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CESIFO WORKING PAPER NO. 3292
CATEGORY 8: TRADE POLICY
DECEMBER 2010

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Abstract

In this paper, we explore the role of trade in differentiated final goods as well offshoring of tasks for inequality both within and between countries. We emphasize the distinction between managerial and production labor. Production labor is assumed to be a variable input composed of tradable tasks, while managerial labor is a fixed, non-tradable input. We use a 2-country model recently developed by Grossman & Rossi-Hansberg (2010b) that highlights trade in production task, driven by Marshallian economies of scale. We analyze country size and relative endowment effects on the managerial wage premium as well as on international inequality measured in income per head. We compare these effects in a world where trade is restricted to differentiated final goods with a world with trade in both final goods and production tasks.

JEL-Code: F12, F16, F23.

Keywords: offshoring, economies of scale, income distribution, international inequality.

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December 2010

1 Introduction

There is a widespread presumption that, other things equal, larger countries should pay higher wages. The underlying assumption is that, in one form or another, many industries feature advantages of large scale production, which should be reflected in higher equilibrium factor rewards in larger countries. However, other things are seldom equal. In particular, many people still prefer to live in small countries, where their specific abilities are scarce, relative to other types of labor and relative to capital or land. In other words, in general equilibrium wages for different types of labor are governed by both, a country's size and its relative labor endowment. In this paper, we draw on a recent contribution by Grossman & Rossi-Hansberg (2010b), in order to explore the interaction of country size and relative endowment effects on inequality both within and between countries, using a 2-country model that highlights trade in differentiated final goods as well as trade in tasks driven by economies of scale.

Theory tells us that the way in which country size and relative endowments translate into a certain pattern of wages or, more generally, factor prices crucially depends on how these countries are connected to each other through trade and factor movements. For instance, models of comparative advantage stress that cross-country differences in relative factor endowments have a very limited role to play for national wages, if there is free trade between countries. Indeed, the factor price equalization theorem of the Heckscher-Ohlin model tells us that under certain conditions they play no role at all. This is sometimes called the "endowment insensitivity" of factor prices. However, there are multiple reasons why, even within the confines of this theory, a country's relative endowment regains importance for its factor prices. Perhaps the most relevant case in point is insufficient diversification of a country's production, as highlighted in Dixit & Norman (1980).

If trade renders national endowment irrelevant for national wages, it seems tempting to view a country's trade exposure as a potential explanatory factor for its trends in inequality. However, establishing the empirical significance of trade as an explanatory factor for observed wage patterns over time has been notoriously difficult.[1] From a trade theory perspective, perhaps the most important caveat to bear in mind is that factor remunerations are primarily determined by traded goods prices, and not by the volume and the factor content of trade per se.[2] Some authors have argued that trade in intermediate inputs, or offshoring, is a more convincing explanatory candidate for the rising skill premium than trade in final goods.[3] However, recent theoretical treatments have shown that under very plausible conditions offshoring of production components

[1] See Krugman (1995) for an early critique. For recent review of the evidence see Lawrence (2008).

[2] See the discussion in Deardorff (2000), Krugman (2000), Leamer (2000), and Panagariya (2000).

[3] See Feenstra & Hanson (1997, 1999, 2003) and Krugman (2008). Based on a version of the traditional model that is similar to Feenstra & Hanson (1997), Trefler & Zhu (2005) show that catching-up of less developed countries may entail a systematic effect towards increasing their skill premium.

or labor services to more labor abundant countries with lower wages may well lower, rather than increase, the domestic skill premium.[4]

If traditional endowment-based models fail to fully explain what we observe, where should we look for alternative, or complementary explanations? Models that focus on scarcity premia and trade to explain wage inequality, almost be definition, have a "north-south" flavor; the focus squarely lies on trade between countries with different relative endowments. Yet, a lot of the more recent increase in world trade has taken place in "north-north" direction, i.e., trade between countries with similar relative endowments. Almost any credible explanation of such trade will incorporate one form or another of economies of large scale production. And with economies of scale, one expects country size to play a role, in addition to relative endowments.

The modern view of trade incorporates two forms of scale economies. Production of intermediates is assumed to to involve a fixed cost. This means scale economies that are *internal to the firm*, which requires departing from the assumption of perfect competition. The literature mostly assumes monopolistic competition. A larger resource base allows exploitation of these economies, leading to a larger variety and lower prices of intermediate inputs. In final goods production, this is felt as higher productivity of primary inputs; see Ethier (1982b). But this effect is clearly *external to the individual firm* which may well perceive a technology with constant returns to scale. Notice, however, that with free trade in intermediates such external scale economies are international in scope; see Ethier (1979).

Perhaps surprisingly, an important conclusion to be derived from this view of technology and trade is that country size should not play a role for wages paid in any one country. However, it regains importance as a determinant of wages once we assume, plausibly, that trade is costly. Workers in large countries will then see a lower share of their consumption basket inflated through trade-cost and will thus enjoy higher real wages. This is the well-known "home market effect" in the presence of monopolistic competition, first pointed out by Krugman (1980). A similar effect obtains for final goods producers using differentiated traded intermediate inputs. Models of new economic geography incorporate this mechanism as a force of agglomeration; see Fujita *et al.* (2001).

Costliness of trade re-establishes some relevance of country size where scale economies external to the firm are inherently international in scope arise, due to pecuniary externalities transmitted through tradable goods. Very often, however, economies of scale are based on non-pecuniary spill-over mechanisms that require regional concentration, hence they will be *national* in scope to start with. Such external, but national scale economies (so-called "Marshallian" scale economies) have long been recognized as a potentially important source of specialization and trade. But they constitute a somewhat awkward case, because they entail a potential of multiple trading equilibria, driven by

[4]See Kohler (2004) and Grossman & Rossi-Hansberg (2008).

arbitrary, but self-fulfilling expectations that each firm may have about other firms' behavior; see Matsuyama (1991) and Krugman (1991). Moreover, as pointed out long ago by Graham (1923), trade based on this form of scale economies need not be beneficial to all countries, even under otherwise ideal conditions, since scale effects are an externality; see Ethier (1982b). For these reasons, external scale economies of this kind have taken somewhat of a back seat in the evolution of trade theory. However, in a recent paper Grossman & Rossi-Hansberg (2010a) show that the scope for multiple equilibria with "Marshallian" scale economies is substantially reduced, if firms are not assumed to be atomistic. If they are assumed, instead, to correctly anticipate the discrete output and productivity effects of setting out-of-equilibrium prices, then the pattern of trade is no longer indeterminate, but driven by underlying comparative advantage.

Our treatment of inequality in this paper deviates in two important ways from existing literature. The first relates to endowment-based models that typically draw a line between high- and low-skilled labor, thus discussing income inequality in terms of skill premia.[5] We argue that this distinction has very limited meaning, unless we explicitly model skill formation. We do acknowledge that there is a sizable body of literature dealing with skill formation; for instance, see for instance Findlay & Kierzkowski (1983) and Kreickemeier (2009). But the skill-focus tends to obfuscate another distinction that we argue is of equal, or even greater, importance, viz. the distinction between managerial and production labor. For want of skill-oriented data, researchers have often resorted to this dimension in lieu of the skill dimension when attempting to measure employment or wages; see for instance Feenstra (2010). But it is all too obvious that a lot of production work involves a high level of skills and human capital, very often exceeding that of non-production work. In this paper, we take this to the extreme by attaching a different meaning to the distinction between managerial and production labor that is orthogonal to the skill dimension.[6]

Assuming away all skill differences, what makes managerial labor a different input from production labor? We follow Rosen (1982) who argues that *managerial activities* are often characterized by inherent indivisibility and scale economies.[7] We model this in a very simple way by defining managerial labor to be a fixed input. In contrast, *production activities* are modeled as representing a variable input. This constitutes second,

[5]See Lawrence (2008) and Krugman (2008) for recent examples.

[6]We do not rule out that management is associated with task that require more skills or education than production tasks. But it is not a key ingredient of our story. For this reason, our approach also picks up, to some extent at least, the concern raised in recent public debates about managerial incomes not reflecting educational premia.

[7]In Rosen's own words: *"Management involves discrete and indivisible choices and commands, such as which goods to produce, in what varieties and volume, and how to produce them. Supervision insures that management directives are carried through at the production level. Indivisibilities inherent in management decisions are represented analytically as a form of total factor productivity improvement and, as such, imply a strong scale economy, not unlike a public good but limited to the confines of the firm. For example, the decision of which good to produce is largely independent of scale, applying equally well to a very large enterprise as to a very small one."* (Rosen, 1982, p. 312).

somewhat subtle deviation from the literature. Trade models featuring monopolistic competition typically assume what Horn (1983) has called a homothetic technology, meaning that the fixed and variable inputs of a production process rely on the same aggregate of primary factors. This seems at odds with the presence of managerial input as a factor of production, and it substantially reduces the role of country size for explaining inequality. Indeed, in assuming a single type of input, most of the "new" trade theory focusing on scale economies is completely silent about inequality.

The fixed *managerial* input represents the ability to organize and monitor an entire production process that leads to a certain differentiated good. It is thus *internal to the firm*. The variable input, on the other hand, requires expertise to perform a potentially large number of different activities dictated by complex value added chains. This expertise often relates to narrowly defined tasks, rather than the entire production process. Moreover, such expertise arguably develops through concentration of certain tasks in certain regions or countries, and not through the scale of firms as such. In other words, *production* work as a variable input is likely to exhibit economies of scale that are a) *external to the firm*, b) are likely to be *national in scope*, and c) are arising at the level of numerous *individual tasks*.

Grossman & Rossi-Hansberg (2010b) therefore assume that, other things equal, a unit of a country's production labor is the more efficient in performing a certain task, the more often that task is performed within the country, independently of firm size. They explore the potential of trade in tasks between two similar countries, similar meaning that they share the same ratio of managerial and production labor endowment. They trace out the role of relative country size for the structure of trade in tasks driven by "Marshallian" economies of scale at the level of single tasks, and for the associated levels of wages for production workers in one country relative to the other. They conduct comparative static analysis over the general costliness of task trade (always assuming that final goods trade is costless), as well as over the degree of external scale economies and the degree of product differentiation in final goods. Given the lack of a full closed form closed solution, they also rely on numerical simulations.

In this paper, we extend the model developed by Grossman & Rossi-Hansberg (2010b) in allowing for trade in tasks to be driven by *relative* endowment differences as well as country size. Moreover, in addition to cross country comparisons of production wages, we also address within-country inequality in terms of the managerial wage premium as well as international inequality in terms of income per capita. A detailed analysis of the influence of country size and relative endowments on these measures of inequality should enhance our understanding of the perennial issue of "trade and wages" as well as the issue of "international convergence and globalization". As in Grossman & Rossi-Hansberg (2010b), we assume exogenous country endowments with managerial and production labor.

There are three recent papers that have addressed issues of inequality along lines

similar to what we do in this paper. Motivated by arguably unconvincing explanations of trends to higher inequality within industrialized countries by traditional endowment-based as well as scale-based models, Manasse & Turrini (2001) introduce a variant of the Krugman (1980) model that, like that of Grossman & Rossi-Hansberg (2010b), departs from homotheticity in technology. Specifically, they assume that the variable input (as well as the incremental fixed cost incurred to enter export markets) relies on " raw" labor, while the fixed input is defined in terms of managing skills. Managerial talent translates into final goods of higher quality, with an associated higher willingness to pay. A key distinction to our approach is that in Manasse & Turrini (2001) each household embodies both "raw" production work as well as managerial skills, whereby firm size is exogenously fixed to a single household. Thus, inequality does not arise between production workers and managers, but between "raw" labor and managerial skills, both embodied in the same individual. A key thrust of the analysis is a potentially convex dependence of a household's remuneration on the amount of her managerial skills, which may explain the observed skewness in income distributions in many countries. However, with a fixed firm size it is obvious that this model is ill-suited to address issues of country size.

In contrast, size effects are at the heart of Epifani & Gancia (2008) who assume external scale economies that are international in scope along the lines of Ethier (1982a). As in this paper, the interest lies in country size effects on inequality within countries. However, Epifani & Gancia (2008) stick to the distinction between high-skilled and low-skilled workers, and they assume technology to be homothetic in the sense of Horn (1983). It turns out that for a closed economy country size works in favor of high-skilled labor, provided that i) the degree of external scale economies based on the variety effect is larger for the high-skill-intensive industry than the low-skill-intensive industry, and ii) the elasticity of substitution in demand for the goods of the two industries is larger than 1. For any given composition of the labor force, an increase in country size increases income per capita, due to enhanced differentiation of intermediate inputs. Under the aforementioned assumptions, the effect is stronger for the skill-intensive industry, and income and substitution effects do not offset each other in demand. The outcome then is a higher scarcity premium for high-skilled labor. And what is true for a closed economy becoming larger is also true for two or many economies becoming more integrated, whence all countries similarly reap the benefits from serving a larger (world) market. These are now doubt important insights, but for reasons mentioned above the focus on skilled versus unskilled labor in a homothetic technology seems questionable.

A recent paper by Egger & Kreickemeier (2008) shares our view that inequality should also be addressed along the distinction between managerial as a fixed input and production labor as a variable input. As in Manasse & Turrini (2001), they assume households to be differently endowed with innate managing abilities. However, they assume that, instead of higher quality output, managerial talent delivers higher

productivity of employed production labor. Moreover, at the stage of production the managerial and production input, respectively, are delivered by distinct individuals, although ex ante any household has the capacity to be either a manager or a worker. Households select themselves into one or the other type of activity, based on expected production wages and managerial income in the form of operating profits. As a firm owner, a manager needs to employ workers subject to a fair wage constraint, whereby workers' notion of fairness involves the desire to participate in the firm's idiosyncratic operating profits, i.e., the income of the firm's manager. This installs a mechanism of compression between production and managerial wages, but this in turn comes at the expense of unemployment as well as inequality within the group of otherwise identical workers who end up being matched with differently talented managers. Importantly, although Egger & Kreickemeier (2008) do assume final goods production with differentiated intermediates, they rule out the above mentioned external economies of scale. Among their conclusions they find that trade may increase inequality, both within the groups of managers and workers and between the two groups, at the same time as it increases unemployment.

While all of these papers no doubt deliver interesting and relevant insights, we believe that further important insights can be derived from the model of trade in tasks developed by Grossman & Rossi-Hansberg (2010b). As we have argued above, the type of "Marshallian" economies of scale highlighted by this model as a source of specialization on the level of tasks is an important element of industrial reality, and such scale economies are known from earlier literature to have important consequences for international inequality. We therefore extend the analysis beyond Grossman & Rossi-Hansberg (2010b) by focusing on domestic inequality and by allowing for trade to be driven by differences in relative endowments in addition to country size. Although this may appear like a minor extension, the challenge is non-trivial, given the analytical difficulties posed by "Marshallian" economies of scale. We also highlight the difference between a world where trade is restricted to final goods and a world where final goods trade is accompanied by trade in tasks.

The paper is structured as follows. Section 2 presents the key relationships of our model and derives comparative statics of size and endowments for the benchmark case of free trade in final goods, but no trade in tasks. In section 3, we derive the equilibrium conditions that govern trade in tasks. We discuss possible equilibrium locations of task performance. Since there are multiple trading equilibria that defy analytical solution, section 4 proceeds with a numerical treatment that sheds light on how "freeness of task trade" affects the interaction between country size and relative endowments in determining managerial and production workers' wages. Section 5 concludes the paper.

2 Trade in final goods

We assume two countries (home and foreign), sharing identical preferences and technology but differing in their exogenous endowments with managerial labor and production workers. Managerial labor endowment is denoted by M for the home country and by M^* for the foreign country. Both types of labor are immobile across countries. The supply of workers is denoted by L and L^* for the home and the foreign country. Preferences feature "love of variety", modeled as usual through a Dixit-Stiglitz-type utility function for varieties of a single final good. We assume varieties to be fully symmetric in both, demand and production. Producing any variety requires hiring f *managers* as a *fixed input*. In addition to managerial input, production requires a *continuum of different tasks*, indexed by $i \in [0, 1]$, to be performed by *production workers*. We use a function $z(i)$ to denote the amount of task i that needs to be performed per unit of the final good.

By definition, firms are headquartered in the country where they hire their managers.[8] We make no distinction between firms hiring managers and managers setting up their own firm. In equilibrium, a manager must earn the same income, whether in terms of entrepreneurial profit, if self-employed, or through a perfect contract with a firm. For simplicity, our entire argument will be framed in terms of managerial wages, denoted by s and s^* for the home and the foreign economy. The equilibrium value of managerial wages is determined by free entry and perfect competition for managers, whence pure profits are zero.

Given Dixit-Stiglitz preferences, producers of differentiated varieties have price-setting power, and they charge a markup over marginal cost equal to $\sigma/(\sigma - 1) > 1$, where $\sigma > 1$ is the elasticity of substitution between any two varieties of the good.[9] Assuming free entry, the number of firms is given by

$$n = M/f \quad \text{and} \quad n^* = M^*/f \tag{1}$$

and competitive managerial wages denoted by s and s^*, are determined from the condition that all profits end up in managerial income:

$$s = \frac{cx}{\sigma - 1}\Big/ f \quad \text{and} \quad s^* = \frac{c^* x^*}{\sigma - 1}\Big/ f \tag{2}$$

where c and c^* are marginal cost from production workers employed by a firm headquartered in the home and the foreign economy, respectively, selling amounts x and

[8] As indicated in the introduction, this is a useful first step. An obvious next step would be to allow for managerial workers to be mobile across countries and to analyze potential agglomeration along the lines of "new economic geography".

[9] This assumes a negligible influence of a single firm's pricing policy on the overall price index of varieties, which implies a relatively large number of firms. We assume that the overall endowment of $M + M^*$ is sufficiently large for a sufficiently large number of firms.

x^* of their respective final-good-variety.[10] We assume no trade costs for final goods, hence the total amounts sold by the two types of firms on the world market satisfies the following goods market equilibrium condition:

$$\frac{x^*}{x} = \left(\frac{c^*}{c}\right)^{-\sigma} \tag{3}$$

Marginal costs c and c^* depend on wages for production workers, and on a firm's organization of production. Firms face given wage rates w and w^* for workers located in the home and the foreign economy, respectively. We compare two trading arrangements. With final goods trade alone, a firm headquartered in the home economy must draw exclusively on home production workers, and similarly for foreign firms. With trade in tasks, a firm need not have all tasks performed in its headquarter-country, but may freely decide to locate some of the tasks in the other country. It then becomes a multinational firm in the sense of Helpman (1984). However, doing so involves an additional cost which varies across tasks; see below.

We use $1/A(i)$ to denote the amount of labor needed per unit of task i, if performed in the home economy. Analogously for the foreign economy. External economies of scale imply that $A(i)$ depends on the entire amount of task i performed domestically, which we denote by $X(i)$. Following Grossman & Rossi-Hansberg (2010b), we model external scale economies in constant elasticity form, such that $A(i) = A\left[X(i)\right] := \left[X(i)\right]^{\theta}$, with $0 < \theta < 1$. By analogy, $A^*(i) = \left[X^*(i)\right]^{\theta}$. Note that these scale economies, while *external to the firm*, do not extend beyond country borders. They are *national* in scope.

The external nature of scale economies in production tasks has two implications. First, it is consistent with the assumption of perfect competition in an institutional environment where individual tasks are performed at arms length through market transactions. Secondly, if we allow for task trade (offshoring), the equilibrium location of tasks depends on firms' beliefs about what other firms will do. From existing literature on external economies of scale, one would expect multiple equilibria; see Ethier (1982b). This is true here as well. However, as shown by Grossman & Rossi-Hansberg (2010b), if any one firm has the option of performing tasks for other firms at arms length (outsourcing), then the scope for multiple equilibria is significantly reduced. We shall return to this below.

We define $\tilde{c}(w)$ as the unit cost function for a final-good that arises for a firm headquartered in the home country, if trade is possible only for *final goods*, meaning that the entire continuum of all tasks for all home firms (and only home firms) are

[10] Equations (2) follow from setting $px - cx - sf = x[\sigma/(\sigma-1) - 1] - sf = 0$. This replaces the zero-profit condition found in conventional models of monopolistic competition.

performed domestically. Analogously for $\tilde{c}^*(w^*)$. We have

$$\tilde{c}(w) = \int_0^1 w \frac{z(i)}{A[z(i)nx]} \mathrm{d}i \quad \text{and} \quad \tilde{c}^*(w^*) = \int_0^1 w^* \frac{z(i)}{A[z(i)n^*x^*]} \mathrm{d}i \tag{4}$$

Notice that the entire amount of task i performance in the home economy is $X(i) = z(i)nx$. Given our specification of $A[X(i)]$, the amount of production work on task i that is required per unit of the final good is equal to $[z(i)]^{1-\theta} \Big/ (nx)^{\theta}$. We now assume that $z(i)$ is uniform across the entire range of i, such that $[z(i)]^{1-\theta} = z$. Moreover, we assume that the entire amount of all tasks required per unit of the final good is of measure 1, meaning $\int_0^1 z \mathrm{d}i = 1$. This leads to

$$\tilde{c}(w) = w/A(nx) \quad \text{and} \quad \tilde{c}^*(w^*) = w^*/A(n^*x^*) \tag{5}$$

Given these assumptions, $w/A(nx)$ and $w^*/A(n^*x^*)$ may also be interpreted as the cost of performing a unit of any task, respectively, in the home and the foreign economy.

If trade is possible also for *production tasks*, then the minimum marginal cost in each of the two countries depends on both wages, w and w^*, since each country potentially has some of these tasks performed abroad. Instead of equations (4), we then have relatively complex expressions involving endogenous sub-ranges of the task continuum that represent central or decentralized task performance. More details will follow below.

Trade in final goods implies that $c = \tilde{c}(w) = w/A(xn)$ and $c^* = \tilde{c}^*(w^*) = w^*/A(x^*n^*)$. Commodity market clearing according to (3) thus requires

$$\frac{x^*}{x} = \left[\frac{w^*/A(x^*n^*)}{w/A(xn)} \right]^{-\sigma} \tag{6}$$

Moreover, managerial wages satisfy

$$s = \frac{w}{A(nx)} \frac{x}{\sigma - 1} \Big/ f \quad \text{and} \quad s^* = \frac{w^*}{A(n^*x^*)} \frac{x^*}{\sigma - 1} \Big/ f \tag{7}$$

Labor market equilibrium for production workers requires

$$L = \frac{nx}{A[X(i)]} = (nx)^{1-\theta} \tag{8}$$

$$\text{and} \quad L^* = \frac{n^*x^*}{A[X^*(i)]} = (n^*x^*)^{1-\theta} \tag{9}$$

whereby the second equality in each line follows from the above assumption of externally

increasing returns to scale.[11] Replacing $n = M/f$ and $n^* = M^*/f$ from equilibrium conditions (1) for the managerial labor market, we thus have 5 equilibrium conditions to determine the equilibrium levels of four wage rates $\{w, w^*, s, s^*\}$ and the two output levels $\{x, x^*\}$.

Choosing the foreign wage rate as our numéraire, $w^* = 1$, we have $s^* = [x^*/A(x^*n^*)]\, f^*/(\sigma - 1)$, and replacing x from the above labor market clearing conditions (1) and (8), we obtain the foreign managerial wage premium

$$\frac{s^*}{w^*} = s^* = \frac{L^*}{M^*(\sigma - 1)} \tag{10}$$

Given $w^* = 1$, the home wage is governed by commodity market clearing (6), which leads to $w = (x/x^*)^{-1/\sigma}(xn)^{\theta}(x^*n^*)^{-\theta} = (x/x^*)^{\theta - 1/\sigma}(n/n^*)^{\theta}$. Taking into account equilibrium in the two labor markets for production workers, $x/x^* = (L/L^*)^{1/(1-\theta)}\,(n^*/n)$, and using $n^*/n = M^*/M$, we arrive at

$$w = \left(\frac{M}{M^*}\right)^{1/\sigma} \left(\frac{L}{L^*}\right)^{(\theta\sigma - 1)/[(1-\theta)\sigma]} \tag{11}$$

Substituting back into (10) gives $s = w(nx)^{1-\theta} \big/ M(\sigma - 1)$, and we thus obtain

$$s = \frac{M^{*-1/\sigma} M^{1/\sigma - 1} L^{*-(\theta\sigma - 1)/[(1-\theta)\sigma]} L^{(\sigma-1)/[(1-\theta)\sigma]}}{\sigma - 1} \tag{12}$$

so that the managerial wage premium in the home economy is

$$\frac{s}{w} = \frac{L}{M(\sigma - 1)}, \tag{13}$$

which will be our measure to analyze within-country inequality. Additionally, we look at cross-country inequality in terms of income per head in the home relative to the foreign economy, denoted by R:

$$R := \frac{s\theta_M + w\theta_L}{s^*\theta_{M^*} + w^*\theta_{L^*}} = \frac{M^* + L^*}{M + L} \cdot (M/M^*)^{1/\sigma}\,(L/L^*)^{\frac{\sigma - 1}{(1-\theta)\sigma}} \tag{14}$$

where $\theta_M = M/(M+L)$ is the share of managers in the home economy and equivalently for all other shares. We are now in a position to explore the comparative statics of our inequality measures.

[11] It is perhaps worth pointing out that these scale economies to not translate into scale economies on the final goods level. Final goods producers do not act under the belief that increasing their output lowers marginal cost on account of a larger task performance. They take marginal cost c and c^* as given parametrically.

Size effect: Remember that the two types of labor are in different positions regarding economies of scale. The scale effect from the fixed managerial input is internal to the firms producing final goods, while the scale economies in production tasks are external to the firms specializing on certain tasks. This fundamental asymmetry notwithstanding, the benefit from a balanced increase in a country's labor force trickles down in equal proportions to both types of labor. The managerial and the production wage increase by the same proportion. This is seen for the home and foreign economy from (13) and (10), respectively. The managerial wage premium is independent of country size and depends only on relative endowments.

Concerning the relative average wage things are quite clearly cut as well. Letting relative changes $\hat{M} := \mathrm{d}M/M = \hat{L} := \mathrm{d}L/L$:

$$\left.\frac{\hat{R}}{\hat{M}}\right|_{\hat{L}=\hat{M}} = -\frac{\theta}{\sigma(1-\theta)} + \frac{\theta}{1-\theta} > 0. \tag{15}$$

The first term is a negative terms of trade effect. Even though both factors grow at the same rate, output of each variety increases due to the economies of scale. The higher output is absorbed by consumers only if accompanied by a decline in the relative price of the domestic varieties. The second term is the direct effect on productivity which is clearly positive and larger than the first term. The home economy therefore unambiguously gains from a balanced growth. There are gains to make from being large due to the economies of scale in the model.

Composition effect: The wage effects of unbalanced growth of the labor force are less straightforward. Intuitively, other things equal, a larger size of the production work force might be considered a good thing for the individual worker, since there are external scale economies in the use of production work. At the same time, we would not expect that managers should benefit from a larger size of the managerial work force, since the economies of scale involved in managerial input are internal to the firm or manager. We first perform comparative statics for an increase in the endowment with managers.

The number of workers in each company has to be reduced in equilibrium. This means less profits and lower managerial salaries. Workers' wages, on the other hand, are driven up which implies a decline in the wage premium

$$\frac{\widehat{s/w}}{\hat{M}} = -1. \tag{16}$$

The intuition is quite straightforward. More managers raise the number of home firms at the expense of lower firm output. However, with a constant production work force L, the amount of aggregate output xn must remain constant; see (9). By complete

analogy, we have $\widehat{s/w} = \hat{L}$. From (12) we see that managerial labor participates in the external scale economies deriving from more production labor. On the other hand, while production workers clearly lose relative to managers, they might still gain in absolute terms if scale economies are sufficiently strong and substitutability between varieties is sufficiently; see (11).

The increased scarcity of each home variety, relative to foreign varieties, implies that each home firm charges a higher price and, thus, pays a higher wage to its production workers. The standard results prevail: A larger endowment with managers has a negative own-effect and a positive cross-effect on wages.

The aggregate effect of this change, however, is not clear ex ante. Performing comparative statics for the average relative wage yields

$$\frac{\hat{R}}{\hat{M}} = \frac{1}{\sigma} - \frac{M}{M+L} \tag{17}$$

which is ambiguous. Since each domestic firm now has lower output, market clearing implies a higher price of domestic varieties, depending on the elasticity of substitution. This constitutes a terms of trade improvement which works against the foreign economy in this income comparison. At the same time, each manager now employs less workers which reduces the salary he can residually claim. This works against domestic income per head, in line with the share of managers in the domestic labor force.

The price effect from (13) lowers domestic income per head in line with the share of managers in the domestic labor force in the second term of (17). The first term captures a quantity effect depending on σ. More managers means more firms, but lower output per firm which is absorbed through a price increase which is the larger the lower σ. An increase in domestic managerial labor endowment thus generates a terms of trade improvement for the domestic economy which may offset the lower managerial incomes in the international income comparison.

A similar ambiguity arises for a change in production labor endowment. We obtain

$$\frac{\hat{R}}{\hat{L}} = -\frac{1}{\sigma(1-\theta)} + \frac{\theta}{1-\theta} + \frac{M}{M+L} \tag{18}$$

The first term again indicates a terms of trade effect, which is negative due to higher output per firm and which is reinforced by a higher productivity due to external scale economies. The negative effect on the terms of trade is now more pronounced than in the case of symmetric changes, since all new production workers are employed producing a constant number of varieties, whereas above the number of varieties was increased as well. The second term captures the income effect derived from higher productivity which clearly dominates the terms of trade effect. The final term is readily interpreted as the effect on managers' salary which now is positive, since each manager employs

more production workers. We summarize these findings in two propositions as follows:

Proposition 1 (symmetric endowment changes)**.** *Countries increasing in size, with the labor force composition unchanged, experience a rise in their income per capita relative to the rest of the world. A negative terms of trade effect is dominated by a positive productivity effect from external economies of scale in production labor.*

Proposition 2 (asymmetric endowment changes)**.** *An asymmetric endowment increase additionally entails a labor force composition effect. It is positive if managers can employ a higher number of production workers and negative in the opposite case, whereby the strength of the composition effect depends on the initial degree of asymmetry. a) For an increase in production labor, the terms of trade effect is negative, but is always dominated by a positive productivity effect. b) For an increase in managerial labor, the terms of trade effect is positive. The productivity effect vanishes. In either case the overall effect is ambiguous.*

All of these *relative* wage effects may be interpreted as relative welfare effects for the respective group of workers, provided that trade in final goods is free and costless, as assumed. Consumers in both countries then pay identical prices for final goods, and they also face the same degree of variety. However, one needs to be cautious when considering *real* wage effects. Two additional channels need to be taken into account for real wages. The first is a change in variety that follows from any change a country's endowment with managers; see the managerial labor market equilibrium condition (1) above. With "love for variety", such changes are of direct relevance for real wages. The second channel runs through final goods prices, which are related to marginal cost through a constant markup. From (2), marginal costs in the home and the foreign economy are related to endowment changes according to

$$\widehat{\tilde{c}} = \hat{w} - \theta\hat{L}/(1-\theta) \quad \text{and} \quad \widehat{\tilde{c}}^{*} = -\theta\hat{L}^{*}/(1-\theta) \tag{19}$$

Based on these considerations, it is relatively straightforward to extend the above analysis to real wages. We leave this to the reader.

3 Trade in production tasks

Remember that $w/A(nx)$ and $w^*/A(n^*x^*)$ is the cost of performing a unit-level of any task, respectively, in the home and the foreign economy. If a task is concentrated for the entire world in the home economy, the cost is equal to $w/A(nx + n^*x^*)$, if it is concentrated in the foreign economy, then the cost is equal to $w^*/A(nx + n^*x^*)$. However, performing a certain task i in a different country from where a firm's headquarter is located, then the amount of labor required is larger than in the case of domestic

performance by a factor $\beta t(i)$. We assume that the additional labor required is labor from the country where the task is located, not where the headquarter is located. This formulation is completely analogous to the familiar "iceberg cost" of transport. Naturally, we have $\beta t(i) \geq 1$, and we order tasks according to the ease with which they can be dislocated, whence $t'(i) > 0$. Moreover, we normalize $\beta t(0) = 1$.

Intra-firm task trade: We first look at cases where all task trade takes place within a firm's boundary, meaning that a final goods producer does not consider performing tasks for other final goods producers, or outsourcing a certain task to be done by another firm. Moreover, we first look at equilibria where a location decision by any one firm is matched by the same decision of all other firms headquartered in the same country. Outsourcing and deviant behavior across firms will be considered below.

As a first step we address the border line between tasks that may be concentrated in either the home or the foreign economy. Obviously, it is tasks with low i-values that are prime candidates for concentration in one of the two countries. Thus, if

$$\beta t(i) < \frac{w^*/A(n^*x^*)}{w/A(nx + n^*x^*)} \tag{20}$$

then task i is a candidate for concentrated performance in the home economy. Foreign firms would find no incentive to relocate this task back to their headquarters. Given the numbers of firms and output levels, as well as the wage rates in either country, the condition

$$\beta t(I) = \frac{w^*/A(n^*x^*)}{w/A(nx + n^*x^*)} \tag{21}$$

implicitly determines a cut-off-value I, separating tasks $i < I$ that *may* in equilibrium be concentrated in the home economy from those that may either be concentrated in the foreign economy, or else not be concentrated in any country, but performed where the respective firm's headquarter is located. A corresponding condition identifies tasks $i < I^*$ that *may* be concentrated in the foreign economy:

$$\beta t(I^*) = \frac{w/A(nx)}{w^*/A(nx + n^*x^*)} \tag{22}$$

Obviously, if the two countries are completely symmetric, then $I = I^*$. Countries may be asymmetric either in absolute size, or in their relative endowments. Intuitively, a larger country should have a larger range of tasks that it may end up performing for the entire world. On the other hand, a higher endowment with managers relative to simple labor has an ambiguous effect. Other things equal, it increases the number of firms headquartered there, which contributes to its size advantage, but it also tends to increase the equilibrium wage paid to simple labor, which reduces its cost competitiveness.

The pattern of task specialization supported by this type of *coordinated* location decisions is ambiguous. For tasks $i < \min(I, I^*)$ equilibrium requires concentration of a task in either the home or the foreign country. Tasks $i > \max(I, I^*)$ will be located at the respective firms' headquarter location. If $I^* < I$, then tasks indexed $i \in [I, I^*]$ are concentrated in the home country, and conversely for $i \in [I^*, I]$ if $I < I^*$.

Outsourcing and deviant behavior: Grossman & Rossi-Hansberg (2010b) show that this indeterminacy of equilibrium task location is reduced, if one allows for single firms to perform tasks for others. When considering where to locate a certain task, a firm may then invest in the capacity of becoming an attractive outsourcing partner for other firms. Whereas in the equilibrium considered above tasks are never traded across firms, although potentially located offshore, we now have tasks being contracted out to independent suppliers. This raises two issues. First, since firms produce different varieties, tasks may be specific to varieties and, thus, relationship-specific. As emphasized by Antràs (2003) and Antràs & Helpman (2004), this may generate a holdup problem, if complete and enforceable contracts cannot be written. For the sake of simplicity, we rule this out.

The second issue relates to pricing. If a firm expects other firms to make similar location decisions regarding the capacity to perform certain tasks, then a reasonable assumption is that they charge prices equal to costs of serving other firms, inclusive of the cost for offshore provision of tasks. However, a firm may also consider a single, isolated deviation from a common location decision. For instance, if a common decision to locate capacity for some task i in the home economy is an equilibrium in the sense described above, a firm may consider the profit potential of an isolated deviation strategy, setting up task-i capacity in the foreign economy and trying to attract all demand for this task through outsourcing relationships. Such a deviant firm is then assumed to set different prices to different buyers, depending on whether the buyer's own capacity of task performance is offshore, or sited at its headquarter location. By construction of the argument, they all have their own capacity of task provision in the same location. But for some of them that will be an offshore location, which allows the deviant firm to charge them a higher price. We follow Grossman & Rossi-Hansberg (2010b) in assuming that a potential deviant charges task-prices just an ε below the respective buyer's cost of in-house provision, given the buyer's own task location. This price discrimination is possible, because tasks are specific to the final goods.

Allowing for such outsourcing relationships, we may reinterpret the condition (21) above as separating tasks $i < I$, where a common decision to place task performance in the home economy is immune to what Grossman & Rossi-Hansberg (2010b) call *local deviation*, from the rest where task concentration is subject to a deviation threat. By local deviation we mean a foreign firm deviating from this common choice of location by placing its task capacity in the foreign economy, hoping to make a profit through

serving *only foreign firms* from a foreign base, thus saving on offshoring cost. It would have a per unit cost equal to $w^*/A(n^*x^*)$, thus forgoing global scale, but would be able to charge a price just below $w\beta t(i)/A(nx + n^*x^*)$, which is what foreign firms have to pay when procuring task i from offshore (i.e., the home economy). A similar reinterpretation for a world with outsourcing relationships obtains for I^* as defined in (22) above. The above ranges of task concentration thus receive further substantiation through allowing for contractual outsourcing.

But deviation may take a second form, where the deviant firm tries to attract task demand from the *entire world*. Grossman & Rossi-Hansberg (2010b) call this *global deviation*. Suppose, again, that all firms have to locate their capacity of performing a certain task $i < \min(I^*, I)$ in the home economy. With intra-firm task offshoring, home firms would then obtain these tasks for a "price" equal to $w/A(nx + n^*x^*)$, while foreign firms have bear the dislocation cost $\beta t(i)$ and, thus, pay a "price" equal to $\beta t(i)w/A(nx + n^*x^*)$. Now consider a deviant firm setting up task-i capacity in the foreign economy and trying to make a profit by selling this task for just an ε below these prices to the two types of firms. If successful in attracting the entire world demand for this task, the deviant would have production costs equal to $w^*/A(nx + n^*x^*)$ plus offshoring costs. She would have the advantage of being able to sell to foreign firms at a price $\beta t(i)w/A(nx+n^*x^*)-\varepsilon$, and to home firms at a price equal to $w/A(nx+n^*x^*)-\varepsilon$. Obviously, whether this generates a positive profit depends on the difference in the wage gap $w^* - w$ and on the size of the two countries, measured through nx and n^*x^*. In turn, the wage gap depends on both, country size and relative endowments.

Given the aforementioned price discrimination, a deviant firm's total revenues from selling task i is equal to $w\left[nx + \beta t(i)n^*x^*\right]/A(nx + n^*x^*)$.[12] The deviant firm's own aggregate cost in the outsourcing case (inclusive of the offshoring cost) would be equal to $w^*\left[n^*x^* + \beta t(i)nx\right]/A(nx + n^*x^*)$. Hence, the profit from a deviation strategy, relative to a concentration of any task $i < \min(I^*, I)$ in the home economy, emerges as

$$\pi_d(i) := \frac{w\left[nx + \beta t(i)n^*x^*\right] - w^*\left[n^*x^* + \beta t(i)nx\right]}{A(nx + n^*x^*)} \tag{23}$$

If this profit from deviation is negative, then a concentrated location of task i in the home economy is the only equilibrium. If $\pi_d(i) > 0$, then a deviation strategy would ultimately lead to an equilibrium where all firms locate task i in the foreign economy and where no contractual outsourcing actually takes place. We may now define a task J that yields a zero profit for the deviant firm, which means $\pi_d(J) = 0$. This condition can be written as

$$\beta t(J)\left(wn^*x^* - w^*nx\right) = w^*n^*x^* - wnx \tag{24}$$

$$\text{or} \quad \beta t(J) = \frac{w^*n^*x^* - wnx}{wn^*x^* - w^*nx} \tag{25}$$

[12] To be precise, revenues are an ε below this magnitude.

Task trade with identical relative endowments: Suppose there is a solution to (25) with $J \in]0,1[$. As we will show below, this is only possible in the case with identical relative endowments as in Grossman & Rossi-Hansberg (2010b). Suppose, moreover, that $J < \min(I, I^*)$. This cut-off value separates tasks with positive deviation profits from those with negative deviation profits. Then, the right-hand side of (25) must have equal signs for the denominator and the numerator. If it is negative, essentially meaning that the home economy is larger than the foreign economy, then it must be true that $\pi_d(i) > 0$ for $i < J$, and conversely for $i > J$. In the opposite case of a relatively smaller home economy, the deviant's profit is positive for $i > J$ and negative for $i < J$.

Let us look at the first of these cases where the home economy is relatively large. Obviously, for tasks $i > J$ and $i < \min(I, I^*)$, meeting world-wide demand for the task from concentrating all capacity in the home economy is immune to global deviation via outsourcing. The same is not true for tasks $i < J$. But let us assume that firms can relocate their own production capacity at no cost. Then any attempt by the deviant with a foreign production base to charge foreign firms a price above here own task cost $w^*/A(nx+n^*x^*)$ would be futile, since these firms would then be prompted to relocate to a foreign production base. The important point to bear in mind here is that these firms would fully benefit from size advantage, if that advantage is external to the firm as assumed. Consequently, the deviant's positive profit would then rely in charging home firms a price above $\beta t(i)w^*/A(nx+n^*x^*)$. But again, such an attempt would be frustrated by home firms shifting their production base for task i to the smaller foreign economy.

Hence, global deviation from coordinated concentration of tasks $i < J$ in the end does not lead to any outsourcing.[13] What it does, instead, is tie down the location of tasks $i < J$ to the smaller of the two countries, which in our argument is the foreign economy, and of tasks $i > J$ and $i < \min(I, I^*)$ in the home economy. It is relatively obvious that a perfectly analogous reasoning leads to concentration of all tasks $i > J$ and $i < \min(I, I^*)$ in the foreign economy, provided that it is the larger of the two economies. For tasks $i > \min(I, I^*)$, the equilibrium allocation of task capacity will be in the home economy, if $I^* < I$, and vice versa. And for tasks i above $\max(I, I^*)$, decentralized location of task performance is the only equilibrium outcome, as we have seen above. The remaining question now is what happens if $J > \min(I, I^*)$. Suppose that $I < I^*$, effectively meaning that the home economy is relatively small. Then, by the above logic we have tasks $i > J$ and $i < I^*$ concentrated in the foreign economy, and all tasks $i < \min(I, I^*)$ - and thus $i < J$ - we have a safe concentration of tasks in the (smaller) home economy. But suppose, instead, that $I^* < I$.

We are now able to fully describe the pattern of task trade between two countries

[13] More precisely, final goods producers are indifferent between in-house procurement of tasks and outsourcing, but the location of task capacity is unambiguous.

that differ only in size. We have five different possibilities separated by whether $I > I^*$ or $I^* < I$ and by whether or not $J < \min(I, I^*)$. In all of these cases, tasks with low offshoring costs are concentrated in the low-wage country which is also the smaller of the two countries. Tasks with intermediate offshoring costs are concentrated in the larger country high-wage country. And tasks at the upper end of the scale of offshoring costs are performed in a decentralized way, with each firm locating its task capacity in its headquarter country. However note that each of these sets of tasks might be empty.

Grossman & Rossi-Hansberg (2010b) show that wages and aggregate output always go hand in hand. In other words, the high-wage country will always have a higher aggregate output than the low-wage country. Intuitively, for most parameter values, the country that is endowed with a higher amount of both factors of production will obtain a higher aggregate output. However, with low offshoring costs and the two countries being sufficiently equal three equilibria are possible, the second equilibrium having the country that is endowed with *less* of both production factors achieving a *higher* aggregate output and therefore a *higher* wage for production workers, while in the third equilibrium both countries have an equal aggregate output, equal wage and the offshoring structure cannot be determined.

Task trade with different relative endowments: In the asymmetric case we assume that both countries are of equal size. Size in this context has to be measured by the amount of task i performance for home and foreign firms respectively, which is equivalent to aggregate output. This can be written as $nx = n^*x^*$. We do this to isolate the effect of relative endowment differences and changes thereof on the offshoring equilibrium. This assumption also improves the analytic tractability of our result.

It can easily be seen that with $nx = n^*x^*$ the right-hand side of equation (25) reduces to -1 and therefore no solution exists for $J \in]0, 1[$. This means that global deviation is possible for the *whole range* of tasks when they are concentrated ex ante in the high-wage country, and *no global deviation* is possible when tasks are concentrated ex ante in the low wage country. Additionally, for $w \neq w^*$, the marginal tasks I and I^* will always be in the same order. This implies that in equilibrium only one offshoring pattern is possible. Tasks with low offshoring costs end up concentrated in the low-wage country while tasks with high offshoring costs are performed dispersedly in both countries. In analogy to Grossman & Rossi-Hansberg (2010b) it is now possible to prove that relative factor endowments and production workers' wages always go hand in hand. The country with a higher relative endowment with managers always has a higher wage for its production workers. We state this result in the following proposition

Proposition 3 (Production wages and factor abundance)**.** *In two countries of identical size* $nx = n^*x^*$, $w \geq w^*$ *if and only if* $\frac{M}{L} > \frac{M^*}{L^*}$

A proof is offered in the appendix. The intuition is as follows. In this model, tasks that

might be performed offshore only require production labor. However, by assumption production workers are equally productive in both countries. With very low offshoring costs and wages "almost" equal the external economies of scale lead to a situation where, in principle, concentration of tasks in both countries is possible. But as we know that in the home economy production labor is relatively scarce, the equalization of production workers' wages is only possible if there is at least one task concentrated in the foreign country. In addition, we know that with unequal wages the marginal tasks I, I^*, and J are always in an order such that only offshoring is possible only in one direction. This, in turn, implies offshoring from the high-wage-country towards the low-wage country. Summarizing this intuition, we can conclude that, with $\frac{M}{L} > \frac{M^*}{L^*}$ and $w \neq w^*$, it must be true that $w > w^*$. However we cannot rule out a possible equilibrium with $w = w^*$, which implies $I = I^*$ and equal aggregate production cost in both countries. This means that offshoring in both directions might take place and no structure is imposed on the sets of tasks that are concentrated in the two countries. In such a case we only know that the set concentrated in the foreign country must be larger than the set of tasks concentrated in the home country, but we cannot determine the exact offshoring pattern.

Some analytical results: The possibility of offshoring modifies some of the equations in the model. As shown above, tasks can now be grouped into three sets. Those tasks concentrated in the home economy, those concentrated in the foreign country, and those performed domestically by firms in both countries. These three sets have to be considered when calculating marginal production costs as

$$c = \frac{wQ(\mathcal{H})}{(nx + n^*x^*)^\theta} + \frac{w^*T(\mathcal{F})}{(nx + n^*x^*)^\theta} + \frac{wQ(\mathcal{B})}{(nx)^\theta} \tag{26}$$

for the home country and

$$c^* = \frac{wT(\mathcal{H})}{(nx + n^*x^*)^\theta} + \frac{w^*Q(\mathcal{F})}{(nx + n^*x^*)^\theta} + \frac{w^*Q(\mathcal{B})}{(n^*x^*)^\theta} \tag{27}$$

for the foreign country where $\mathcal{H}$ is the set of tasks concentrated in the home country, $\mathcal{F}$ is the set of tasks concentrated in the foreign country, and $\mathcal{B}$ is the set of tasks performed in both countries. $Q(.)$ is a Lebesgue measure for the set of tasks and $T(.)$ is the same measure inclusive of offshoring costs.

Analogously, production workers can be working in three different occupations. Performing tasks that are concentrated domestically for domestic firms, performing tasks that are concentrated domestically for firms from the other country, and performing tasks for domestic firms that are performed in both countries. The new full

employment conditions can therefore be written as

$$L = \frac{nxQ(\mathcal{H})}{(nx + n^*x^*)^\theta} + \frac{n^*x^*T(\mathcal{H})}{(nx + n^*x^*)^\theta} + \frac{nxQ(\mathcal{B})}{(nx)^\theta} \tag{28}$$

for home production workers, and

$$L^* = \frac{nxT(\mathcal{F})}{(nx + n^*x^*)^\theta} + \frac{n^*x^*Q(\mathcal{F})}{(nx + n^*x^*)^\theta} + \frac{n^*x^*Q(\mathcal{B})}{(n^*x^*)^\theta} \tag{29}$$

for foreign production workers.

From the equilibrium condition of the managerial salary $s = cx/f(\sigma - 1)$ it is then possible to obtain a result for the wage sum paid to home managers

$$sM = \frac{1}{\sigma - 1}\left(wL + \frac{nx}{(nx + n^*x^*)^\theta}w^*T(\mathcal{F}) - \frac{n^*x^*}{(nx + n^*x^*)^\theta}wT(\mathcal{H})\right). \tag{30}$$

Note that this is not a general equilibrium result, since production volumes, number of varieties and offshoring volumes are all determined endogenously, however, it already gives interesting insight into the distributional mechanisms between the to types of labor. Compared to the non-offshoring case in equation (13), home managers can increase their wage bill if there is a substantial amount of domestic tasks offshored to the foreign economy, whereas their wage bill is reduced if foreign tasks are offshored to the home economy and performed by home production workers. The total offshore labor employment is weighted by the wage paid to offshore labor. This is very intuitive since concentration of production in a country means that less domestic workers perform manufacturing tasks for domestic managers and output per manager declines.

Combining the conditions on the wage bill for firms from the two countries yields

$$sM + s^*M^* = \frac{1}{\sigma - 1}\left(wL + w^*L^*\right). \tag{31}$$

This means that the aggregate wage bill in the two countries still remains in the same proportions as in the case with no offshoring. One implication thereof is that in the case with symmetric endowments, a rising managerial wage premium in one country always has to be paralleled by a falling managerial wage premium in the other country. We summarize these results in the following proposition.

Proposition 4 (Offshoring and within-country inequality)**.** *a) Everything else equal, concentration of tasks in the home economy decreases the domestic managerial wage premium. This effect is the larger, the higher the wage of domestic workers and the larger the foreign economy. Conversely, concentration of tasks in the foreign economy increases the domestic wage premium. A corresponding relationship holds for managers in the foreign country. b) In the presence of offshoring the distribution between managers and workers in the aggregate of the two countries is the same as the one that*

obtains for each country individually in an equilibrium where offshoring is ruled out. For identical relative endowments a rising managerial wage premium in one country must thus be accompanied by a falling wage premium in the other.

4 Simulation Results

There are two reasons to use simulation methods in this context. First, as Grossman & Rossi-Hansberg (2010b) point out, the equilibrium parameter values depend on integrals over the set of tasks concentrated in each economy or performed in both countries. But these sets themselves are functions of the parameters in question. Furthermore the external nature of the economies of scale might give rise to multiple equilibria. This implies only little scope for analytical tractability. An additional benefit of the numerical simulation is that it allows us to highlight non-monotonic outcomes regarding the offshoring pattern and wage payments. In the following we illustrate some results obtained by a numerical simulation of the model.

We choose parameter values so as to ensure comparability with Grossman & Rossi-Hansberg (2010b). Offshoring cost is linear with $t(i) = i + 1$ and the external scale economy takes the form $[X(i)]^{\theta}$ with $\theta = 0.8$, while $f = 1$ and $\sigma = 2$. Grossman & Rossi-Hansberg (2010b) demonstrate that the choice of $\sigma = 2$ implies for the symmetric case offshoring in both directions whenever there is offshoring. As we show in section 2 this choice has the additional advantage of yielding equal remuneration for managers and workers in the symmetric case whenever there is no offshoring.

We analyze inequality in two dimensions: Inequality *between* countries, measured by income per capita, and inequality *within* countries measured by the managerial wage premium. For each of these dimensions we differentiate between two cases: First, we have a look at a symmetric case where relative endowments are the same in both countries. We following Grossman & Rossi-Hansberg (2010b) in assuming $M/L = M^*/L^* = 0.5$, with a world endowment equal to $M + M^* = 2$ and $L + L^* = 2$, and in looking at cases where the home economy is larger, i.e., $M = L > M^* = L^*$. Secondly, we analyze the asymmetric case, whereby we assume the home economy to be abundantly endowed with managers, meaning $M/L > M^*/L^*$. In this asymmetric case, we sharpen our focus on the relative endowment by shutting down the country size channel through the assumption $nx = n^*x^*$.

4.1 Cross-country Inequality

We measure inequality between the two countries by the ratio of incomes per head, which may be written as

$$\frac{s\theta_M + w\theta_L}{s^*\theta_{M^*} + \theta_{L^*}} \tag{32}$$

where $w^* = 1$ through choice of the numéraire, and θ_M is the share of managers in the home economy, with $\theta_L = 1 - \theta_M$,and analogously for the foreign economy. For the symmetric case with $M/L = M^*/L^* = 0.5$, this simplifies to

$$\frac{s + w}{s^* + 1} \tag{33}$$

First we turn to the results of the symmetric case. Figure 1 depicts international inequality for varying degrees of size advantage as well as varying amounts of offshoring, driven by underlying values of β which measures the costliness of trade in tasks. The figure clearly indicates that in the absence of relative endowment differences the economies of scale work to the benefit of both types of labor in the large country. A further general insight is that for very similar countries offshoring has a very moderate effect on the relative incomes per capita. For example, with $M = L = 1.01$ a jump from zero offshoring to complete specialization in tasks increases the gap in the average wage from 1.05 to a mere 1.14.

For larger differences, however, the average income gap is highest for medium levels of offshoring. This means that very high and very low levels of offshoring work to the benefit of the smaller (poorer) country. For instance, with an endowment of $M = L = 1.1$ and offshoring autarky the wage gap is 1.5. Opening up to offshoring it reaches its maximum of 1.55 at an offshoring volume of 0.2 and subsequently declines until it reaches 1.24 at the point of complete specialization in tasks.

The intuition for this non-monotonicity is as follows. For low levels of offshoring, the home country benefits more from the first tasks moved to the respective other country, since tasks with low offshoring costs are concentrated in the small country while tasks with higher offshoring costs are concentrated in the large country, so that the large country has to spend less on transport costs. This effect is further strengthened since it is obvious that even though offshoring in both directions occurs, a higher share of tasks is concentrated in the large country than in the small country. This means that production workers' productivity in the large country rises more than in the small country, due to the scale effect. At the other extreme, if there already is a substantial amount of infra-marginal tasks to be affected, a further decrease in the offshoring costs that induces a higher level of offshoring brings more benefits to the small country. Small-country producers save on transport costs for the high share of tasks already concentrated in the large country. Also, these are the more costly tasks to offshore, whence a cost reduction is bound to have a large effect. Large-country producers do

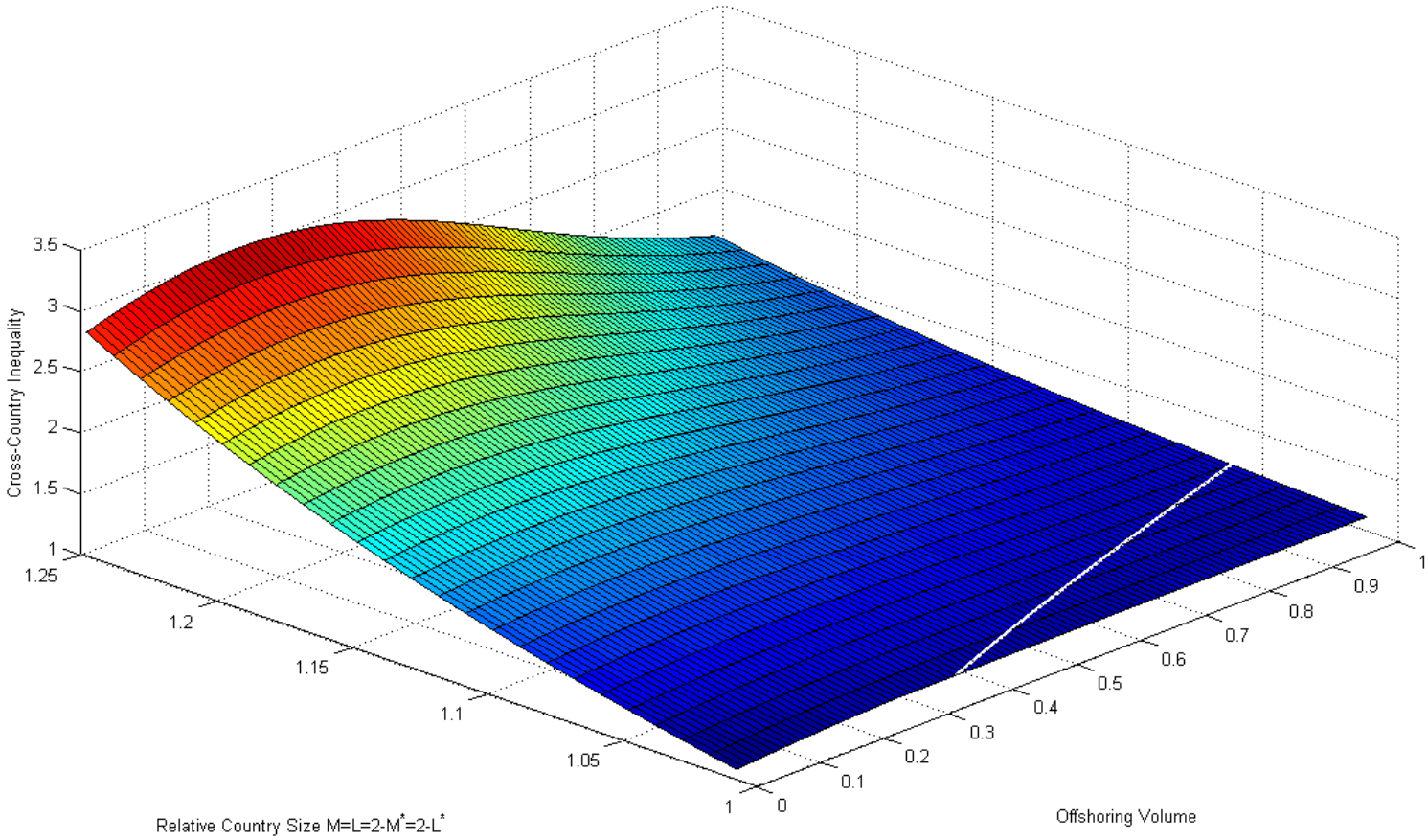

Figure 1. Symmetric Case: Cross-country inequality
Independent Variables: $M = L = 2 - M^* = 2 - L^*$ and $VOL = \mathcal{D} + \mathcal{F}$
$\sigma = 2$, $\theta = 0.8$, $f = 1$

not benefit as much, since less tasks are concentrated in the small country.

It can be shown that in an equilibrium without offshoring, the relative average wage is identical to the inverse of the relative production cost for the varieties of the two countries. As the offshoring volume increases this relationship break down since more and more foreign production workers are employed in manufacturing of home goods, and vice versa.

There is a small caveat though: Imagine both countries to be of relative similar size and globalization having gone very far, meaning a high volume of offshoring. This case, which corresponds to parameter values in the south of the white line, implies the possibility of multiple equilibria and the larger country may end up producing less aggregate output and having a lower average wage. We generally restrict our figures to only depict the equilibrium where the larger country produces a higher aggregate output and has higher wages.

Now let us move on to the asymmetric case where the home country is relatively manager-abundant while the foreign country is abundantly endowed with production workers. Note that this puts it at a disadvantage for hosting concentration of tasks. The case is depicted in figure 2. Opening up to offshoring now gives rise to a different pattern of task trade in that offshoring only takes place in one direction. When the first tasks are concentrated in the country which is abundant in production workers, it is the workers there who benefit from an increase in productivity and wages. However, when more offshoring is induced though a fall in offshoring costs, this pattern changes. Decreasing offshoring costs for infra-marginal tasks only work to the benefit of the manager-abundant country, so that with more and more specialization it can achieve an ever higher average wage.

A further, more subtle insight is that the disadvantage from a relatively low endowment with production labor is the larger, the more extreme the relative distribution of factors is. This is due to the fact that the income distribution *within* this country changes more rapidly in favor of the factor that becomes increasingly scarce than does the income distribution *within* the production-labor-abundant country.

In this specification again, we have to consider a caveat. For very similar countries and high levels of offshoring home production workers, although being the scarce production factor, can even end up with the same wage as their foreign counterparts, which implies $I = I^*$. In such an equilibrium, up to a cutoff task C, offshoring of *some* tasks from the home to the foreign economy equalizes wages in both countries. However, the set of tasks that yields equal wages when performed offshore in the foreign country might be smaller than the set of tasks for which offshoring is feasible as implied by I and I^*. If this is the case, then for all tasks i with $C < i \leq I = I^*$ there is nothing in the model to determine the location of production. We only know that there exists a non-empty set of tasks concentrated in the foreign economy and that

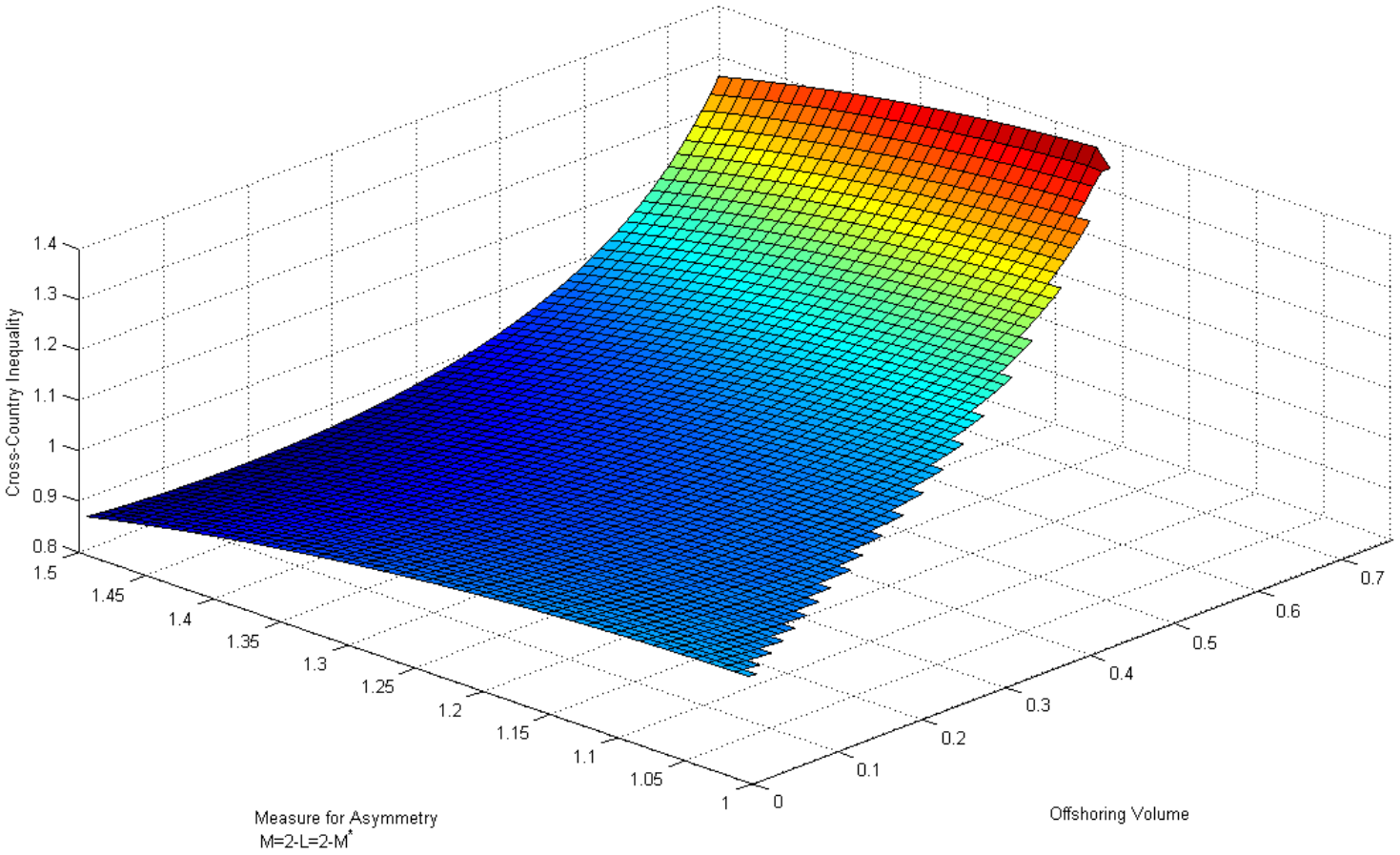

Figure 2. Asymmetric Case: Cross-country inequality
Independent Variables: $M = 2 - L = 2 - M^*$ and $VOL = \mathcal{D} + \mathcal{F}$
$\sigma = 2,\ \theta = 0.8,\ f = 1$

this set is larger than the set of tasks concentrated in the home economy. Since this indeterminacy has an influence on wages and salaries due to the differing offshoring costs, we do not report results for the parameter values for which this indeterminacy arises.

4.2 Within-country inequality

In this section we investigate the effect of country size and endowment ratios on managerial wage premia in the two countries. We report results for the home economy, assumed to be the large country in the symmetric case and the manager-abundant country in the asymmetric case. Again, first we have a look at the symmetric case.

As above, in figure 3 the parameter combinations for which a second equilibrium with higher wages in the small country might occur is indicated by a white line. However, we ignore this possibility for now. From a rapid glance at the figure we readily learn two things. Generally, a more disparate endowment of labor between the two countries appears to work in favor of production workers. However, this effect is negligible for very small volumes of offshoring. This is due to the fact that – keeping the overall offshoring volume constant – a more disparate distribution means that less tasks are concentrated in the small country, and more tasks in the large country. This implies that in the large economy more workers perform concentrated high-productivity tasks which means that their wage rises. Intuitively, the higher the offshoring volume, the stronger this productivity increase due to concentration and the stronger this wage effect.

Second, we see that higher levels of offshoring work in favor of managers. The effect is smaller for highly unequal endowments. This is because higher levels of offshoring imply a higher productivity and a higher output for each fixed manager input. Workers' wages rise due to the increased productivity in tasks concentrated *domestically*. However, managers' salaries move proportionally with output, which is an increasing function of the *total* volume of offshoring and therefore rises even faster and leads to an increase in the managerial wage premium. Clearly, if the home country is larger, a larger share of total offshoring is concentrated there so that workers benefit almost as much as managers, and the increase in the managerial wage premium is less pronounced.

A closer look reveals that complete specialization entails the highest managerial wage premium only for medium values of relative country size, at about $M = L = 1.15$. For more unequal countries the maximum manager premium occurs with an offshoring volume of about 0.75, while for more equal countries it heavily depends on the exact level of country size. In the asymmetric case we can identify a similar pattern of the managerial wage premium in the manager-abundant country. Intuitively, for any level of offshoring, if managers become more numerous in an economy, this has a negative ef-

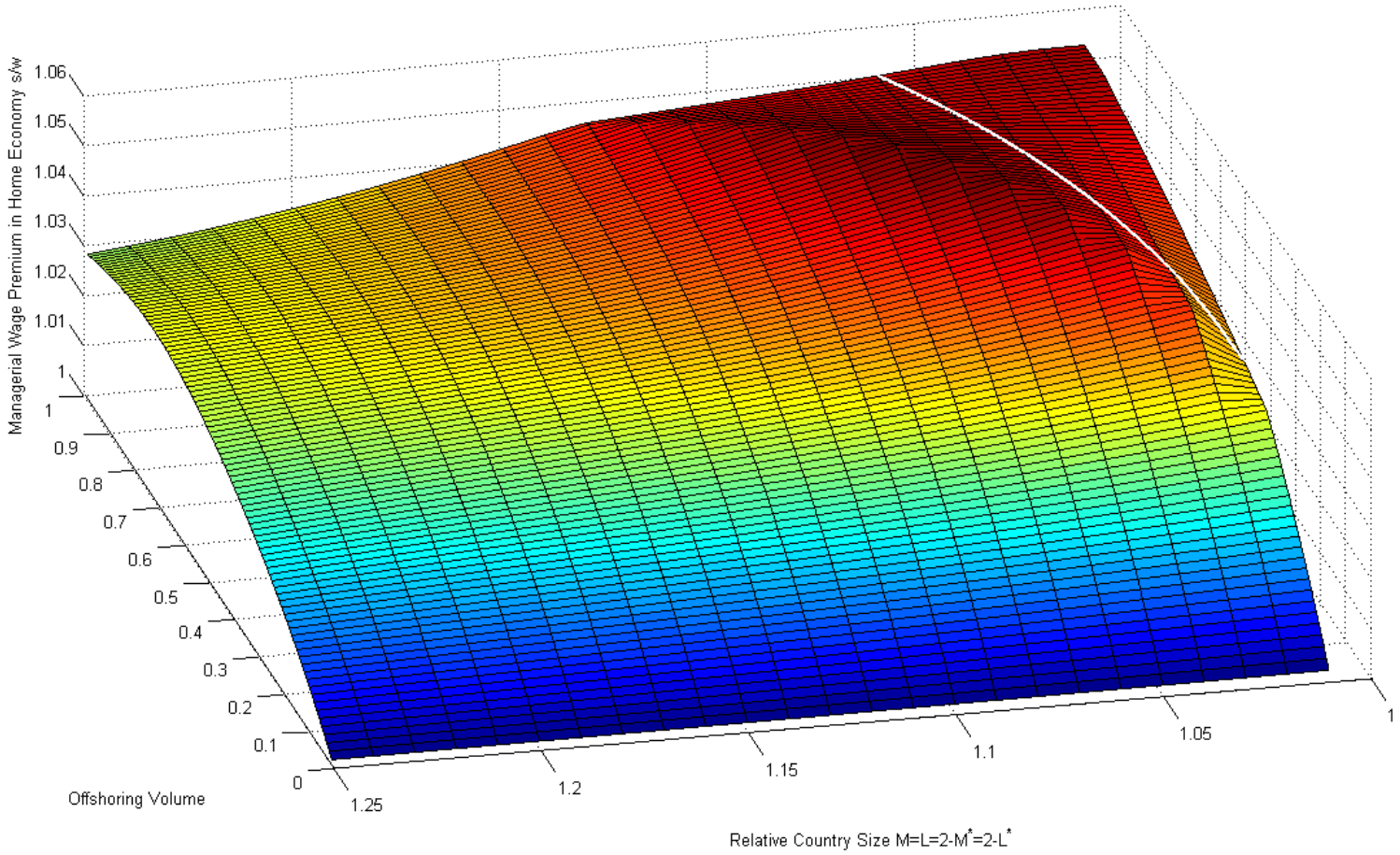

Figure 3. Symmetric Case: Within-country inequality
Independent Variables: $M = L = 2 - M^* = 2 - L^*$ and $VOL = \mathcal{D} + \mathcal{F}$
$\sigma = 2$, $\theta = 0.8$, $f = 1$

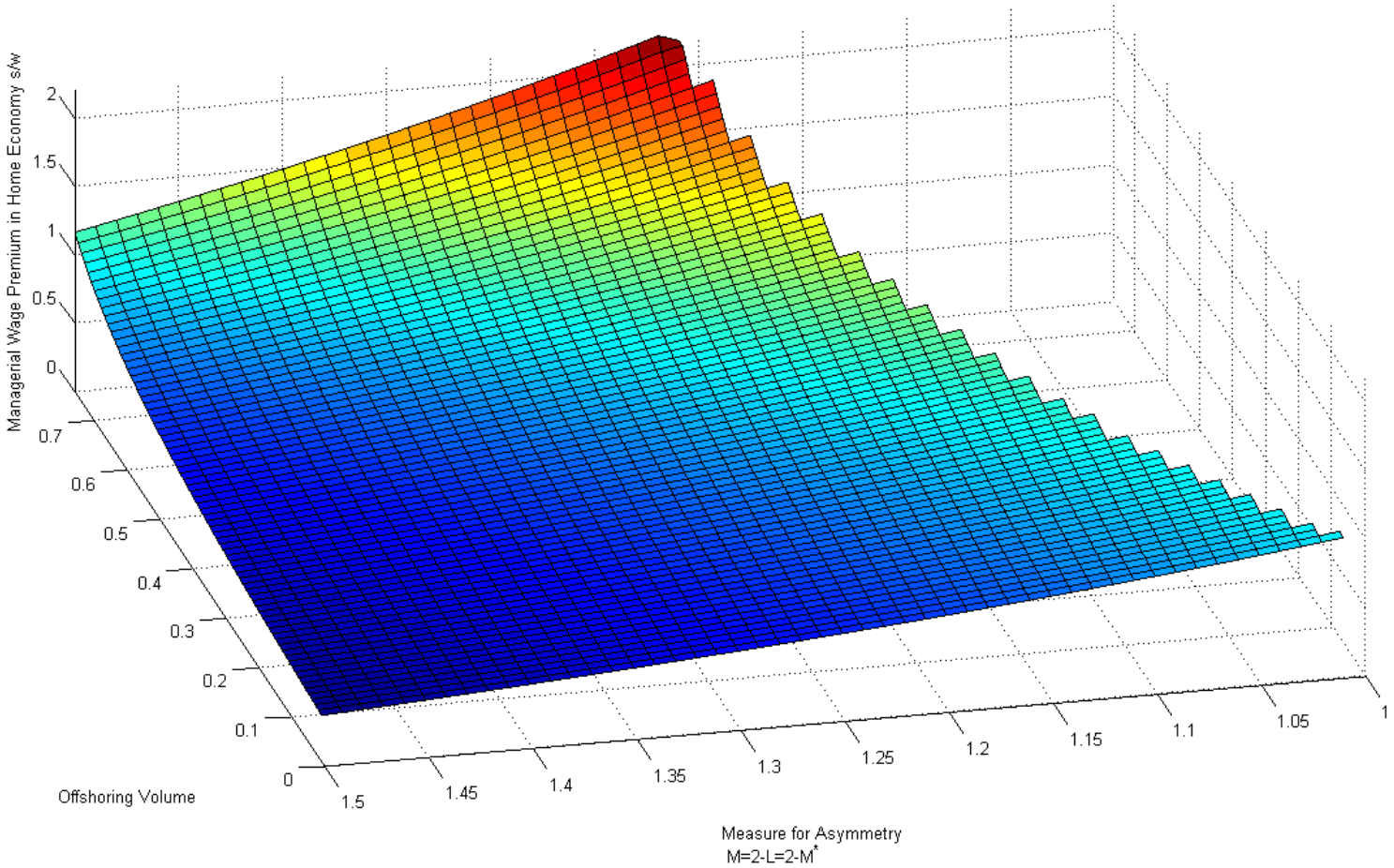

Figure 4. Asymmetric Case: Within-country inequality
Independent Variables: $M = 2 - L = 2 - M^*$ and $VOL = \mathcal{D} + \mathcal{F}$
$\sigma = 2,\ \theta = 0.8,\ f = 1$

fect on their income. As above, an increase in the offshoring volume has a positive effect on the managerial wage premium. Clearly, since offshoring now implies concentration of tasks only in the economy with a higher relative endowment of production labor, home workers do not become more productive. However, home managers benefit from the increased productivity of their firms due to the offshoring possibility and receive higher salaries. In contrast to the above case, the rising managerial wage premium due to globalization is thus independent of the factor endowments.

Comparing the size of these two channels, it is intuitive that offshoring in the asymmetric setup has a larger effect than with symmetric countries. In the asymmetric case, moving from no offshoring to a high levels of offshoring while holding endowments fixed can increase the managerial wage premium by a factor of around 2.5. In the symmetric case, moving from no offshoring to a substantial amount of offshoring only increases the premium by a much lower factor of 1.05.

5 Conclusion

In this paper, we have argued that wage and inequality effects of trade should be addressed focusing on the distinction between managerial and production workers. For a large part, managerial labor is a fixed input in production, while production work serves as a variable input. A key tenet of our analysis is that this asymmetry importantly shapes the determination of managerial salaries and production wages. A second fundamental assumption underlying our analysis is that production labor often benefits from local spill-over effects related to narrowly defined tasks along complex value added chains, and that modern technology of communication and transport increasingly makes such tasks tradable. This installs a rationale for concentrating performance of single tasks in single countries, using countries' endowments with production workers, and to exchange the performance of such tasks across firms with headquarters located in different countries, depending on their endowment with managerial labor. This is an instance of trade based on "Marshallian" economies of scale.

We have used a 2-country model of such task trade recently developed by Grossman & Rossi-Hansberg (2010b), in order to address inequality both within and between countries. Our analysis has focused on the role of country size and relative endowments with managerial and production workers, respectively, on the managerial wage premium as well as on income per capita in one country relative to the other. We have also compared these effects in a world with trade only in differentiated final goods, with a world where there is trade in tasks governed by varying degrees of trade costs.

We have first presented a number of analytical results. For instance, in a world without trade in tasks, we can neatly identify three different channels through which country endowments affect international inequality: There is a terms of trade effect,

but also a productivity effect of countries becoming larger. In addition, there is a composition effect if endowments change in an asymmetric fashion.

Trade in tasks between symmetric countries is mostly two-way in nature, with small and large countries concentrating on different subsets of tasks. We have shown that task trade between asymmetric countries is typically one-way in nature, whereby the production-worker-abundant economy exports task performance against imports of differentiated final goods. A further analytical result states that countries of equal size will have different wages for production workers in line with standard intuition from endowment-based models of comparative advantage, meaning that a larger relative endowment with production workers necessarily means lower production wages, notwithstanding the scope for productivity effects deriving from task specialization based on scale economies. Moreover, concentration of tasks in a certain country always works against managerial wages in that country.

These analytical results have been complemented by numerical simulations that highlight certain non-monotonicities as well as orders of magnitude. An interesting non-monotonicity arises for international inequality between differently sized countries that are symmetrically endowed with managers and workers. Starting out from low levels of offshoring, a reduction in the cost of task trade tends to generate gains mainly for the large country, while the opposite is true once these cost fall below a certain threshold. A similar non-monotonicity arises in the asymmetric case, where for low levels of offshoring it is the country with more production workers that reaps the bulk of globalization gains, while manager-abundant economies benefit once globalization as gone sufficiently far.

An interesting result regarding orders of magnitude relates to how the managerial wage premium is affected by offshoring. If offshoring takes place in a ""north-north" fashion", i.e., between countries with symmetric endowments with managers and workers, then a jump from very low to very high levels of offshoring, measured as the percentage of tasks concentrated in a single country, has a moderate positive effect on the wage premium in the vicinity of 5 percent. It is, however, much more severely affected if this same change takes place for task trade between countries with asymmetric factor endowments where the managerial wage premium increases by as much as 150 percent. Of course, these are numbers pertaining to a highly stylized model and should not, therefore, be taken literally. Overall, however, our analysis clearly demonstrates that task trade among similar and asymmetric countries is likely to have differential wage effects for managers and workers that have so far not received sufficient attention in the literature.

Appendix

Proof of proposition 3. With the definitions of I and I^* in equations (22) and (21), $nx = n^*x^*$ and $w > w^*$ imply that $I^* > I$. This means that the offshoring equilibrium will necessarily have tasks $[0, I^*]$ concentrated in the foreign country, whereas tasks $(I^*, 1]$ will be performed in both countries. Therefore, the full employment condition for production workers in the home economy from equation (28) implies

$$L = (1 - I^*)\frac{nx}{A(nx)} \tag{34}$$

Equation (29) can now be reduced to give an equation for full employment of production workers in the foreign economy as

$$L^* > (1 - I^*)\frac{n^*x^*}{A(n^*x^*)} + I^*\frac{nx + n^*x^*}{A(nx + n^*x^*)} \tag{35}$$

due to iceberg offshoring cost $T(I^*) > I^*$. Full employment of high-skilled managers in both countries gives

$$H = nf \tag{36}$$

and

$$H^* = n^*f \tag{37}$$

respectively. $\frac{H}{L} > \frac{H^*}{L^*}$ is equivalent to $\frac{H}{H^*} > \frac{L}{L^*}$.

We proof the proposition by establish a contradiction. Suppose $\frac{H^*}{H} > \frac{L^*}{L}$. Then,inserting equations (34) to (37) yields

$$\frac{n^*}{n} > \frac{(1 - I^*)\frac{n^*x^*}{A(n^*x^*)} + I^*\frac{nx+n^*x^*}{A(nx+n^*x^*)}}{(1 - I^*)\frac{nx}{A(nx)}}. \tag{38}$$

From the assumption of $nx = n^*x^*$, it follows that $\frac{n^*}{n} = \frac{x}{x^*}$. Inserting this and transforming the right-hand side gives

$$\frac{x}{x^*} > 1 + \frac{I^*\frac{2nx}{A(2nx)}}{(1 - I^*)\frac{nx}{A(nx)}} > 1 \tag{39}$$

Inspecting production cost in equation (26) it is easy to determine that the marginal cost of producing the Northern good is

$$\begin{aligned} c &= \frac{w(1 - I^*)}{A(nx)} + \frac{w^*T(I^*)}{A(nx + n^*x^*)} \\ &= \frac{w(1 - I^*)A(nx + n^*x^*) + w^*T(I^*)A(nx)}{A(nx)A(nx + n^*x^*)} \end{aligned} \tag{40}$$

The marginal cost of producing the Southern good follows from equation (27):

$$\begin{aligned} c^* &= \frac{w^*(1-I^*)}{A(n^*x^*)} + \frac{w^*I^*}{A(nx+n^*x^*)} \\ &= \frac{w^*(1-I^*)A(nx+n^*x^*) + w^*I^*A(n^*x^*)}{A(n^*x^*)A(nx+n^*x^*)} \end{aligned} \tag{41}$$

With $nx = n^*x^*$ and $w > w^*$, and since $T(I^*) > I^*$, this implies

$$\frac{c}{c^*} = \frac{w(1-I^*)A(2nx) + w^*T(I^*)A(nx)}{w^*(1-I^*)A(2nx) + w^*I^*A(nx)} > 1 \tag{42}$$

Finally we remember equation (3), relating the relative price of two varieties to the relative amount sold under CES preferences:

$$\frac{x}{x^*} = \left(\frac{c}{c^*}\right)^{-\sigma} \tag{43}$$

Since by assumption $\sigma > 1$

$$\frac{x^*}{x} \geq \frac{c}{c^*} \tag{44}$$

we arrive at a contradiction, since $\frac{c}{c^*} > 1$ in equation (42) and $\frac{x^*}{x} < 1$ in equation (39). □

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