_{MSI} = mc_{MS} \tag{3c′}$$

where $\sigma_{wMSC} = \dfrac{W_{MSC}}{W_{MSC} - W_{MSI}}$, and $\sigma_{wMSI} = \dfrac{W_{MSI}}{W_{MSC} - W_{MSI}}$.

The linearised definitions of real household income are

$$\begin{aligned} j_{si} &= \sigma_{jSi\pi hA}(p - \lambda p + \pi h_{Ai}) + \sigma_{jSi\pi hM}(-\lambda p + \pi h_{Mi}) + \sigma_{jSiw}(-\lambda p + w_{MSi}) \\ &\quad + \sigma_{jSir}(r_i + l_{MUi} - l_{MSi}), i = I, C \end{aligned} \tag{4a′}$$

where $\sigma_{jSi\pi hA} = \dfrac{P^{1-\lambda}\Pi H_{Ai}}{J_{Si}}$, $\sigma_{jSi\pi hM} = \dfrac{P^{-\lambda}\Pi H_{Mi}}{J_{Si}}$, $\sigma_{jSiw} = \dfrac{P^{-\lambda} W_{MSi}}{J_{Si}}$, and

$\sigma_{jSir} = \dfrac{R_i(L_{MUi}/L_{MSi})}{J_{Si}}$.

$$\begin{aligned} j_{Ui} &= \sigma_{jUi\pi hA}(p - \lambda p + \pi h_{Ai}) + \sigma_{jUi\pi hM}(-\lambda p + \pi h_{Mi}) + \sigma_{jUiwA}(p - \lambda p + l_{AUi} - l_{Ui} + w_{AUi}) \\ &\quad + \sigma_{jUiwM}(-\lambda p + l_{MUi} - l_{Ui} + w_{MUi}) - \sigma_{jUir}(r_i + l_{MUi} - l_{Ui}), i = I, C \end{aligned} \tag{4b′}$$

where $\sigma_{jUi\pi hA} = \dfrac{P^{1-\lambda}\Pi H_{Ai}}{J_{Ui}}$, $\sigma_{jUi\pi hM} = \dfrac{P^{-\lambda}\Pi H_{Mi}}{J_{Ui}}$, $\sigma_{jUiwA} = \dfrac{P^{1-\lambda} W_{AUi} L_{AUi}/L_{Ui}}{J_{Ui}}$,
$\sigma_{jUiwM} = \dfrac{P^{-\lambda} W_{MUi} L_{MUi}/L_{Ui}}{J_{Ui}}$, and $\sigma_{jUir} = \dfrac{R_i L_{MUi}/L_{Ui}}{J_{Ui}}$.

$$r_i = l_{MUi} + W_{MUi} + \delta_i - \lambda p, i = I, C \tag{4c′}$$

where δ is the change in the migration cost parameter.
The linearised production functions are

$$y_{Ai} = d_{Ai} + \alpha_{AGi} grf_{Ai} + \alpha_{AUi} l_{AUi}, i = I, C \tag{5a′}$$

$$y_{Mi} = d_{Mi} + \alpha_{MGi} grf_{Mi} + \alpha_{MUi} l_{MUi} + \alpha_{MSi} l_{MSi}, i = I, C \tag{5b′}$$

The linearised profit definitions are given by

$$\pi f_{Ai} = \sigma_{y\pi fAi} y_{Ai} - \sigma_{tAi}\sigma_{y\pi fAi} t_{Ai} - \sigma_{w\pi fAUi}(w_{AUi} + l_{AUi}), i = I, C \tag{6a′}$$

where $\sigma_{y\pi fAi} = \dfrac{(1 - T_{Ai})Y_{Ai}}{\Pi F_{Ai}}$, $\sigma_{tAi} = \dfrac{T_{Ai}}{1 - T_{Ai}}$, and $\sigma_{w\pi fAUi} = \dfrac{W_{AUi} L_{AUi}}{\Pi F_{Ai}}$.

$$\pi f_{Mi} = \sigma_{y\pi fMi} y_{Mi} - \sigma_{tMi}\sigma_{y\pi fMi} t_{Mi} - \sigma_{w\pi fMUi}(w_{MUi} + l_{MUi}) - \sigma_{w\pi fMSi}(w_{MSi} + l_{MSi}), i = I, C \tag{6b'}$$

where $\sigma_{y\pi fMi} = \dfrac{(1-T_{Mi})Y_{Mi}}{\Pi F_{Mi}}$, $\sigma_{tMi} = \dfrac{T_{Mi}}{1-T_{Mi}}$, $\sigma_{w\pi fMUi} = \dfrac{W_{MUi}L_{MUi}}{\Pi F_{Mi}}$, and $\sigma_{w\pi fMSi} = \dfrac{W_{MSi}L_{MSi}}{\Pi F_{Mi}}$.

The manufacturing sector's profit maximisation condition in linear form is

$$y_{Mi} - \sigma_{tMi} t_{Mi} = w_{MSi} + l_{MSi}, i = I, C \tag{7a'}$$

$$y_{Mi} - \sigma_{tMi} t_{Mi} = w_{MUi} + l_{MUi}, i = I, C \tag{7b'}$$

and that for agriculture is given by

$$y_{Ai} - \sigma_{tAi} t_{Ai} = w_{AUi} + l_{AUi}, i = I, C \tag{7c'}$$

The central government's budget constraint is linearised as

$$\sigma_{gcIgc}(l_I + gc_I) + \sigma_{gcCgc}(l_C + gc_C) = \theta^* + t_v + \sigma_{jSIj}(l_{SI} + j_{SI}) + \sigma_{jUIj}(l_{UI} + j_{UI}) + \sigma_{jSCj}(l_{SC} + j_{SC}) + \sigma_{jUCj}(l_{UC} + j_{UC}) \tag{8'}$$

where $\sigma_{gcIgc} = \dfrac{L_I GC_I}{L_I GC_I + L_C GC_C}$, $\sigma_{gcCgc} = \dfrac{L_C GC_C}{L_I GC_I + L_C GC_C}$,

$$\sigma_{jSIj} = \frac{L_{SI}J_{SI}}{L_{SI}J_{SI} + L_{UI}J_{UI} + L_{SC}J_{SC} + L_{UC}J_{UC}},$$

$$\sigma_{jUIj} = \frac{L_{UI}J_{UI}}{L_{SI}J_{SI} + L_{UI}J_{UI} + L_{SC}J_{SC} + L_{UC}J_{UC}},$$

$$\sigma_{jSCj} = \frac{L_{SC}J_{SC}}{L_{SI}J_{SI} + L_{UI}J_{UI} + L_{SC}J_{SC} + L_{UC}J_{UC}},$$

$$\sigma_{jUCj} = \frac{L_{UC}J_{UC}}{L_{SI}J_{SI} + L_{UI}J_{UI} + L_{SC}J_{SC} + L_{UC}J_{UC}}, \text{ and } \theta^* = d\theta/\theta.$$

The regional government's budget constraint in linear form is given by

$$\sigma_{grhIgr}(l_I + grh_I) + \sigma_{grfAIgr} grf_{AI} + \sigma_{grfMIgr} grf_{MI} = \sigma_{tAIgr}(t_{AI} + p - \lambda p + y_{AI}) + \sigma_{tMIgr}(t_{MI} - \lambda p + y_{MI}) + \sigma_{tvIgr}(-\sigma_\theta \theta^* + t_v + \sigma_{lSIj}(l_{SI} + j_{SI}) + \sigma_{lUIj}(l_{UI} + j_{UI})) \tag{9a'}$$

where $\sigma_{grhIgr} = \dfrac{L_I GRH_I}{L_I GRH_I + GRF_{AI} + GRF_{MI}}$, $\sigma_{grfAIgr} = \dfrac{GRF_{AI}}{L_I GRH_I + GRF_{AI} + GRF_{MI}}$,

$$\sigma_{grfMIgr} = \frac{GRF_{MI}}{L_I GRH_I + GRF_{AI} + GRF_{MI}}, \sigma_{\theta} = \frac{\theta}{1-\theta},$$

$$\sigma_{tAIgr} = \frac{T_{AI} P^{1-\lambda} Y_{AI}}{T_{AI} P^{1-\lambda} Y_{AI} + T_{MI} P^{-\lambda} Y_{MI} + (1-\theta) T_V (L_{SI} J_{SI} + L_{UI} J_{UI})},$$

$$\sigma_{tMIgr} = \frac{T_{MI} P^{-\lambda} Y_{MI}}{T_{AI} P^{1-\lambda} Y_{AI} + T_{MI} P^{-\lambda} Y_{MI} + (1-\theta) T_V (L_{SI} J_{SI} + L_{UI} J_{UI})},$$

$$\sigma_{tvIgr} = \frac{(1-\theta) T_V (L_{SI} J_{SI} + L_{UI} J_{UI})}{T_{AI} P^{1-\lambda} Y_{AI} + T_{MI} P^{-\lambda} Y_{MI} + (1-\theta) T_V (L_{SI} J_{SI} + L_{UI} J_{UI})},$$

$\sigma_{lSIj} = \dfrac{L_{SI} J_{SI}}{L_{SI} J_{SI} + L_{UI} J_{UI}}$, and $\sigma_{lUIj} = \dfrac{L_{UI} J_{UI}}{L_{SI} J_{SI} + L_{UI} J_{UI}}$.

$$\begin{aligned} &\sigma_{grhCgr}(l_C + grh_C) + \sigma_{grfACgr} grf_{AC} + \sigma_{grfMCgr} grf_{MC} \\ &\quad = \sigma_{tACgr}(t_{AC} + p - \lambda p + y_{AC}) + \sigma_{tMCgr}(t_{MC} - \lambda p + y_{MC}) \\ &\quad\quad + \sigma_{tvCgr}(-\sigma_{\theta}\theta^* + t_v + \sigma_{lSCj}(l_{SC} + j_{SC}) + \sigma_{lUCj}(l_{UC} + j_{UC})) \end{aligned} \tag{9b$'$}$$

where $$\sigma_{grhCgr} = \frac{L_C GRH_C}{L_C GRH_C + GRF_{AC} + GRF_{MC}},$$

$$\sigma_{grfACgr} = \frac{GRF_{AC}}{L_C GRH_C + GRF_{AC} + GRF_{MC}},$$

$$\sigma_{grfMCgr} = \frac{GRF_{MC}}{L_C GRH_C + GRF_{AC} + GRF_{MC}},$$

$$\sigma_{tACgr} = \frac{T_{AC} P^{1-\lambda} Y_{AC}}{T_{AC} P^{1-\lambda} Y_{AC} + T_{MC} P^{-\lambda} Y_{MC} + (1-\theta) T_V (L_{SC} J_{SC} + L_{UC} J_{UC})},$$

$$\sigma_{tMCgr} = \frac{T_{MC} P^{-\lambda} Y_{MC}}{T_{AC} P^{1-\lambda} Y_{AC} + T_{MC} P^{-\lambda} Y_{MC} + (1-\theta) T_V (L_{SC} J_{SC} + L_{UC} J_{UC})},$$

$$\sigma_{tvCgr} = \frac{(1-\theta) T_V (L_{SC} J_{SC} + L_{UC} J_{UC})}{T_{AC} P^{1-\lambda} Y_{AC} + T_{MC} P^{-\lambda} Y_{MC} + (1-\theta) T_V (L_{SC} J_{SC} + L_{UC} J_{UC})},$$

$\sigma_{lSCj} = \dfrac{L_{SC}J_{SC}}{L_{SC}J_{SC} + L_{UC}J_{UC}}$, and $\sigma_{lUCj} = \dfrac{L_{UC}J_{UC}}{L_{SC}J_{SC} + L_{UC}J_{UC}}$.

The definition of national output is linearised as

$$y_i = \sigma_{yyAi}(p - \lambda p + y_{Ai}) + \sigma_{yyMi}(-\lambda p + y_{Mi}), i = I, C \tag{10a'}$$

where $\sigma_{yyAi} = \dfrac{P^{1-\lambda}Y_{Ai}}{P^{1-\lambda}Y_{Ai} + P^{-\lambda}Y_{Mi}}$ and $\sigma_{yyMi} = \dfrac{P^{-\lambda}Y_{Mi}}{P^{1-\lambda}Y_{Ai} + P^{-\lambda}Y_{Mi}}$.

$$y = \sigma_{yyI}y_I + \sigma_{yyC}y_C, \tag{10b'}$$

where $\sigma_{yyI} = \dfrac{Y_I}{Y_I + Y_C}$, $\sigma_{yyC} = \dfrac{Y_C}{Y_I + Y_C}$ and we assume that $\lambda = \dfrac{Y_{AI} + Y_{AC}}{Y}$.

The definition of national income is linearised as

$$j_i + l_i = \sigma_{lUij}(j_{Ui} + l_{Ui}) + \sigma_{lSij}(j_{Si} + L_{Si}), i = I, C \tag{11a'}$$

$$j + l = \sigma_{jjI}(j_I + l_I) + \sigma_{jjC}(j_C + l_C) \tag{11b'}$$

where $\sigma_{jjI} = \dfrac{J_I}{J_I + J_C}$, and $\sigma_{jjC} = \dfrac{J_C}{J_I + J_C}$.

The definition of national welfare is linearised as

$$v_i + l_i = \sigma_{lUiv}(l_{Ui} + v_{Ui}) + \sigma_{lSiv}(l_{Si} + v_{Si}), i = I, C \tag{12a'}$$

where $\sigma_{lUiv} = \dfrac{L_{Ui}V_{Ui}}{L_{Ui}V_{Ui} + L_{Si}V_{Si}}$, and $\sigma_{lSiv} = \dfrac{L_{Si}V_{Si}}{L_{Ui}V_{Ui} + L_{Si}V_{Si}}$.

$$v + l = \sigma_{lvI}(v_I + l_I) + \sigma_{lvC}(v_C + l_C) \tag{12b'}$$

where $\sigma_{lvI} = \dfrac{L_I V_I}{L_I V_I + L_C V_C}$, and $\sigma_{lvC} = \dfrac{L_C V_C}{L_I V_I + L_C V_C}$

The definition of GH_i is linearised as

$$gh_i = \sigma_{grhigh}grh_i + \sigma_{gcigh}gc_i, i = I, C \tag{13'}$$

where $\sigma_{grhigh} = \dfrac{GRH_i}{GH_i}$, and $\sigma_{gcigh} = \dfrac{GC_i}{GH_i}$.

Equation (14), the goods markets clearing conditions, can be written in linear form as

$$\begin{aligned}&\sigma_{yIj}y_{jI}+\sigma_{yCj}y_{jC}-\sigma_{tyIj}(t_{jI}+y_{jI})-\sigma_{tyCj}(t_{jC}+y_{jC}),\ j=A,M\\&=\sigma_{tv}t_v+\sigma_{lUIcj}(l_{UI}+c_{jUI})+\sigma_{lSIcj}(l_{SI}+c_{jSI})\\&\quad+\sigma_{lUCcj}(l_{UC}+c_{jUC})+\sigma_{lSCcj}(l_{SC}+c_{jSC})\end{aligned}\tag{14′}$$

where $\sigma_{yIj}=\dfrac{Y_{jI}}{Y_{jI}+Y_{jC}-T_{jI}Y_{jI}-T_{jC}Y_{jC}}$, $\sigma_{yCj}=\dfrac{Y_{jC}}{Y_{jI}+Y_{jC}-T_{jI}Y_{jI}-T_{jC}Y_{jC}}$,

$$\sigma_{tyIj}=\frac{T_{jI}Y_{jI}}{Y_{jI}+Y_{jC}-T_{jI}Y_{jI}-T_{jC}Y_{jC}},\sigma_{tyCj}=\frac{T_{jC}Y_{jC}}{Y_{jI}+Y_{jC}-T_{jI}Y_{jI}-T_{jC}Y_{jC}},$$

$$\sigma_{lUIcj}=\frac{L_{UI}C_{jUI}}{L_{UI}C_{jUI}+L_{SI}C_{jSI}+L_{UC}C_{jUC}+L_{SC}C_{jSC}},$$

$$\sigma_{lSIcj}=\frac{L_{SI}C_{jSI}}{L_{UI}C_{jUI}+L_{SI}C_{jSI}+L_{UC}C_{jUC}+L_{SC}C_{jSC}},$$

$$\sigma_{lUCcj}=\frac{L_{UC}C_{jUC}}{L_{UI}C_{jUI}+L_{SI}C_{jSI}+L_{UC}C_{jUC}+L_{SC}C_{jSC}},\text{ and}$$

$$\sigma_{lSCcj}=\frac{L_{SC}C_{jSC}}{L_{UI}C_{jUI}+L_{SI}C_{jSI}+L_{UC}C_{jUC}+L_{SC}C_{jSC}}.$$

The labour market-clearing conditions imply

$$\sigma_{llAUi}l_{AUi}+\sigma_{llMUi}l_{MUi}=l_{Ui}, i=I,C\tag{15a′}$$

where $\sigma_{llAUi}=\dfrac{L_{AUi}}{L_{AUi}+L_{MUi}}$, and $\sigma_{llMUi}=\dfrac{L_{MUi}}{L_{AUi}+L_{MUi}}$.

$$l_{MSi}=l_{Si}, i=I,C\tag{15b′}$$

$$\sigma_{lkki}l_{kI}+\sigma_{lkkC}l_{kC}=l_k, k=U,S\tag{15c′}$$

where $\sigma_{lkkI}=L_{kI}/L_k$, and $\sigma_{lkkC}=L_{kC}/L_k$.

$$\sigma_{lUi}l_{Ui}+\sigma_{lSi}l_{Si}=l_i, i=I,C\tag{15d′}$$

where $\sigma_{lUi}=L_{Ui}/L_i$, and $\sigma_{lSi}=L_{Si}/L_i$.

$$\sigma_{lI}l_I+\sigma_{lC}l_C=l\tag{15e′}$$

where $\sigma_{lI}=l_I/l$, and $\sigma_{lC}=l_C/l$.

The profit distribution conditions can be linearised to give

$$\pi f_{Ai} = l_i + \pi h_{Ai}, i = I, C \qquad (16a')$$

$$\pi f_{Mi} = l_i + \pi h_{Mi}, i = I, C \qquad (16b')$$

Appendix 3 Calibrating the Linearised Model

The linearised model contains a number of parameters, which have to be evaluated before the model can be put to work to simulate the effects of various shocks. These parameters fall into two groups. The first are parameters which appear in model relationships; γ_{jki}, γ_{Gki}, and ρ_{ki} appear in the utility function (1) and α_{jGi} and α_{jki} appear in the production function (5). The remainder, on the other hand, are linearisation parameters, which are all shares of some sort.

The model parameters were evaluated as follows. For the parameters of the utility function we broadly followed the method set out in Mansur and Whalley (1984) in which the substitution elasticity $\sigma_{ki} = 1/(1 + \rho_{ki})$ is derived from the equation:

$$\sigma_{ki} = \frac{\eta_{ki} - \gamma_{ki}^{\sigma_{ki}}}{1 - \gamma_{ki}^{\sigma_{ki}}}$$

where η_{ki} is the (uncompensated) own-price elasticity, values for which were derived as averages from Table 4 in Mansur and Whalley, and $\gamma_{ki}^{\sigma_{ki}}$ can be derived from ratios of consumption expenditure and our assumption that $\gamma_{Aki} + \gamma_{Mki} + \gamma_{Gki} = 1$. We experimented with alternative values of the substitution elasticity (some of which are reported in Appendix 5) but found the results to be relatively insensitive to reasonable variations.

The manufacturing sector production parameters, α_{MSi}, α_{MUi}, and α_{MGi}. were calibrated as follows. Normally we would use the firm's first-order condition for profit maximisation, equation (7a) and (7b) to write the parameters in terms of costs shares:

$$\alpha_{MSi} = \frac{W_{MSi} L_{MSi}}{Y_{Mi}(1 - T_{Mi})}$$

$$\alpha_{MUi} = \frac{W_{MUi} L_{MUi}}{Y_{Mi}(1 - T_{Mi})}$$

However, this is not strictly possible for the government infrastructure variable since it is not one of the firm's choice variables but is determined by the government and taken as parametric by the firms. If we assume, nevertheless, that the quantity of the infrastructure is chosen to maximise profits or that the government provides a profit-maximising amount, we can also write

$$\alpha_{MGi} = \frac{GRF_{Mi}}{Y_{Mi}(1 - T_{Mi})}$$

We make this assumption and use data for the wage bill, government infrastructure expenditure, and manufacturing output net of tax to compute the parameters. The agriculture sector production parameters α_{AUi} and α_{AGi} are calibrated in the same way.

The linearisation parameters can be evaluated directly from their definitions, given values for C_{jki}, GH_i, T_v, P, J_{ki}, ΠH_{ji}, L, L_i, L_k, L_{ki}, Y_{ji}, L_{jUi}, L_{MSi}, GRF_{ji}, ΠF_{ji}, T_{ji}, W_{jUi}, W_{MSi}, GC_i, GRH_i, θ, Y, Y_i, J, J_i, V, V_i, R_i, Δ_i, MC_{AU}, and MC_{MS}. We normalise P at unity and set θ at 0.75 to reflect the current division of VAT revenue between the central and regional governments. We then use these assumed values and the data for Y_{ji}, L_{jUi}, L_{MSi}, W_{jUi}, W_{MSi}, GC_i, GRH_i, GRF_{ji}, T_v, T_{ji}, together with the model definitions to calculate the value of all other variables. The use of the model definitions ensures that the parameter values used in the simulations are consistent with the model constraints.

We therefore need data for two regions, the interior and the coast, for the variables Y_{ji}, L_{jUi}, L_{MSi}, W_{jUi}, W_{MSi}, GC_i, GRH_i, GRF_{ji}, T_v, T_{ji}. The data we use are based on those for the Chinese provinces, which we have allocated to the two regions as follows. The coastal region consists of Beijing, Tianjin, Hebei, Guangdong, Hainan, Shandong, Fujian, Zhejiang, Jiangsu, Shanghai, Liaoning , and Guangxi with the remaining provinces being allocated to the interior region. The interior therefore consist of Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Sichuan, Chongqing, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Tibet, Xinjiang. A map of the two regions is provided in Figure 1.

For each region, we use data averaged over the 7-year period 2000–2006 to avoid cyclical influences on the share parameters. All the data come from *China Statistics Year Book* (State Statistical Bureau 2001–2007).